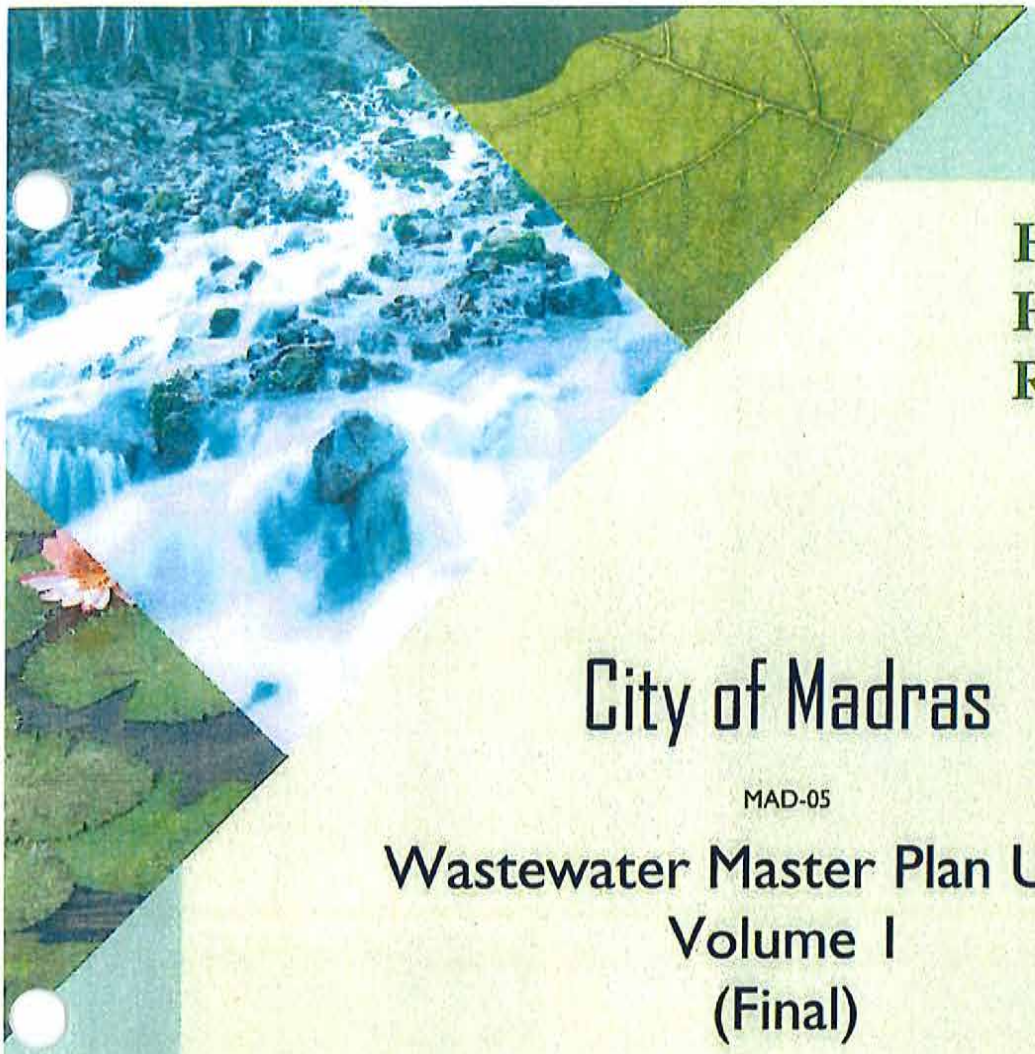

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City of Madras

MAD-05

Wastewater Master Plan Update
Volume I
(Final)

May 2018

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CITY OF MADRAS

WASTEWATER MASTER PLAN UPDATE

VOLUME ONE

(FINAL)

EXPIRES 12-31-2019

May 2018

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WASTEWATER MASTER PLAN UPDATE
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EXECUTIVE SUMMARY

S.1 INTRODUCTION

General. This Wastewater Master Plan (WWMP) Update addresses the City's service needs for a 20-year planning period and presents recommendations for meeting those needs. The City had a comprehensive WWMP prepared in 1996 that provided an analysis of the City's wastewater (WW) facilities and many of the recommendations from that original study have been implemented. This update builds on the results of the 1996 study to the extent they still apply.

Planning Area. This study addresses needs for the area inside the City's Urban Growth Boundary (UGB), with a few exceptions. The City serves two customers outside the UGB: the State's Deer Ridge Correctional Institution (DRCI) and the Madras Municipal Airport. Also, the WW treatment, effluent storage and effluent recycling facilities addressed in this study extend beyond the UGB.

Regulations for Wastewater Facilities. The City operates the WW facilities according to a Water Pollution Control Facility permit and the governing rules issued by the State Department of Environmental Quality (DEQ). These rules mainly pertain to treatment requirements at each wastewater treatment plant (WWTP) and recycling practices for the treated effluent and biosolids.

If the City were to pursue a discharge of treated effluent to Willow Creek, water quality standards (WQS) established by the DEQ for the Deschutes Basin would apply. The City would also need to obtain a different type of operating permit from the DEQ under the National Pollution Discharge Elimination System (NPDES).

Guidelines on Airport Impacts. The existing WWTP located adjacent to the municipal airport is affected by Federal Aviation Administration (FAA) guidance that recommends constraints on land uses near airports. These FAA guidelines would impact potential WWTP expansions due to concerns about the attraction of wildlife and any expansion plans would require FAA review.

S.2 EXISTING FACILITIES

S.2.1 Descriptions

General. Madras began providing centralized WW service in 1975 with the construction of a collection system and WWTP. Since then, the City has constructed expansions that have reshaped these facilities. The main elements of the existing facilities serving Madras are listed below:

- Two separate collection systems that receive and convey sewage to the City's two WWTPs.
- The North and South Wastewater Treatment Plants (NWWTP and SWWTP).
- Storage ponds and transmission systems that support effluent recycling as irrigation water on farmland and the municipal golf course.
- A supervisory control and data acquisition (SCADA) system.
- Onsite WW treatment and disposal systems on properties not served by or connected to a sewer.

Collection Systems. The City's WW facilities include a Main Collection System serving most of the City and a smaller Industrial Park Collection System. The smaller system serves the industrial/commercial area near the airport plus a group of residences north of Birch Lane and east of the Municipal Golf Course.

Major components of the two collection systems include approximately 208,000 linear feet of gravity sewers, 878 manholes, five pump stations, and close to 43,800 linear feet of force mains.

NWWTP. The NWWTP was constructed as part of the City's original WW facilities and is located on the southwest side of the airport. Upgrades to the plant were completed in the 1990s, but most original components remain in service. The plant capacity is 0.50 million gallons per day (MGD).

The main treatment process is a lagoon system that provides biological treatment. During cold weather, lagoon effluent is pumped to an open pond for storage. During the growing season, clarification and disinfection equipment provide additional treatment for both the lagoon system effluent and the stored effluent from the pond. Following clarification and disinfection, the effluent is recycled through irrigation of City-owned farmland and the Desert Peaks Golf Course.

SWWTP. The SWWTP was constructed in 2001 as part of the improvements recommended in the 1996 WWMP. The plant site is located on the south side of "J" St., between Willow Creek and Grizzly Road. The City expanded the facility in 2008 to treat flows from the DRCI and the current capacity is 0.54 MGD. The plant is configured to accommodate another expansion.

A sequencing batch reactor (SBR) process provides biological treatment and cloth filters polish the SBR effluent. Disinfection equipment provides final treatment before the effluent is either pumped to a storage pond or used to irrigate the adjacent, City-owned farmland.

S.2.2 Condition Assessments

Gravity Sewers and Force Mains. Available information indicates the sewers, force mains and appurtenances in the two collection systems are generally in adequate to good condition. Our analysis also shows the pipes have adequate capacity to handle existing WW flows generated in the City, plus the design flows from the DRCI when that facility is fully occupied. Age should only become a concern for the existing pipes near the end of the 20-year planning period.

Pump Stations. Age and condition concerns for each collection system pump station (PS) are outlined below. The City will need to implement PS renovations during the planning period.

- **"B" Street PS North.** Originally constructed in 1975; overall in poor to good condition. The main areas of concern are the age of original components from the 1970s and problems with pump clogging due to increased amounts of non-degradable materials such as flushable wipes.
- **"B" Street PS South.** Constructed in 2001; overall in adequate to good condition. The main area of concern is rusting of valves and piping in the valve vault.
- **"B" Street Standby Generator Facilities.** Constructed in 1999; overall in good condition.
- **South 97 PS.** Age not available; overall in adequate to good condition. The pumps operate infrequently due to low incoming flows. The main area of concern is rusting of valves.
- **Golf Course PS.** Constructed in 1996; overall in poor to adequate condition. The main areas of concern are the age of the existing facility, the condition of the pumps and valves, and the lack of a SCADA unit for remote monitoring of alarms.
- **Demers PS.** Constructed in 1989-90; overall in poor to adequate condition. The pumps had to be replaced with used units in 2017 after the condition assessment was performed for this study. The main areas of concern are heavy corrosion and overall wear on components in the valve vault.

NWWTP. The condition of the NWWTP is generally adequate and a few pieces of equipment have recently been replaced. However, the replacement aerators the City recently installed are used units. Overall, due to the age of most components, the facility will require major renovations during the planning period to continue to provide reliable service. Since some condition issues would need to be addressed sooner than others, a phased upgrade would be appropriate.

Key condition issues with the NWWTP are summarized below.

- No influent screening to remove debris that can accumulate in the lagoons.
- Sediment buildup in the lagoons that reduces the available volume for treatment.
- Deteriorated components at the lagoon transfer/outlet structures.
- The age and the outdoor location of the clarifier process. Because the equipment is subject to freezing in cold weather, the City cannot operate the process during the winter.
- Some pumping equipment, valves and instrumentation are old and in need of replacement.
- The main electrical service components should be replaced within 10 years.

SWWTP. The overall condition of the SWWTP is good. Structural components and yard piping should generally be adequate for the next 20 years and beyond. The age of most equipment will not become a concern for about 10 years. However, there are some key condition and operating issues that should be addressed within the next 3 years. These are listed below.

- Control system hardware and software components are either obsolete or soon will be.
- The fine-bubble, diffuser tubes in the SBR basins are at the end of their service life.
- The SBR effluent control valves for the two SBR basins do not close tightly and leak.
- The filter backwash pump and skid are heavily corroded and the electric actuators on the control valve may also be subject to corrosion due to their location in a below-grade gallery.
- The performance and efficiency of the aerobic digester process can be improved by installing dissolved oxygen (DO) probes in the digesters and adding new DO control programming.
- The practice of hauling dilute liquid sludge (biosolids) from the SWWTP to the sludge drying beds at the NWWTP can fill up all available drying-bed capacity when unusually cold and wet weather occurs.

S.2.3 Maintenance Plan Recommendations

Recommendations for completing major maintenance tasks and corrective work were developed in cooperation with the City and are presented in this study. The items covered by the recommended plans are non-routine tasks that often must be performed by outside contractors or repair shops. Routine preventive maintenance tasks are not included in the plan recommendations.

S.3 BASIS OF PLANNING

S.3.1 Population and Dwelling Units

Table S-1 (following page) lists the population forecasts published by the Portland State University Population Research Center (PSU), as well as corresponding numbers of dwelling units (DUs). Census data shows the average unit occupancy was about 2.7 people per household (PPH) in 2010 and this unit occupancy is anticipated to decline in the future. Therefore, this study used 2.6 PPH to estimate the projected numbers of DUs.

Table S-1
Madras UGB Forecasts for Population and DUs

Year	Population	Occupied DUs (1)	AAGR (2)
2015	7,484 (3)	2,880	---
2020	8,070	3,105	1.52%
2025	8,700	3,345	1.51%
2030	9,268	3,565	1.27%
2035	9,815	3,775	1.15%
2065	12,749	4,905	0.88%

(1) Forecasts for occupied DUs based on an average unit occupancy of 2.6 PPH.
(2) AAGR is calculated for each incremental 5-year period to 2035 and for the 30-year period from 2035 to 2065.
(3) PSU 2015 population estimate for entire area within UBG.

S.3.2 Wastewater Flows

Records for 2010 through 2014 indicate that the aggregate, average unit flow from all users, residential and nonresidential, is approximately 200 gallons per day (gpd)/DU. We applied a factor of 1.2 to this average unit flow to estimate a peak-monthly unit flow of 240 gpd/DU.

Consistent with recent planning forecasts, the WW flow projections in this study assume nonresidential growth will be proportional to residential growth. Therefore, the overall flow per DU is projected to remain constant over the planning period.

Table S-2 lists the WW flow projections used in this study. The WWMP assumes the DRCI will produce its full design flow throughout the planning period due to the absence of any population or flow projections from the Department of Corrections.

Table S-2
Wastewater Flow Projections for Madras UGB

Year	Flows (MGD) (1)		DRCI Flows (MGD) (2)	Total Flows (MGD)	
	Avg. Annual	Peak Month		Avg. Annual	Peak Month
2020	0.55	0.66	0.23	0.78	0.89
2025	0.67	0.80	0.23	0.90	1.03
2030	0.71	0.86	0.23	0.94	1.09
2035	0.76	0.91	0.23	0.99	1.14
2065	0.98	1.18	0.23	1.21	1.41

(1) Average annual and peak monthly flows based on 200 and 240 gpd/DU, respectively.
(2) DRCI flow based on dedicated capacity allotted to DRCI by agreement with ODOC.

To be conservative, the flow projections for the Year 2025 and beyond assume the entire population within the UGB will be served. The forecasts for 2020 assume sewer service will be extended to 25% of the projected population outside the City, but inside the UGB.

S.3.3 Wastewater Strength

We used estimates of the influent WW strength along with flow capacity to establish the basis of planning for WWTP expansions. Concentrations of five-day biochemical oxygen demand (BOD) and total suspended solids (TSS) are the parameters used for this purpose.

Data for both WWTPs and the DRCI show the following WW strengths are appropriate for planning treatment needs.

- **NWWTP – Combined flows:** 300 mg/L average BOD and TSS concentration
- **SWWTP – City flows:** 250 mg/L average BOD and TSS concentration
  DRCI flows: 750 mg/L average BOD and TSS concentration

S.4 ANALYSIS OF COLLECTION SYSTEMS

S.4.1 Sewer Modeling

General. Computer models of the City's two collection systems were generated using the InfoSWMM program to analyze sewer-pipe capacities. Sewer data were obtained from the 1996 WWMP model, available City records, and field investigations. We executed models to analyze sewer capacities under both existing and projected flow conditions.

Estimated peak flows were input to the models using estimated distributions of tributary dwellings, the estimated average flow per DU, and a peaking factor. Proposed developments inside the UGB and input from the City were used as the basis for distributing future tributary DUs.

Most existing DUs not connected to the existing systems were added into the models of future conditions. Only the unserved, existing homes most distant from existing sewers were excluded because of the low probability sewers will be extended to these areas within 20 years.

Modeling Results – Main Collection System. The model of existing conditions confirmed the sewers have enough capacity to convey peak flows to the "B" Street Pump Stations and the WWTPs. The model of projected flows showed the following two sections of existing sewers will have insufficient capacity under future conditions.

- **North Wye Sewer.** The 8-inch interceptor sewer extending southwest from U.S. 97 at Cedar Street to the intersection of 4th and Maple Streets.
- **Culver Highway Sewer.** The 8-inch interceptor sewer extending along Marshall Street, Culver Hwy. and 1st Street, between "G" and "B" Streets.

Modeling Results – Industrial Park Collection System. The model of existing conditions confirmed the existing sewers have enough capacity to convey peak flows to the Demers PS and NWWTP. A model of future conditions with projected flows from the planned Willowbrook development also showed no capacity deficiencies in the existing sewers.

As part of industrial site readiness planning, we performed additional analyses to address the impacts of major industrial developments contributing high WW flows. We applied a 1.0-MGD average flow with a peaking factor to model future flows from three currently-undeveloped areas in the industrial park. The modeling results show the existing sewers serving these three selected areas do not have enough capacities to convey peak flow from such major users.

The parallel sewers required to carry the major WW contributions we modeled from each area are listed below. These potential sewers are identified to support industrial site readiness planning. The size, length and alignment of a parallel sewer will depend on actual development plans.

- **East Area** – Approximately 4,800 linear feet of 15-inch parallel sewer along Cherry Lane.
- **South Area** – Up to 2,400 linear feet of 18-inch parallel sewer along Demers Drive.
- **North Area** – Approximately 2,240 linear feet of 18-inch parallel sewer along Airport Way.

S.4.2 Sewer Extensions

Main Collection System. Gravity sewers need to be installed in several unsewered areas to extend service to existing housing developments. New sewer extensions will also be needed in three locations to serve proposed housing developments not immediately adjacent to existing sewers. These proposed sewer extensions are listed below.

- **Extensions into Existing Unsewered Areas:** Bel Air/Herzberg Heights (~5,100 linear feet); Jefferson Street/North Unit (~2,900 linear feet); Mountain View/Sky Ridge (~4,500 linear feet); and Juniper Heights (~5,350 linear feet).
- **Extensions to Reach Proposed Developments:** Willow Creek North (~2,500 linear feet); Madras South Town Center (~2,400 linear feet); and Eldorado Estates/The Ridge (~1,800 linear feet).

The pipe size for all the above-listed sewers would be 8-inch. The sewer lengths listed for extensions to future developments exclude the sewers required within the developments since those would be installed by developers.

Industrial Park Collection System. The City has identified two sewer extensions in the Industrial Park to serve infill locations. These projects include 8-inch sewers extending along Hess Street and Mill Street for about 1,670 and 1,430 linear feet, respectively.

S.4.3 Pump Stations

The collection system pump stations and their associated force mains all have adequate capacity for existing conditions. However, PS improvements will be required during the planning period due to condition and/or capacity issues. The following paragraphs summarize projected PS needs.

- **"B" Street PS North.** The "B" Street North PS needs influent screening equipment to reduce maintenance costs from clogging. The existing PS will also need a renovation to replace and upgrade aging components in 11 to 15 years.
- **"B" Street PS South.** Due to age and wear, the City should plan to replace some components within 20 years This PS will also need to be expanded when the SWWTP is expanded.
- **"B" Street Standby Generator.** The generator equipment is projected to require a major overhaul or replacement within 15 years. Renovation work on the Generator Building should also be scheduled at that time.
- **South 97 PS.** The City should plan to renovate this PS in 6 to 10 years to address age issues.
- **Golf Course PS.** The Golf Course PS will need to be replaced when development of the Willowbrook subdivision proceeds. If that development does not occur, the City should plan to replace the existing PS within 10 years due to its age and condition.
- **Demers PS.** The City will need to replace components in the valve vault and rebuild the pumps in 3-5 years due to condition issues. The City should also plan to replace the PS in 16-20 years.

S.5 TREATMENT ALTERNATIVES DEVELOPMENT AND SCREENING

S.5.1 Background for Alternatives Development

NWWTP. Key factors in developing alternatives for the NWWTP are outlined below.

- The existing lagoon system has relatively low operations and maintenance (O&M) costs.
- The facility is strategically located close to both the Industrial Park and farmland used for effluent recycling.
- The NWWTP requires renovation to keep the facility in operation for another 20 years.
- FAA guidelines identify WWTPs as potential wildlife attractants that should not be located near airports unless acceptable mitigation measures are implemented.
- The shallow depth to underlying rock in the area significantly impacts construction costs.

SWWTP. Key factors in developing alternatives for the SWWTP are outlined below.

- The plant has significant useful service life remaining and should provide reliable service for the next 20 years with scheduled renovations of existing equipment.
- The facilities are designed to accommodate another expansion with common-wall construction.
- The site accommodates gravity flow from sewers in the east and southeast parts of the City. Pumping flows from these gravity sewers to a remote site would require costly upgrades.
- The SBR process has higher O&M costs relative to a lagoon system, but requires far less land.

Effluent Uses. The City has always reused treated effluent for irrigation purposes and has never obtained a permit for a surface-water discharge. Incentives for the City to continue the practice of effluent recycling include a successful track record, the local availability of farmland, and a favorable and stable regulatory climate for this beneficial reuse.

Given the above-listed incentives, the scope of this study is based on the premise the City would continue the current practice of effluent recycling. Therefore, this WWMP Update includes only a preliminary examination of the issues impacting a surface-water discharge.

The City would need to have a separate study prepared to investigate the feasibility of a direct or indirect discharge to Willow Creek. Such a feasibility study would need to examine discharge options, the impacts of WQS, DEQ guidance, potential treatment requirements, site constraints, and related issues. At this point, it is uncertain whether DEQ would approve a Willow Creek discharge.

Biosolids Handling. Existing biosolids treatment systems include aerobic digesters at the SWWTP and sludge drying beds at the NWWTP. These facilities are generally in good condition and the digesters have adequate capacity for current solids production. However, liquid biosolids hauled from the SWWTP can fill the sludge drying beds to capacity when cold and wet weather prevents adequate drying from drainage and evaporation. This capacity limitation needs to be addressed.

The City spreads dried biosolids as Class B biosolids on City-owned farmland accordingly to an approved biosolids management plan. The rules and guidelines for land application of Class B biosolids have not changed significantly over the last decade.

S.5.2 Basis for Treatment and Storage Requirements

Influent WW Flow. Table S-3 lists the maximum-monthly and peak-hourly flow projections identified from the basis of planning. The net available treatment capacity listed to the right is the difference between the maximum-monthly flow projection and the existing combined WWTP capacity. Maximum-month flows are projected to reach existing capacity in about 10 years.

Table S-3
Wastewater Treatment Capacity Requirements

Year	Projected Total Flows (MGD) [1]		Net Available ADF Capacity [2]
	Maximum Monthly	Peak Hourly	
2020	0.89	2.43	0.15
2025	1.03	2.75	0.01
2030	1.09	2.91	– 0.05
2035	1.14	3.04	– 0.10
2065 (build-out)	1.41	3.76	– 0.37

(1) Flow projections assume full occupancy of the DRCI and nonresidential flows will increase in proportion with projected growth in residential flows.
(2) Based on the existing total ADF capacity of 1.04 MGD.

Treatment Level. The development of alternatives was based on the premise that the City would continue the following practices:

- Treat WW to produce Class B effluent for recycling by irrigation.
- Process biosolids to produce dried, Class B biosolids for recycling by spreading on farmland.

Effluent Storage. Since effluent can only be recycled during the growing season, all alternatives would require storage capacity for about 6 to 6.5 months of treated effluent. The effluent storage pond needed for each 0.5-MGD of treatment capacity would require a gross area of about 30 acres.

Solids Handling. The continued practice of land applying Class B biosolids as a dry material is the recommended option at this time and was used as the basis for alternatives development. This conclusion is based on the current conditions of the existing biosolids handling facilities, the availability of farmland, and the regulatory climate.

S.5.3 Overall Treatment Scenarios

We identified and screened five overall WW treatment scenarios for serving the City over the next 20 years. These alternative scenarios are summarized below:

- **Scenario One** – No expansion; renovate existing WWTPs to maintain current capacity.
- **Scenario Two** – Abandon both existing plants and construct one or two new WWTPs.
- **Scenario Three** – Abandon one WWTP and expand the other to treat all flows.
- **Scenario Four** – Maintain one WWTP at its current capacity and replace or expand the other.
- **Scenario Five** – Implement modifications to both WWTPs to expand the capacity of each.

Initial screening eliminated Scenarios One, Two and Three from further evaluation because they are not suitable for the City's planning needs. The City should plan for a small, capacity expansion to treat projected flows and additional expansions to serve potential growth in the Industrial Park. At this time, the City should also plan to maintain both WWTPs in service.

Our evaluation shows either Scenario Four or Scenario Five could fit projected WW service needs. However, accelerated industrial development may drive expansions to both plants. Therefore, to address industrial site readiness, we selected Scenario Five as the preferred overall treatment scenario for planning purposes. Table S-4 summarizes this recommended scenario.

Table S-4
Preferred Overall Treatment Scenario

Expand SWWTP to Treat Projected Flows and Dedicate NWWTP to Serve North Area

1. Phased improvements to the SWWTP.
   - Phase 1. Modify the plant to provide a small increase in capacity to 0.65-MGD and renovate the existing facilities as needed to maintain reliable service.
   - Phase 2. If necessary, construct the additional 0.5-MGD treatment module for which the SWWTP is designed to provide a total 1.14-MGD ADF capacity. This second phase would free up capacity at the NWWTP to serve industrial developments.
2. Renovate, retrofit, or replace the existing NWWTP to maintain the 0.5-MGD capacity. After SWWTP expansions, the NWWTP would be dedicated to serving the North Area and would be expanded as necessary to serve Industrial Park developments.

The proposed Phase 1 SWWTP expansion would provide an overall treatment capacity that meets the 20-year flow projection. The Phase 2 SWWTP expansion would free-up the entire NWWTP capacity to serve the North Area. This additional expansion would only be necessary if industrial development creates the need for more capacity than currently projected. Otherwise, Phase 2 for the SWWTP would not be justified.

S.5.4 Improvements to Existing NWWTP

An upgrade of the NWWTP is part of the overall treatment scenario because improvements must be made within the planning period to maintain reliable service. The plant could be renovated to keep existing treatment processes in service, retrofitted to modify existing processes, or replaced with a new facility.

The following options for upgrading the 0.5-MGD lagoon system were evaluated in coordination with the alternatives evaluation for future NWWTP expansions. Upgrades and/or replacements of the clarification and disinfection systems would be part of each approach.

1. **Full Renovation.** Renovate the existing lagoons to maintain the same capacity and footprint.
2. **Partial Renovation.** Renovate half the lagoon system to provide a 0.25-MGD and construct an adjacent treatment module to maintain or expand capacity.
3. **Retrofit to Maintain Capacity and Reduce Footprint.** Retrofit half the existing lagoon system with a new, higher-rate system to maintain a 0.5-MGD capacity in about half the existing lagoon footprint.
4. **Retrofit to Increase Capacity.** This retrofit option would convert both primary lagoons to aerated lagoons in two phases to double the plant capacity within the existing footprint.

5. **Complete Replacement.** Construct a new 0.5-MGD WWTP adjacent to the existing facility and abandon all existing components.

Modifications to the NWWTP must address FAA constraints on the siting of wildlife attractants near airports. Plans for any modifications would need to be submitted to FAA for review and, if costly mitigation measures are mandated, the City may need to investigate alternative sites.

S.5.5 Alternative Treatment Processes for NWWTP Expansions (Industrial Site Readiness Planning)

As a first step in determining the most cost-effective approach to expanding the NWWTP, we conducted a technology review to identify alternatives that should be screened for further evaluation This review identified treatment processes that have been found to be suitable for the required plant size and treatment level in Madras.

We then screened the alternatives we identified by evaluating and comparing the processes with regard to O&M considerations, treatment reliability, safety considerations, and siting constraints. These criteria were used to eliminate processes that do not fit this application well and identify the alternatives that have the potential of being cost effective solutions for Madras.

Table S-5 lists the alternatives that remained after the initial review and screening efforts. These processes were further evaluated in a cost-effectiveness analysis using more detailed criteria.

Table S-5
NWWTP Alternatives Recommended for Further Evaluation

1. **Preliminary Treatment at Headworks:** Mechanically-Cleaned Screen and Low-Energy, Vortex Grit Chamber
2. **Secondary Treatment** a. Renovation of existing Partially-Aerated, Facultative Lagoon System (no stabilization) b. Aerated/Partially Mixed Lagoon System – retrofit and expansion (no stabilization) c. Oxidation Ditch Extended Aeration d. Compact Extended Aeration Process Configuration e. SBR Extended Aeration
3. **Disinfection** a. Sodium Hypochlorite Bulk Storage and Feed b. Onsite Sodium Hypochlorite Generation and Feed c. Tablet Chlorination (Calcium Hypochlorite) Equipment
4. **Biosolids Stabilization:** Aerobic Digestion
5. **Biosolids Dewatering:** Sludge Drying Beds

S.6 EVALUATION OF TREATMENT ALTERNATIVES

S.6.1 Overview of Alternatives Evaluation

Evaluations of alternatives for NWWTP expansions were completed in two stages. We first evaluated the alternative processes that remained after screening. Then we evaluated alternatives for renovating, retrofitting or replacing the existing NWWTP in coordination with expansions.

A separate alternatives evaluation was also performed to identify the most cost effective method for handling SWWTP biosolids to address hauling requirements and drying-bed capacity limitations.

We evaluated alternatives by comparing probable present worth costs, O & M requirements, land use impacts, treatment reliability, operating flexibility, and sustainability. Probable present worth costs include estimates of construction costs, annual O&M costs and salvage values after 20 years. Our analysis used December 2016 dollars.

S.6.2 Development of Alternatives for NWWTP Secondary Treatment and Disinfection

Preliminary process sizing and layouts were developed for the NWWTP alternatives that remained after the screening effort and were used to estimate probable life-cycle costs. Each alternative secondary process requires the following support facilities to provide complete systems.

- a headworks for preliminary treatment;
- secondary clarifiers for biosolids separation and removal;
- aerobic digesters for biosolids stabilization;
- building to house accessory equipment and process controls; and
- sludge drying beds for biosolids dewatering and land application of Class B biosolids.

All disinfection alternatives include a building to house the process equipment, piping and controls.

S.6.3 Summary of Secondary Process Alternatives Comparison and Ranking

We compared the secondary alternatives using both our estimates of probable, present-worth costs and the nonmonetary criteria. The aerated lagoon process had the highest overall ranking based on these criteria and the SBR process, with similar life-cycle costs, was a close second. The other two processes, oxidation ditches and compact extended aeration, had significantly higher life-cycle costs and were ranked lower.

Based on our evaluation, an aerated lagoon system is the most cost-effective secondary treatment alternative to implement at the NWWTP. The main advantages to this process are the lower O&M requirements and the associated cost savings relative to the other alternatives. Therefore, we recommend that the City implement aerated lagoons as the secondary treatment process for a retrofit or replacement of the existing NWWTP and for plant expansions.

Overall, aerated lagoons and SBRs rank close in both costs and nonmonetary factors. If the Federal Aviation Administration (FAA) requires covers over lagoons and basins, then the SBR process could be worth further consideration due to its smaller footprint.

S.6.4 Summary of Disinfection Alternatives Comparison and Ranking

Using both monetary and nonmonetary considerations, our analysis identified the tablet chlorination system as the most cost effective disinfection alternative. A tablet chlorinator is estimated to have a lower life-cycle cost and about 20% lower O&M costs than the bulk storage and feed system the City currently uses.

S.6.5 Evaluation of Alternatives for Existing NWWTP Facilities

General. As previously described, the City will need to renovate, retrofit, or replace the existing facility within 15 years. We evaluated alternatives for upgrading the NWWTP in conjunction with an expansion to identify a preferred approach for addressing condition issues while maintaining industrial site readiness. Aerated lagoons were incorporated into the alternatives evaluation as the recommended secondary treatment process for expansions, consistent with our analysis of process alternatives.

The evaluation compared alternatives for providing an expanded NWWTP capacity of 1.0 MGD and also considered site requirements for an additional expansion to 1.5 MGD. The main considerations in evaluating alternative NWWTP upgrades are summarized below:

- the pace of development in the North Area;
- the need for flexibility to accommodate expansions for maintaining industrial site readiness;
- the impacts on the airport that expansions of open lagoons would have;
- the recommended secondary treatment alternative for NWWTP expansions; and
- the availability of farmland near the NWWTP for effluent recycling by irrigation.

Alternatives for Upgrading and Expanding the NWWTP. The alternative approaches to upgrading and expanding the existing NWWTP are summarized below.

1. **Option 1 – Full Renovation of Lagoon System and Adjacent Expansion.**
   - Renovate the existing lagoons in phases to maintain a 0.5-MGD capacity in the same area.
   - Expand the capacity to 1.0 MGD by constructing a 0.5-MGD aerated lagoon module and additional effluent storage capacity on adjacent land.
2. **Option 2 – Partial Renovation Combined with Adjacent Expansion.**
   - Renovate half the lagoon system to provide a 0.25-MGD capacity. To expand to 1.0 MGD, construct a 0.75-MGD aerated lagoon module on adjacent land.
   - The remainder of the existing lagoon system could be converted to an effluent storage pond as part of the expansion to reduce the required area outside the existing footprint for effluent storage.
3. **Option 3 – Retrofit to 0.5-MGD Aerated Lagoons with Adjacent Expansion.**
   - Retrofit one primary cell of the existing lagoon system to convert it to a 0.5-MGD aerated lagoon system. This retrofit would use a more intensive process to reduce the volume required for a 0.5-MGD capacity.
   - Adjacent aerated lagoons would be constructed for expansions and the remainder of the existing lagoon footprint would be converted to effluent storage.
4. **Option 4 – Retrofit to Increase Capacity with Aerated Lagoons.**
   - This retrofit option would convert both existing primary lagoons to the higher-rate aerated lagoons in two phases to double the plant capacity to 1.0 MGD within the existing footprint.
   - Effluent storage capacity would need to be constructed on adjacent land for the expansion.

5. **Option 5 – Complete Replacement with New Facility.**

   - This option would replace the existing facilities with an entirely new 0.5-MGD WWTP. The replacement facilities would consist of the same aerated lagoon and disinfection processes we recommend for expansions.
   - The existing lagoon footprint would be converted to effluent storage when the plant is expanded to 1.0 MGD.

Common Facilities. Each option would include new headworks, clarification and disinfection equipment, pumps, and valves. The clarifiers would be housed in a new process building for weather protection. The existing sludge drying beds would be expanded when necessary.

Probable Costs for NWWTP Alternatives. Our estimates show the probable present worth costs for Options 1 and 4 are essentially equal and the probable present worth costs for the other three options are estimated to be 5% to 11% higher.

Recommended Approach to NWWTP Upgrades and Expansions. We recommend the City plan to implement Option 4, a phased retrofit to upgrade and expand the NWWTP with aerated lagoons, for the following reasons.

- Option 4 is estimated to have lower O&M costs than the other alternatives while the life-cycle costs are estimated to be approximately equal to Option 1 and lower than the other options.
- Option 4 would eliminate the larger facultative lagoons (secondary cells) that would remain under both Options 1 and 2. Facultative lagoons not only require more area, they also are more prone to algae growth and more likely to act as wildlife attractants.
- There is considerable flexibility in how the aerated-lagoon retrofits can be configured and the types of equipment that can be installed. This provides flexibility in tailoring the design capacity of the retrofits to actual development conditions.
- Aerated lagoons receive more aeration and mixing than the existing lagoon system. This reduces algae growth and provides a less attractive environment for water fowl due to greater surface agitation.

We recommend the implementation of the 0.5-MGD retrofit in phases due to limitations in funding and differing priorities for component replacements. The recommended phasing, our estimates of probable project costs for each phase, and project timing are presented in the capital improvements plan.

S.6.6 Evaluation of Biosolids Alternatives for Existing SWWTP

Existing Biosolids Handling. Biosolids must be wasted from the SBR process at the SWWTP and treated in adjacent aerobic digesters. Currently, the treated (digested) biosolids are hauled in a tank truck as a dilute liquid (98.5 – 99.0% water) to the sludge drying beds at the NWWTP. This practice requires the hauling of approximately 500 truckloads of liquid biosolids annually. In the winter, cold and wet conditions can result in no net loss of water. Therefore, the drying beds must effectively store all of the liquid hauled over a period of up to three months.

SWWTP Biosolids Alternatives. We evaluated the following three alternatives for drying digested biosolids before land application by spreading.

- Alternative One – Continue Hauling Dilute Biosolids and Expand Sludge Drying Beds.

- Alternative Two – Add Biosolids Thickening Process at SWWTP and Reduce Scope of Sludge Drying Bed Expansion. Haul thickened liquid with 4 – 5% solids content (95 – 96% water) in a tank truck.
- Alternative Three – Add Biosolids Thickening and Dewatering Processes at SWWTP and Avoid Sludge Drying Bed Expansion. Haul material with about 20% solids content using a dump truck.

The City could potentially use an existing storage building at the SWWTP to house the process equipment required for Alternatives Two and Three.

Recommended SWWTP Biosolids Alternative. Alternative Two, the thickening process, is estimated to have significantly lower life-cycle costs than the other alternatives. This includes both lower capital costs and lower O&M costs. Alternative Two would also reduce fuel consumption and safety concerns relative to current practice by lowering the number of truck trips for hauling biosolids.

Given the clear monetary and nonmonetary benefits to adding a thickening process at the SWWTP, we recommend the City implement Alternative Two. Because the thickener will reduce O&M costs, we propose the City consider this a high-priority improvement.

S.7 EFFLUENT STORAGE AND RECYCLING

S.7.1 General

We developed estimates for future effluent storage and farmland requirements based on the assumption that the City will continue to recycle all effluent flows with no surface water discharge. The following paragraphs summarize our estimates of these projected needs.

S.7.2 Effluent Storage Volume Requirements

Volume Requirement. Our calculations show an effluent storage volume of 79 MG is required in Madras for each 0.5-MGD in average treatment capacity. This estimated volume is based on a water balance using records for the maximum annual precipitation (1983) and minimum annual evaporation (1993).

NWWTP Effluent Storage. Currently, the NWWTP includes one 79-million gallon (MG) storage pond. This means there is adequate volume for the existing capacity, but no surplus storage volume. Therefore, a plant expansion to 1.0 MGD would require the storage volume to be doubled.

SWWTP Effluent Storage. There are two existing storage ponds near the SWWTP with a total volume of 113 MG. This translates to a surplus storage volume of 28 MG at the current design capacity and a 10-MG surplus volume after the recommended expansion to 0.65 MGD. A Phase 2 expansion to 1.15 MGD would require 70 MG of additional storage volume. The existing site of the upper storage pond for the SWWTP has room for the future addition of another pond.

S.7.3 Existing Land Available for Effluent Recycling

NWWTP Sites. The City owns 246 acres of farm fields around the airport that can still potentially be used to recycle NWWTP effluent. The municipal golf course also has about 75 acres that can be irrigated with effluent. Not all of the irrigation demands for crops and the golf course are satisfied using effluent. Water from the North Unit Irrigation District (NUID) is used as a supplemental source.

Some farmland is designated for future development in the around the airport. Overall, about 135 gross acres of farmland would be lost, if airport developments occur and the NWWTP were expanded to a 1.5 MGD capacity. Alternatively, there are tentative plans to expand the golf course and potentially increase available land for irrigation by 43 acres.

SWWTP Sites. The City owns 304 acres of land near the SWWTP that can potentially be used for effluent recycling. Currently, 111 acres are available for irrigation. The other 193 acres are unimproved and are planned as a future golf course site that would be irrigated with recycled effluent. If the land is not developed as a golf course before the City needs it for SWWTP effluent recycling, this site could be used as farmland.

S.7.4 Farmland Requirements for Effluent Recycling

General. We estimated the amount of farmland required for future effluent volumes based on information presented in the effluent reuse plans previously prepared for the City. We also updated the information in these reuse plans based on input from the City regarding effluent uses.

Effluent use for irrigation was estimated using water demand for alfalfa as an average condition. Grass crops generally have higher water demands and grains generally require lesser amounts. Costs for securing additional irrigable land will depend on several factors and further study into available options will be needed to develop planning-level estimates of probable costs.

NWWTP Recycling Farmland Requirements. We project the NWWTP would have a farmland deficit of 37 acres when peak monthly flows reach 0.50 MGD. This estimate accounts for the potential loss of fields near the airport due to commercial/industrial development. Some of this deficit could be offset, if more of the golf-course water demand were met using recycled water. However, the City should plan to identify and purchase at least 42 more acres of farmland to use for irrigation within the planning period. This figure includes allowances for field access and buffers.

Our projections also show the NWWTP site would face a farmland deficit of about 300 acres and 610 acres at future flows of 1.0 MGD and 1.5 MGD, respectively. These deficits would be less, if more of the golf-course demand can be met with recycled water in the future. However, these deficits would each increase by about 20 acres, if the municipal golf course is not expanded as planned.

SWWTP Recycling Farmland Requirements. We project the City would need to make about 125 acres of the upper parcel available as irrigable farmland to recycle the current SWWTP capacity of 0.54 MGD. Therefore, the City should plan to make the future golf course parcel available for irrigation in 6 to 10 years or sooner, if flow contributions from DRCI begin to increase significantly.

With the entire upper parcel available for irrigation as farmland, the City would have a surplus of about 28 acres when peak monthly flows reach an expanded capacity of 0.65 MGD.

We project a farmland deficit of almost 180 acres if the City constructed a Phase 2 SWWTP expansion and peak monthly flows reached 1.15 MGD. This deficit could be reduced, if the future golf course is developed as planned and effluent is used to meet most or all of the irrigation demand. This is because water demands are higher for turf grass than alfalfa.

S.8 RECOMMENDED IMPROVEMENTS AND PLANNING CONSIDERATIONS

S.8.1 Capital Improvements Plan

The projects identified in the capital improvements plan (CIP) and the anticipated project timing are listed below. Actual project schedules will depend on a variety of factors.

1. **Gravity Sewer Projects.** The CIP identifies 10 gravity sewer projects for the collection systems with an estimated total probable project cost of $7,822,000. These improvements and the projected time frames for their implementation are listed below.

   A. Within 5 years: Three projects to bring service to unsewered residential areas (Bel Air/Herzberg Heights, Mountain View/Sky Ridge, and Jefferson Street/North Unit).

   B. In 6-10 years: Two sewer extension projects in the Industrial Park to serve unsewered pockets of land along Hess and Mill Streets.

   C. In 11-15 years: The North Wye sewer replacement to increase capacity for proposed developments and unsewered areas.

   D. In 16-20 years:

   - The Culver Highway parallel sewer to increase system capacity for proposed developments and unsewered areas .
   - The Juniper Heights project to bring service to that unsewered area.
   - The Willow Creek North sewer to extend service to future developments.

   E. Industrial Site Readiness Planning: The potential North Area-Airport Way parallel sewer project as the least-cost alternative to serve a major WW contributor in the Industrial Park. The project scope and timing are development dependent.

2. **Pump Station and Force Main Projects.** The CIP identifies the following PS and force main projects for the two collection systems. The estimated total probable project cost of these improvements is $5,555,000.

   A. Within 5 years: Add an influent mechanical screen at the "B" Street North PS.

   B. In 6-10 years: The Golf Course PS replacement with capacity expansion for the planned Willowbrook subdivision (project would be sooner if the Willowbrook development proceeds).

   C. In 11-15 years:

   - "B" Street North PS renovation with no capacity expansion.
   - Generator replacement at the "B" Street pump stations.
   - South U.S. 97 PS Renovation with no capacity expansion.

   D. In 16-20 years:

   - Demers PS replacement with allowance for future expansion(s).
   - "B" Street South PS renovation and expansion.

   E. Industrial Site Readiness Planning: Potential force main replacement project from Demers PS to NWWTP when PS capacity is expanded beyond 0.70 MGD. Project timing is development dependent.

3. **WWTP Projects.** The CIP identifies the following WWTP and effluent storage projects. The estimated total probable project cost of these improvements is $77,315,000. These improvements are based on the City continuing the current practice of recycling Class B effluent on farmland and the golf course. The NWWTP projects also are contingent on FAA reviews and acceptance.

   A. Within 5 years:

   - NWWTP Phase 1A improvements to allow reliable year-round operation of the clarifier, disinfection and pumping equipment.

     Alternate Phase 1A Project: Our CIP also identifies an alternate project with a more limited scope to allow reliable year-round operation of the NWWTP in the near term. Other work we included in the full Phase 1A improvements would then be completed separately as funds become available.

   - A SWWTP biosolids thickening process to reduce biosolids hauling costs and reduce the amount of sludge drying bed capacity that is required.

   B. In 6-10 years:

   - A SWWTP expansion to increase average design capacity to 0.65 MGD and partial renovation to upgrade aging equipment.
   - A SWWTP irrigation system expansion to allow effluent recycling and crop production on the 193-acre site of the future golf course east of the SWWTP site.

   C. In 11-15 years:

   - NWWTP Phase 1B improvements to retrofit the existing lagoon system with an aerated lagoon system and related facilities with no capacity expansion.
   - NWWTP effluent transmission and irrigation system expansion for effluent recycling (add farmland, effluent pipeline, and irrigation system components).

   D. In 16-20 years:

   - SWWTP Phase 2 expansion and renovation to increase average design flow capacity to 1.15 MGD.
   - SWWTP Phase 2 effluent storage and irrigation system expansions to increase effluent recycling capacity (add farmland, effluent pipeline, and irrigation system components).

   E. Industrial Site Readiness Planning (scope and timing are development dependent):

   - Potential NWWTP Phase 2 expansion
     - ➢ increase average design capacity to 1.0 MGD;
     - ➢ increase effluent storage by 79 MG; and
     - ➢ increase irrigation system capacities (add farmland, effluent pipeline, and irrigation system components).
   - Potential NWWTP Phase 3 expansion
     - ➢ increase average design capacity to 1.5 MGD;
     - ➢ increase effluent storage by another 79 MG; and
     - ➢ increase irrigation system capacities (add farmland, effluent pipeline, and irrigation system components).

Table S-6 summarizes the estimated probable project costs for each major project category (sewers, PS and force mains, and WWTPs).

Table S-6
Capital Improvements Summary
Estimates of Probable Costs and Anticipated Timing (1)

Project Description	Probable Construction Cost	Probable Project Cost
A. Short-Term Projects (within 5 years)		
1. Gravity Sewer Projects	$2,139,000	$2,885,000
2. Pump Station and Force Main Projects	$345,000	$465,000
3. WWTP and Effluent Recycling Projects (2)	$1,931,000	$2,610,000
Subtotal for Short-Term Projects	**$4,415,000**	**$5,960,000**
B. Mid-Term Projects (6 – 10 years)		
1. Gravity Sewer Projects	$480,000	$650,000
2. Pump Station and Force Main Projects	$361,000	$490,000
3. WWTP and Effluent Recycling Projects	$1,303,000	$1,760,000
Subtotal for Mid-Term Projects	**$2,144,000**	**$2,900,000**
C. Mid- to Long-Term Project (11 – 15 years)		
1. Gravity Sewer Projects	$1,213,000	$1,640,000
2. Pump Station and Force Main Projects	$678,000	$915,000
3. WWTP and Effluent Recycling Projects	$7,267,000	$9,810,000
Subtotal for Mid- to Long-Term Projects	**$9,158,000**	**$12,365,000**
D. Long-Term Projects (16 – 20 years)		
1. Gravity Sewer Projects	$1,455,000	$1,965,000
2. Pump Station and Force Main Projects	$1,869,000	$2,520,000
3. WWTP and Effluent Recycling Projects	$16,771,000	$22,640,000
Subtotal for Long-Term Projects	**$20,095,000**	**$27,125,000**
E. Potential Industrial Site Readiness Projects (3)		
1. Gravity Sewer Projects	$695,000	$940,000
2. Pump Station and Force Main Projects	$2,909,000	$3,925,000
3. WWTP and Effluent Recycling Projects	$43,199,000	$58,315,000
Subtotal for Long-Term Projects	**$46,803,000**	**$63,180,000**
Total – Proposed & Potential Capital Projects	**$82,615,000**	**$111,530,000**

(1) Estimates of probable costs are updated to December 2017 dollars. Refer to Chapter 8 for more information on the basis for the estimates of probable cost.

(2) Subtotal includes the alternate NWWTP Phase 1A Improvements project rather than full Phase 1A upgrade described in Chapter 8.

(3) Potential improvements identified for industrial site readiness planning. Actual projects would be driven by development and must be reevaluated based on actual development proposal(s). Capital costs for development-driven projects would typically be covered by developers or other funding sources and not come from the City's capital improvements fund.

S.8.2 Additional Planning Considerations

Planning Effort for Surface-Water Discharge. Before the City proceeds with the Phase 1 SWWTP expansion and renovation, it may be worthwhile to investigate the feasibility of an indirect discharge to Willow Creek. An early step in this effort would be to solicit input from the DEQ regarding the prospects for a discharge permit. Depending on DEQ's input, the City might then want to proceed with a feasibility study to evaluate the potential cost effectiveness of an indirect discharge to Willow Creek through constructed wetlands.

Capacity, Management, Operations and Maintenance (CMOM) Program Planning. The intent of CMOM program planning is to support the City's efforts in properly managing, operating and maintaining the sewer systems and overall WW facilities it owns. The general goals of a formal CMOM program are as follows:

- Assure that adequate sewer capacity remains available.
- Develop a proactive (predictive) approach to system management, operations and maintenance.
- Provide quality customer service to generate and sustain support for adequate local investment in the WW facilities.

Since Madras has had centralized sewer service for over 40 years, the City has been following many recognized CMOM practices for an extended period. The City can improve current practices by conducting a thorough review of their CMOM practices, developing a written CMOM program, and establishing specific objectives for CMOM performance.

We recommend the City conduct an assessment of current CMOM practices to identify areas of improvement. The City should then establish performance objectives in coordination with current priorities for addressing areas of concern. The key is to clearly define the target objectives, develop a process for tracking progress, and determine whether staff can meet these objectives.

The information presented in this WWMP Update can be used as a tool in CMOM program planning and regular WWMP updates can help keep CMOM activities current.

Solar Power Array Funding and Partnering Opportunities. Solar photovoltaic (PV) panels have become increasingly cost competitive as a way to generate electricity onsite and reduce the amount of electricity purchased from a utility. Due to the availability of State and Federal incentives, it may be cost effective for the City to install an array of PV panels at either or both WWTP sites as a means for lowering power costs.

To take advantage of tax incentives, a City could enter into a power purchase agreement (PPA) with a private, solar service provider. Under a PPA, the service provider would furnish, install, own and maintain the power-generating system. In exchange, the City would agree to purchase the electricity produced by the system for the term of the PPA.

The main advantages to a PPA for the City include:

- low initial cost for a solar array;
- the ability to benefit from Federal tax benefits;
- a predictable cost of electricity for the term of the PPA;
- no need to deal with the solar system permitting, design, and construction; and
- no operations and maintenance responsibilities for the array.

Because the NWWTP is adjacent to the airport, a solar array installed at that plant site would need to be designed according to FAA standards and technical guidance. The FAA recognizes the benefits of installing solar power projects at airports and generally supports their implementation. To promote aviation safety, the FAA has studied the visual impacts of solar panels and has issued guidance to address technical considerations.

Master Plan Updates. We recommend the City update the WWMP on a regular basis, particularly when changes occur that are likely to have significant impacts on previous recommendations. In general, the City should plan to have a WWMP update prepared every 5 years.

S.9 WASTEWATER SYSTEM DEVELOPMENT CHARGE UPDATE

S.9.1 General Description

The City levies system development charges (SDCs) as one-time fees on new developments to recover a fair share of the capital costs of facilities that provide capacity for future growth. As part of this master planning effort, FCS GROUP performed an analysis to update the SDCs for wastewater services. A full analysis to update other sewer rates will be completed at a later date.

In general terms, the updated SDC calculation involves dividing eligible costs for capital improvements by the customer-base expansion that can be served by these improvements. The recommended SDCs for wastewater facilities include a reimbursement fee component, an improvement fee component, and an administrative cost component.

S.9.2 Customer Base

Different types of customers have differing service needs. Therefore, the existing and expanded customer base are each estimated on an equivalent basis using water meter size. A standard residential meter has a meter capacity equivalent (MCE) of 1.0 and larger meters have higher MCEs based on their relative capacity.

According to the current breakdown of water meter sizes in Madras, the City's wastewater facilities have an existing MCE of 3,074. Updated flow data and the total future capacity proposed in this Master Plan Update show the recommended wastewater facilities could serve another 5,779 MCEs in future growth. This available growth in customer base was used to calculate the reimbursement and improvement components of the SDCs.

S.9.3 Recommended SDC Components

Reimbursement Fee. The reimbursement fee is based on the City's eligible costs for constructing that portion of the existing wastewater facilities capacity that is unused and available for future growth. Currently, 30% of the existing capacity is available and the net eligible cost basis for this unused capacity is approximately $3.4 million.

Improvement Fee. The improvement fee cost basis is the portion of the Capital Improvements Plan presented in Chapter 8 that constitutes net eligible costs for SDCs. Ineligible capital costs will include costs for projects not expected to be funded by the City and/or improvements that do not expand capacity. The net eligible cost basis for the improvement fee is estimated to be approximately $24.7 million.

Administrative Cost Component. The annual administrative costs to comply with SDC rules include an amortized cost for the SDC study and costs to account for SDC expenditures.

S.9.4 Summary of Recommended SDCs

Table S-7 summarizes the wastewater SDC components and overall fee per MCE that FCS GROUP calculated from current planning information. The City should plan to periodically adjust these proposed SDCs to account for inflation.

Table S-7
Recommended Wastewater System Development Charge

A. Updated SDC Components per MCE	
Reimbursement Fee	$586
Improvement Fee	$4,281
Administrative Cost Recovery	$279
B. Total Updated SDC per MCE	**$5,146**
Net Decrease from Existing SDC	**($143)**

CHAPTER 1
INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this Wastewater Master Plan (WWMP) Update is to develop and present a plan for meeting the City's projected, 20-year wastewater (WW) service needs inside the planning area. The preparation of this study was approved and authorized by the Madras City Council on December 9, 2014. The scope generally consists of the following main elements.

1. Collect and review available background data associated with the existing WW facilities as well as with the management, operation and maintenance of those facilities.
2. Develop a WW facilities inventory and complete condition assessments of the facilities in coordination with City staff.
3. Establish the planning criteria and basis of design for WW facilities to identify projected needs, develop and evaluate alternative improvements, and select a recommended alternative.
4. Develop and execute a collection-system hydraulic model to identify capacity deficiencies under current and projected flow conditions, and analyze alternative sewer improvements.
5. Develop and evaluate alternative improvements and select the recommended improvements.
6. Prepare a Capital Improvements Plan (CIP) that lists the projects proposed to implement the recommended improvements.
7. Describe the elements of a Capacity, Management, Operations and Maintenance (CMOM) Program, identify CMOM goals, and address the steps the City should take to meet these goals.
8. Identify other planning issues the City may need to address in the future to sustain sewer services.
9. Use the CIP and data supplied by the City to calculate updated system development charges.
10. Prepare materials and participate with City staff in a public information efforts to solicit input and obtain buy in from the community.
11. Prepare a complete WWMP Report that presents the results of the study.

1.2 BACKGROUND

1.2.1 Previous Master Planning Effort

ACE Consultants completed a Wastewater System Master Plan for Madras in November 1996 that provided a comprehensive analysis of the existing facilities and the impacts from projected growth. The 1996 study recommended extensive modifications and expansions to the WW facilities that were largely implemented over the following five years.

Due to the comprehensive nature of the 1996 WWMP, this update builds on the information and conclusions presented in that study to the extent feasible. Most of the WW infrastructure constructed based on the recommendations of the 1996 Plan still has useful service life remaining.

As a result, this study has been prepared with the understanding that significant portions of the WW infrastructure, particularly major structures and pipelines, can continue to serve the City for the next 20 years. Alternatives that would require the abandonment of these relatively-new components were generally eliminated from consideration.

1.2.2 General Description of Planning Area

The planning area for this WWMP Update corresponds to the area currently lying inside the City's Urban Growth Boundary (UGB). Figure 1-1 shows both the current UGB and City Limits for Madras, as well as elevation contours at 10-foot intervals. This planning area encompasses approximately 6.0 square miles (3,850 acres). By comparison, the study area for the 1996 WWMP was 7.4 square miles and the UGB at that time encompassed 4.5 square miles.

This study addresses WW service requirements for existing and projected developments within the UGB shown in Figure 1-1. The City also currently provides WW service outside the UGB in two locations, the State's Deer Ridge Correctional Institution (DRCI) and the Madras Municipal Airport. Therefore, this study takes into account the ongoing service needs for these two developments as part of the master planning effort.

Service requirements for the DRCI, which is located about one mile east of the City limits, were established in a 2006 agreement between the City and Oregon Department of Corrections (ODOC). The airport is west of the Industrial Park at the north end of the City. The 2010 Airport Master Plan Update prepared by Century West did not identify expansion plans that would significantly affect WW contributions from the airport.

The City's WW treatment, effluent storage and effluent recycling facilities extend beyond the UGB in certain locations. Therefore, this study addresses siting considerations for expansions to WW facilities both inside and in adjacent areas immediately outside the UGB.

Current planning information on population and development within the Madras UGB are presented in Chapter 3 of this study. Descriptions of the Madras planning area, including information on local topography, climate, geology and soils are presented in the 1996 WWMP.

1.2.3 History and Development of Existing Wastewater Facilities

Municipal System. The following paragraphs provide a brief background overview of the City's WW facilities. Chapter 2 provides a more detailed description and inventory of these existing facilities.

The City of Madras originally constructed a collection system and wastewater treatment plant (WWTP) in 1973-75. Prior to the construction of this centralized system, residents and businesses in Madras had onsite disposal systems generally consisting of septic tanks with disposal wells and/or drainfields.

The main components of the original municipal facilities were a gravity sewer system serving what is now the central part of town, a pump station on "B" Street at 1st Street, a force main (pressure sewer), and a WWTP. The WWTP provided biological treatment in a series of stabilization ponds and the effluent was pumped into a spray irrigation system for reuse on nearby land. This original WWTP was constructed outside the City on land adjacent to the municipal airport.

North Area (Industrial Park). A small, North Unit sewer system and pump station were built adjacent to the airport in the 1940s by the U.S. War Department and were operated by the North Unit Irrigation District. At the time, the airport was an army airfield. The original pump station discharged WW through a force main and into a drainage ditch on airport land.

After the municipal WWTP was constructed in the 1970s, the sewers, pump station and force main in this north area were replaced and the WW was pumped from a pump station at Demers Lane to the City's WWTP. The north area is now part of the City's Industrial Park and the sewer system has been expanded to serve nearby developments.

Recent Developments. Following the adoption of the 1996 WWMP, the City implemented a series of upgrades that reconfigured the WW facilities. The result is flows from the main part of the City are now split and pumped to two separate WWTPs: the original plant, now called the North WWTP (NWWTP), and a newer South WWTP (SWWTP) in the southeast part of the City. The SWWTP was expanded in 2008 to receive flows from the DRCI.

Sludge drying beds were constructed at the NWWTP to receive biosolids from the SWWTP. The dried biosolids are land applied on farmland.

Onsite Sewage Disposal. A small proportion of the dwellings within the UGB continue to rely on septic tanks with disposal wells and/or drainfields to handle the WW they generate. Most of these properties are outside the City limits on County land, but some are also inside the City.

1.3 REGULATORY FRAMEWORK

1.3.1 Operating Permit

The City of Madras WW facilities operate under the requirements set forth in the Water Pollution Control Facility (WPCF) permit issued in 2006 by the Oregon Department of Environmental Quality (DEQ). This WPCF permit, attached as Appendix A, was issued under the authority of Oregon Administrative Rule (OAR) 340-045. These rules were published to conform to the federal National Pollution Discharge Elimination System (NPDES) established under the Clean Water Act.

The WPCF permit establishes the maximum quantities of treated effluent the City's WWTPs are allowed to produce and the minimum levels of treatment the WWTPs must provide. The permit also contains monitoring and reporting requirements for the influent to each plant, effluent discharged from each plant and biosolids produced at each plant.

The expiration date for the current permit was October 31, 2016 and the City applied for a permit renewal in August 2016. The terms and conditions of the previous permit remain in force until the issuance of a renewal permit by DEQ.

The City's WPCF permit does not allow the discharge of treated WW into Willow Creek or any other surface water body. Therefore, the City currently must reuse all treated effluent as recycled water and does so through spray irrigation onto farmland and the Desert Peaks Golf Course.

If in the future the City wants to implement a WWTP discharge into Willow Creek or into the groundwater, a separate NPDES permit would need to be obtained from DEQ. As with the WPCF permit, an NPDES permit would identify treatment, monitoring and reporting requirements for the WWTP that would produce the surface-water or groundwater discharge.

The permit would establish treatment requirements by identifying the discharge limits the WWTP would need to meet to comply with water quality standards (WQS) for the receiving waters. WQS are published by DEQ after they are approved by the United States Environmental Protection Agency (USEPA). Subsection 1.3.2 provides more information on the WQS that DEQ would use to regulate a discharge to Willow Creek.

1.3.2 Current Regulations

Water Recycling. The use of treated effluent from WWTPs as recycled water is regulated in Oregon by DEQ according to OAR 340-055 (latest revision 2008).

Where WWTP effluent is recycled, the WPCF permit identifies the class(es) of recycled water the WWTP is designed to produce. Table 1-1 (following page) summarizes the recycled water classifications defined in OAR 340-055 and lists the minimum treatment and monitoring requirements established for each class.

Table 1-1
Classes of Recycled Water (1)

Description	Class A	Class B	Class C	Class D	Non-Disinfected
Former Water Reuse Level (2)	IV	III	II	Enhanced I	I
Oxidized	Yes	Yes	Yes	Yes	Yes
Disinfection	Yes	Yes	Yes	Yes	
Filtered	Yes				
Turbidity Limit (NTU):					
24-Hour Mean	2				
5% of Time in 24-Hr. Period	5				
Max. at Any Time	10				
Monitoring Frequency	Hourly				
Total Coliform: (3)					
7-day Median	2.2	2.2	23		
Max. in Any Sample	23	23			
Max. in 2 Consecutive Samples			240		
Monitoring Frequency	Daily	3/Week	1/Week		
E. Coli: (3)					
30-Day Log Mean				126	
Max. in Any Sample				406	
Monitoring Frequency				1/Week	
Beneficial Purposes	More Allowable Uses			Fewer Allowable Uses	
Conditions on Use	Less Restrictive			More Restrictive	

(1) Taken from Table 3 in DEQ Internal Management Directive – Implementing Oregon's Recycled Water Rules (June 19, 2009).
(2) Similar, but inexact correlation to levels in previous rules.
(3) Measured as Organisms/100 mL.

Table 1-2 (following page) identifies the allowable beneficial uses for each class. In general, Class A water must receive the highest level of treatment, but has the most allowable uses and the least restrictive conditions of use. The City's WPCF permit was issued when an earlier version of OAR 340-055 was in force and lists both Level II and Level IV effluent classes as options for recycling. These levels approximately correlate to current recycled water Classes C and A, respectively.

The City has prepared an Effluent Reuse Plan for each WWTP and submitted these plans to DEQ for approval. Copies of these reuse plans are included as Appendices B-1 and B-2. The WPCF permit requires the City to submit an annual report to the DEQ by February 1 documenting compliance during the prior year with the reuse plans, the current OAR, and the permit.

The Effluent Reuse Plans must be updated and submitted to DEQ at the time of permit renewal. Updated plans must also be submitted if the City needs to change their recycling practices during the permit cycle.

Table 1-2
Recycled Water Beneficial Purposes

Description	Class A	Class B	Class C	Class D	Non-Disinfected
Irrigation					
Fodder, fiber, seed crops not intended for human ingestion, commercial timber	Yes	Yes	Yes	Yes	Yes
Firewood, ornamental nursery stock, Christmas trees	Yes	Yes	Yes	Yes	No
Sod	Yes	Yes	Yes	Yes	No
Pasture for animals	Yes	Yes	Yes	Yes	No
Processed food crops	Yes	Yes	Yes	No	No
Orchards or vineyards if an irrigation method is used to apply recycled water directly to the soil	Yes	Yes	Yes	No	No
Golf courses, cemeteries, highway medians, industrial or business campuses	Yes	Yes	Yes	No	No
Any agricultural or horticultural use	Yes	No	No	No	No
Parks, playgrounds, school yards, residential landscapes, other landscapes accessible to the public	Yes	No	No	No	No
Industrial, Commercial, or Construction					
Industrial cooling	Yes	Yes	Yes	No	No
Rock crushing, aggregate washing, mixing concrete	Yes	Yes	Yes	No	No
Dust control	Yes	Yes	Yes	No	No
Nonstructural fire fighting using aircraft	Yes	Yes	Yes	No	No
Street sweeping or sanitary sewer flushing	Yes	Yes	Yes	No	No
Stand alone fire suppression systems in commercial and residential buildings	Yes	Yes	No	No	No
Non-residential toilet or urinal flushing, floor drain trap priming	Yes	Yes	No	No	No
Commercial car washing	Yes	No	No	No	No
Fountains when the water is not intended for human consumption	Yes	No	No	No	No

Surface Water Discharge. The effluent limitations that determine WWTP treatment requirements for a surface-water discharge are based on the effluent quality necessary to meet the published WQS outside a discharge mixing zone. The current WQS for Oregon water bodies, including the Deschutes Basin, are published in OAR 340-041.

Since Willow Creek flows into the Deschutes River at Lake Simtustus, a discharge to the creek would need to meet the WQS that apply to the mid-Deschutes Basin. Table 1-3 describes the current WQS for the mid-Deschutes.

Table 1-3
Key Numerical Water Quality Standards for Mid Deschutes Basin and Willow Creek (1)

Water Quality Criterion	Limitation	
1. Five-Day Biochemical Oxygen Demand (BOD_5)		
Winter Season (November 1 – March 31)		
Maximum Monthly Average (2)	30	mg/L
Maximum 7-Day Average (2)	45	mg/L
Summer Season (April 1 – October 31):		
Maximum Monthly Average	10	mg/L
Maximum 7-Day Average	15	mg/L
2. Total Suspended Solids – Same as BOD_5 for winter & summer		
3. Bacteria (E. Coli Organisms)		
Maximum Monthly Log Mean	126	per 100 ml
Maximum (single sample)	406	per 100 ml
4. Dissolved Oxygen (DO) – Minimum (3)	8.0	mg/L
5. pH Range (Hydrogen Ion Concentration)	6.5 – 8.5	
6. Temperature – Maximum 7-day average (4)	18.0	degrees
7. Total Dissolved Solids – Maximum	500	mg/L
8. Chlorophyll-a – Average (5)	0.015	mg/L

NOTES:

(1) Numerical WQS as of January 2017 for Deschutes Basin reach between Bend Diversion Dam and Pelton Dam, including Willow Creek and other tributaries.

(2) Representative numerical limits for required secondary treatment.

(3) Numerical DO criterion for water bodies potentially supporting cold-water aquatic life. With adequate background data, allowable limits may be modified to 6.0 mg/L as an absolute minimum, 6.5 mg/L as a 7-day mean, and 8 .0 mg/L as a minimum 30-day mean.

(4) Numerical temperature criterion for stream potentially having salmon and trout rearing and migration uses.

(5) Numerical chlorophyll-a limit intended to prevent nuisance phytoplankton growth.

Key non-numerical WQS that would potentially affect a proposed discharge into Willow Creek are briefly summarized below.

1. **Antidegradation – OAR 340-041-0004.** The Antidegradation Policy is generally intended to prevent unnecessary water quality degradation from new or increased sources of pollution. The policy also aims to protect, maintain, and enhance existing, surface water quality and thereby ensure the full protection of all existing beneficial uses. In order to obtain a new NPDES, the City would probably be required to submit a pollution fate analysis documenting that a new discharge would not degrade existing water quality.
2. **Effluent Dilution and Mixing – OAR 340-041-0007, Article (15)(a)(A)(i).** Effluent organic materials, as measured by BOD_5 concentration, must not exceed the dilution factor. This factor is defined as the ratio of receiving-stream flow to effluent flow. This criteria would prohibit the discharge of any measurable BOD_5 during those periods when there is no stream flow.

   Since Willow Creek is a seasonal stream, it frequently has no background flow during summer, fall, and potentially even winter months. Therefore, in order to obtain a new NPDES, the City would either need an exemption from this criteria or limit discharges to periods when there is adequate stream flow. Even then, the potential for low stream flows may result in DEQ issuing a low BOD_5 discharge limit that would require an expensive treatment process.

Biosolids. DEQ regulates biosolids handling according to the requirements of OAR 340-050 (latest revision 1995) and the U.S. EPA's Biosolids Rule (40 CFR Part 503). The City has prepared, and amended, a Biosolids Management Plan according to the OAR that describes the City's practices for handling, treating and land applying the biosolids. Appendix B-3 includes a copy of this plan.

The WPCF permit requires the City to submit a report to the DEQ by February 19 that documents the biosolids handling activities during the prior year. The minimum required information in the report is outlined in OAR 340-050-0035.

The Biosolids Management Plan must also be updated and submitted to DEQ at the time of permit renewal or whenever the City changes the way the biosolids are handled.

Onsite Disposal. The onsite sewage disposal systems within the UGB are regulated by Jefferson County under agreement with DEQ according to OAR 340-071 (latest revision 2014). The rules require a property owner to obtain a permit for the construction of a new onsite system or the repair/replacement of an existing system.

If a property is within 500 feet of an existing sewer, then any new development on that property is required under the OAR to connect to the sewer and a permit for an onsite system will not be issued. Similarly, if an existing onsite system fails and a sewer is within 500 feet, then the system user must connect to the sewer.

1.3.3 Federal Aviation Administration Standards for Airports

Federal Aviation Administration (FAA) guidelines place constraints on potential expansions to the existing NWWTP due to the proximity of the airport to the plant site. The FAA has published guidance identifying WWTPs as potential wildlife attractants that should not be located near airports unless acceptable mitigation measures are implemented. As a result, a mitigation plan for deterring wildlife attraction must be developed as part of any NWWTP expansion and the FAA must accept both the expansion and mitigation plans. The FAA relies on the United States Department of Agriculture – Wildlife Services to review and approve mitigation plans.

1.3.4 Potential for Regulatory Changes

The OAR and federal rules that govern the operation of the City's WW facilities are periodically revised and reissued based on new legislation or other factors. As part of this study, HHPR contacted the DEQ Eastern Region office in Bend to ask about the potential for upcoming revisions to the governing regulations.

DEQ reported that the agency had no plans at the time this report was written to revise and reissue the OAR covering WPCF permits, effluent recycling, biosolids handing or onsite sewage disposal. There are also no indications the USEPA will be revising federal rules pertaining to effluent recycling or biosolids handling.

Municipalities such as Madras that recycle their WWTP effluent tend to experience fewer regulatory changes than WWTPs with surface-water discharges. Facilities with NPDES permits for surface-water discharges tend to experience more changes permit requirements.

Changes to NPDES permit requirements often stem from the promulgation of stricter WQS for a specific water body that then result in stricter WWTP effluent limitations. The mid-Deschutes Basin and Willow Creek are listed as being water quality impaired for certain criteria and the federal Clean Water Act currently requires regulating authorities to issue Total Maximum Daily Loads (TMDLs) that cover these criteria for such impaired water bodies.

The TMDLs identify the maximum amounts of certain pollutants that can be discharged into a basin without degrading water quality. No TMDLs have been proposed yet for the Deschutes Basin and DEQ has indicated that the issuance of the TMDLs is not a priority. The lack of TMDLs for the criteria not conforming to current WQS creates uncertainty regarding future effluent limits for a discharge into Willow Creek.

In general, it can be difficult from a regulatory standpoint to obtain an NPDES permit for a new surface-water discharge, particularly into a water body listed as water-quality impaired. This regulatory climate provides an incentive for communities such as Madras to continue the practice of effluent recycling.

1.4 ACKNOWLEDGEMENTS

HHPR and FCS Group appreciate the valuable input, data-collection efforts, and other support provided by City and County staff. We particularly wish to acknowledge the contributions of the following individuals:

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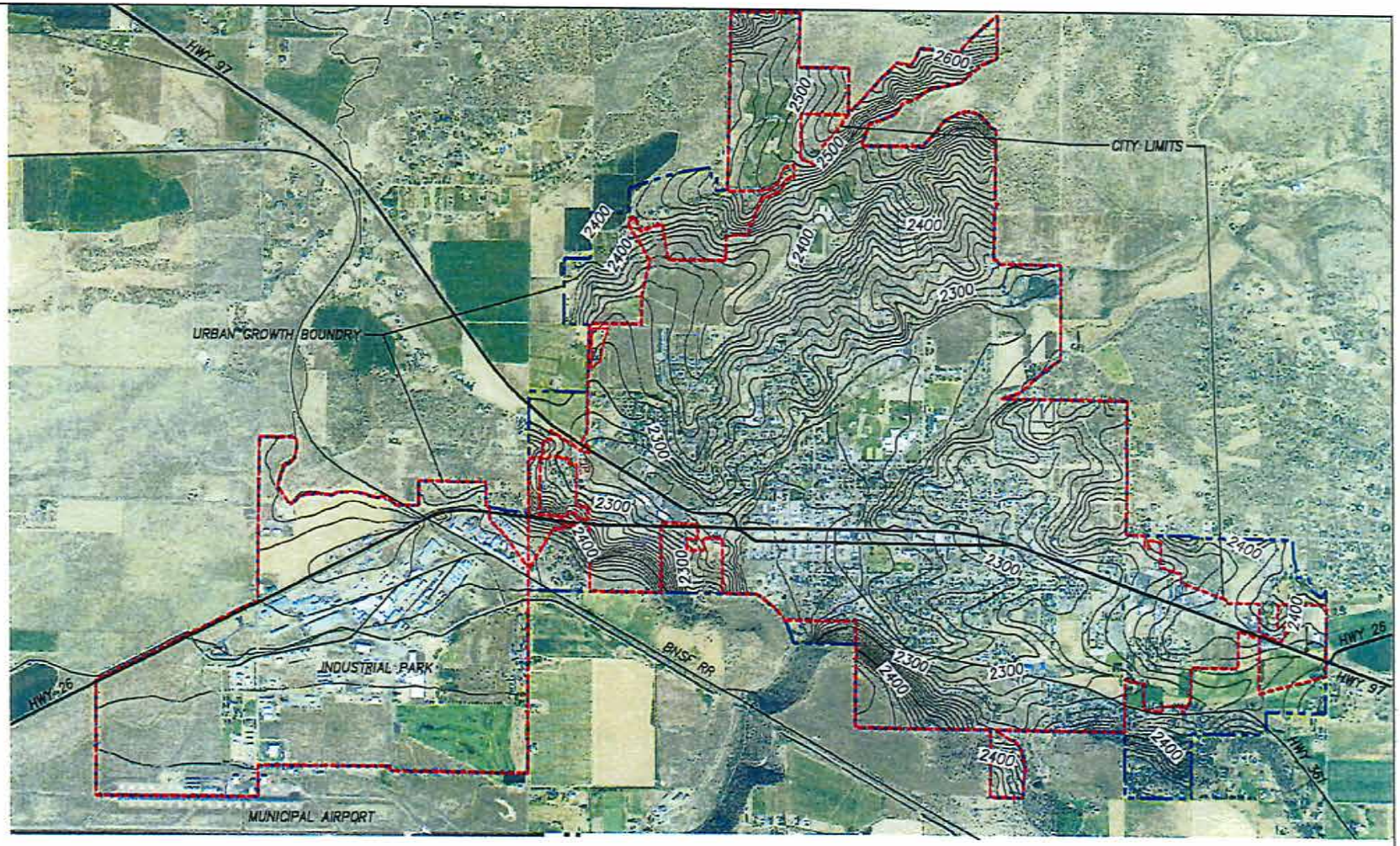

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STUDY AREA

WASTEWATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

FIG 1-1

MAD-05

CHAPTER 2
EXISTING FACILITIES INVENTORY AND CONDITIONS ASSESSMENTS

2.1 FACILITIES DESCRIPTIONS

2.1.1. General Description

The major elements of the existing wastewater (WW) facilities serving Madras are listed below:

- collection systems that receive and convey sewage to the City's two treatment plants;
- the North and South Wastewater Treatment Plants (NWWTP and SWWTP);
- storage ponds and transmission systems that allow effluent recycling as irrigation water;
- a supervisory control and data acquisition (SCADA) system; and
- onsite WW treatment and disposal systems on properties not served by or connected to a sewer.

Each of these elements are described in the following paragraphs. Figure 2-1 shows their locations and Figure 2-2 shows a simplified schematic of the general flow patterns through the WW facilities.

2.1.2. Collection Systems

General. The City's WW facilities include two separate collection systems. The Main Collection System serves most of the City and the Industrial Park Collection System serves the Madras airport and a relatively small area to the east and southeast of the airport. Major components of the collection systems include gravity collector and interceptor sewers, manholes (MHs), pump stations, and force mains.

Main Collection System. This system includes 188,620 feet of gravity sewers with associated MHs, three pump stations, and 29,410 feet of pump station (PS) force mains. Gravity sewers in the Main Collection System are divided into three drainage basins: a central sewer basin that serves most of the City, a southeast sewer basin, and a small sub-basin at the south end of the City.

Most of the large central basin was the original sewer system for the City. The sewers in this basin convey flows to the "B" Street Pump Stations located at the northwest corner of NW 1st and "B" Streets. An onsite diversion structure splits incoming flows between the "B" St. North PS and "B" St. South PS. The North PS pumps flows through a 10-inch force main that extends to the NWWTP. The South PS pumps flows to the SWWTP via a 14-inch force main that discharges into a gravity sewer in McTaggart Road that is part of the SE sewer basin.

Flows in the SE basin are conveyed by gravity to the SWWTP. This basin consists of interceptor sewers in McTaggart Rd., "J" St., City View Drive, and Ashwood Rd., as well as tributary collector sewers. The Ashwood Rd. sewer receives the WW pumped from the Deer Ridge Correctional Institution (DRCI) and also includes an inverted siphon. Currently, there is limited development within the SE basin and the DRCI is not fully occupied. Therefore, most flow to the SWWTP comes from the "B" St. South PS.

The third basin in the Main Collection System consists of a short run of gravity sewer near the south City limit, on the east side of U.S. Highway 97. This sewer segment flows east to west and drains into the South 97 PS. A 4-inch force main carries the flows north from the PS to the central sewer basin described above.

Industrial Park Collection System. This system consists of 24,330 linear feet of gravity sewers with MHs, two pump stations, and 14,370 linear feet of force mains. The gravity sewers are divided into two drainage basins: one sewer system serves the Industrial Park and airport and a second, smaller sub-basin serves a residential area along Birch Lane.

The Golf Course PS is located at the west end of this smaller basin and pumps these residential flows north, through a 4-inch force main, to a manhole south of Adler St.

The Industrial-Park sewers are tributary to the Demers PS located south of the intersection of Cherry Lane and Demers Drive. The Demers PS directs flows through dual 4-inch force mains that connect to the 10-inch force main extending from the "B" St. North PS to the NWWTP.

2.1.3. Wastewater Treatment Plants

General. Each wastewater treatment plant (WWTP) includes liquid-stream processes to treat the wastewater and solids-stream processes to handle the solids produced as byproducts of the liquid-stream processes. The NWWTP was originally constructed in 1973 and remained the City's sole treatment plant until 2001 when the SWWTP was constructed. Upgrades to the NWWTP were implemented in 1993 and 1998 and an expansion of the SWWTP was constructed in 2008.

NWWTP. This facility is located adjacent to the Municipal Airport and has an average design capacity of 0.5 million gallons per day (MGD). Figure 2-3 provides a site plan of the NWWTP. The plant consists of the following main processes:

- a five-cell lagoon system,
- mechanical clarification equipment with chemical addition,
- disinfection equipment that feeds sodium hypochlorite and a chlorine contact basin,
- an effluent storage pond,
- in-plant liquid-stream and sludge pumps,
- a sludge pond to store solids generated by the clarification equipment, and
- sludge drying beds.

The lagoon system includes two primary cells, two secondary cells, and a polishing cell that support the growth of microorganism for biological treatment. The primary cells are aerated, partially-mixed lagoons, whereas the secondary cells are unaerated and act as facultative lagoons. The polishing cell is also a facultative lagoon. The mechanical clarifier uses dissolved air flotation (DAF) to remove algae and other solids in the lagoon effluent. This reduces chlorine demand and prevents fouling of irrigation components.

PLC-based controls are provided for the process equipment. The clarifier is part of a proprietary process that includes a sand filter unit. But since the City does not need to produce Class A effluent, the filter has not been used recently and is no longer functional. The sludge drying beds are used to dry biosolids trucked from the SWWTP as a dilute liquid. Sludge from the sludge pond can also be pumped to the beds for drying. The dried materials are spread on farmland as Class B biosolids.

SWWTP. This facility is located on the south side of "J" St., between Willow Creek and Grizzly Road. A site plan of the SWWTP is shown in Figure 2-4. The plant consists of the following main processes:

- headworks for preliminary treatment,
- a sequencing batch reactor (SBR) process,
- an onsite storage lagoon,
- tertiary filters and chemical feed equipment,
- disinfection equipment that feeds sodium hypochlorite,
- influent, effluent and other in-plant pumps,
- aerobic digesters for biosolids processing, and
- two effluent storage ponds.

The plant headworks consist of influent screening and grit removal processes. The screenings and grit removed by these processes are disposed of at a landfill. The SBR process is an activated-sludge system that provides biological treatment. The filters remove suspended solids to reduce chlorine demand and prevent fouling of irrigation components. Because the City does not need to produce Class A effluent, chemicals are not added upstream of the filters to increase solids removal.

The SWWTP was designed to ultimately have three 0.5-MGD SBR modules and two of those modules have been built. But when the second module was added, the plant design was modified to treat more-highly concentrated WW from the DRCI. The design WW strength for the DRCI is three times the design strength for the City. As a result, the expansion increased the capacity to treat a higher organic loading, but did not significantly increase the flow capacity. Now the two SBR modules have a 0.54-MGD average design flow capacity rather than a 1.0-MGD capacity.

The agreement between the City and the State Department of Corrections stipulates that an average flow capacity of 0.23 MGD at the SWWTP is dedicated to serving the DRCI. Although the DRCI is not fully occupied, this study assumes it will be contributing the maximum allowed flow within five years to avoid reliance on capacity that is dedicated to the DRCI. This currently leaves the City with an available capacity of 0.31 MGD at the SWWTP.

2.1.4. Effluent Recycling

General. Both WWTPs are zero-discharge facilities and all treated effluent is recycled as irrigation water. The WW conveyed to each WWTP receives biological treatment throughout the year to produce oxidized effluent suitable for further treatment, storage, and recycling. Biological treatment helps reduce the risk of nuisance odors and vector attraction.

The City generally operates the two plants to split flows between them, but adjusts the proportions to make sure all stored effluent from each WWTP is recycled by the end of the growing season. The growing season extends from about April 15 to October 15. During the colder months, treated WW is stored in ponds. The treated WW is stored either as secondary effluent that will receive further treatment before recycling or as disinfected effluent ready to be recycled.

NWWTP. The influent WW flows by gravity through the NWWTP lagoon system for biological treatment and is then pumped to a single storage pond. When recycling occurs, the water in the storage pond is pumped through the DAF clarification process and then disinfected. The disinfected effluent is then pumped from the chlorine contact tank into the irrigation system for recycling. NWWTP effluent is currently used on nearby farm land and the Municipal Golf Course.

SWWTP. Wastewater entering the SWWTP is treated in the SBR process and then discharged to a post equalization basin and an onsite storage pond. The SBR effluent flows by gravity through the filters from the onsite pond and the post equalization basin. The filtered water is disinfected to produce recycled water that is then pumped either the irrigation systems for farm fields near the SWWTP or a remote, upper storage pond about 1.5 miles east of the plant. Recycled water stored in the upper pond flows by gravity down to the irrigation systems.

Water Recycling. Both WWTPs produce Class B effluent as defined in OAR 340-055 and the City follows the access, exposure, and notification requirements listed for Class B water. The City owns the farm lands that receive recycled water and leases it to growers with the understanding the crops will be irrigated with recycled water. The objective is to use all stored effluent by the end of each growing season so the storage ponds are empty before cold weather forces a halt to irrigation for the winter. Figure 2-1 shows the land currently irrigated with recycled water.

Irrigation practices follow the approved Effluent Reuse (Recycled Water Use) Plans for each WWTP. A plan was prepared for the NWWTP in 1993 and a similar plan was prepared for the SWWTP in 2004 and updated in 2007 when the SWWTP was expanded. These plans address irrigation practices, application rates, land requirements and other recycling considerations.

2.1.5. Onsite Wastewater Disposal Systems

There are estimated to be 106 residential properties within the City not currently served by sewers and assumed to have onsite septic systems for wastewater disposal. There are approximately 210 additional lots within the UGB, but outside the City limits, also not served by sewers and assumed to have onsite disposal systems. Figure 2-1 outlines the general areas where most of the onsite systems are located. These properties are generally outside the current City limits.

2.2 INVENTORIES OF WW FACILITIES

2.2.1. Collection Systems

Sewers and Force Mains. Table 2-1 summarizes the gravity sewer and force main lengths in each collection system broken down by size. The numbers of sewer MHs in each system are also listed. Appendix C provides a tabulation of the pipe and MH data for the existing sewer lines in the two collection systems. Figures 4-1A through 4-1D provide aerial maps of the service area with the locations of the sewer lines and MHs shown.

Table 2-1
Existing Collection-System Pipe Lengths

1. Main Collection System:

Gravity Sewers		Force Mains	
Pipe Size (in.)	Length (ft.)	Pipe Size (in.)	Length (ft.)
6	2,600	4	1,140
8	167,700	8	6,070
10	4,770	10	15,980
12	3,380	14	6,220
15	2,300	Total Length:	29,410
18	2,870		
Total Length:	183,620		
No. of Gravity Sewer MHs:	807		

2. Industrial Park Collection System:

Gravity Sewers		Force Mains	
Pipe Size (in.)	Length (ft.)	Pipe Size (in.)	Length (ft.)
8	15,920	4	14,370
10	6,970		
12	1,440		
Total Length:	24,330		
No. of Gravity Sewer MHs:	71		

Gravity sewers constructed in the 1970s are asbestos cement (AC) pipe with rubber-gasketed joints. Since then, sewers and force mains have been constructed of polyvinyl chloride (PVC) pipe, also with rubber-gasketed joints.

Pump Stations. Table 2-2 summarizes the configurations and capacities of the collection system pump stations. Inventories of the main PS components are provided in Appendix D.

Table 2-2
Existing Collection-System Pump Stations

1. Main Collection System:

"B" Street South Pump Station

Configuration:	Submersible
No. of Pumps:	Two
Design Capacity:	920 gpm @ 53 feet TDH (each pump)
Motor Size & Speed:	23 horsepower & 1,750 rpm

South 97 Pump Station

Configuration:	Submersible
No. of Pumps:	Two
Design Capacity:	40 gpm @ 49.5 feet TDH (each pump)
Motor Size & Speed:	1.9 horsepower & 3,395 rpm

2. Industrial Park Collection System:

"B" Street North Pump Station

Configuration:	Wetwell/Drywell
No. of Pumps:	Four Total (two pairs in series)
Design Capacities:	770 GPM @ 165 feet TDH (each pump)
Motor Size & Speed:	60 horsepower & 1,785 rpm

Demers Pump Station

Configuration:	Submersible
No. of Pumps:	Two
Design Capacities:	290 GPM @ 76.0 feet TDH (each pump)
Motor Size & Speed:	10 horsepower & 1,750 rpm

Golf Course Pump Station

Configuration:	Submersible
No. of Pumps:	Two
Design Capacity:	Not Available
Motor Size & Speed:	1.7 horsepower & 1,750 rpm

The "B" St. North PS has a wetwell/drywell configuration and, as a result, is the only PS with an aboveground building. A standby generator set (genset) is installed in a separate building at the "B" St. site to supply backup power to both the North PS and South PS.

An outdoor chemical storage tank and an RV dump station are also located at the "B" St. PS site. The tank is used to store calcium nitrate that is fed into the South PS wet well to control odors at the force main discharge MH in McTaggart Road.

The rest of the City's pump stations have submersible pump assemblies and the structural components are almost entirely below ground. The enclosures for electrical and control panels are the only components mounted above-grade at these submersible stations. City personnel must bring a portable genset to these other pump stations to provide backup power during outages.

All the pump stations, except the existing Golf Course PS, contain radio telemetry equipment that communicates alarms and PS status to the SCADA system. The SCADA system records pump run times and alarm histories.

2.2.2. *Wastewater Treatment Plants*

Tables 2-3 and 2-4 identify the general design parameters and summarize the major process components for the NWWTP and SWWTP, respectively. Appendix E includes inventories of the equipment and other major components at each plant.

Table 2-3
Existing NWWTP Design Parameters and Components

1. Plant Influent Design Parameters	
Average Daily Flow:	0.50 MGD
Peak Hourly Flow:	1.35 MGD
Design Average BOD_5 Concentration:	200 mg/L
Design Average TSS Concentration:	215 mg/L
2. Biological (Oxidation) Process	
Process:	Partially-Aerated/Facultative Lagoon System
Total System Surface Area & Volume:	28 acres & 50 MG
Average Organic Surface Loading Rate:	30 lbs. BOD_5/acre/day
Primary Lagoon Aerators (each cell):	10 units @ 5.0 hp each (50 hp/cell)
3. Clarification/Filtration Process	
Process Capacity:	1.0 MGD Avg. Recycling Flow
Clarification Process:	Krofta SupraCell (SPC) Dissolved Air Flotation (DAF) Clarifier
Filtration Process (Not Used):	Krofta Sandfloat (SASF 20) Filter
4. Disinfection Process	
Disinfectant:	Sodium Hypochlorite Solution
Maximum Feed Rate:	170 gpd
5. Effluent Storage Pond	
Total Storage Volume:	79 MG
Design Storage Capacity:	Five Months @ 0.5 MGD Avg. Flow
6. Intermediate Lift & Effluent Irrigation Pumps	
No. of Pumps:	Two (one intermediate & one effluent)
Design Pump Capacity:	700 gpm each
7. Sludge Drying Beds	
No. of Beds:	24
Bed Dimensions:	24 ft. x 100 ft. x 12 in. Deep (each)
Total Bed Area	57,600 square feet

Table 2-4
Existing SWWTP Design Parameters and Components

1. Plant Influent Design Parameters	
Average Daily Flow:	0.54 MGD
Peak Hourly Flow:	1.33 MGD
Design Average BOD_5 Concentration:	465 mg/L
Design Average TSS Concentration:	465 mg/L
2. Headworks	
Influent Screening:	One Mechanically-Cleaned Fine Screen
Design Screen Capacity:	4.0 MGD
Grit Removal Process	One Low-Energy Vortex Circular Chamber
Design Grit Removal Capacity:	2.5 MGD
3. Biological (Oxidation) Process	
Process:	SBR, Activated-Sludge System
No. of SBR Basins:	Two
Design Effluent BOD_5 Concentration:	10 mg/L
Design Organic Loading Rate:	0.5 lbs. BOD_5/lb. MLSS @ 4,500 mg/L MLSS
Design Oxygen Requirements:	1.5 lbs. O_2/lb. BOD_5 and 4.6 lbs. O_2/lb. TKN
4. Filter Process	
Process:	Cloth-Media Disk Filter
Peak Process Capacity:	2.4 MGD
No. of Filter Disks:	Four
Design Effluent TSS Concentration:	5.0 mg/L
5. Disinfection Process	
Disinfectant:	Sodium Hypochlorite Solution
Maximum Feed Rate:	170 gpd
6. Biosolids Handling	
Stabilization Process:	Aerobic Digesters
No. of Digester Basins:	Three
Design Avg. Retention Time:	60 Days
Drying Process:	AC-Lined Sludge Drying Beds @ NWWTP
Biosolids Disposal:	Land Application of Class B Biosolids
7. Storage Ponds	
Lower Pond Volume:	25 MG (Onsite SBR Effluent Storage)
Upper Pond Volume:	88 MG (Remote Site)
Design Storage Capacity:	Five Months @ 0.54 MGD Avg. Flow
8. Effluent Pumps	
No. of Pumps:	Two
Design Pump Capacity:	1,050 gpm each

2.3 CONDITIONS ASSESSMENTS

2.3.1. Criteria for Conditions Assessments

General. The main factors to consider when assessing the condition of each WW facilities component are listed below:

- how well the component functions;
- the actual physical state of the materials (or age, if component cannot be checked visually);
- whether the item meets current industry standards or codes;
- whether the capacity of the component is sufficient to handle existing flow conditions; and
- the criticality of a component in the overall purpose of safely conveying, treating and disposing of the WW and byproducts.

These factors must be weighed both when deciding whether the City should plan to improve a component within the next 20 years and in prioritizing the recommended improvements. If an improvement is recommended, the condition assessment can also help determine, where practical, whether the City should plan to repair, modify or replace a component. However, further evaluation may be needed to determine if an item can still be repaired.

Since a visual inspection of all facilities is not practical for this level of study, particularly in the case of buried components, many of the condition assessments are based on age. If the age of an item is a key driver in recommending an improvement, further investigation may be warranted in the future to help focus and prioritize the City's efforts.

The issues of required future capacity and identification of future capacity deficiencies for WW facilities are addressed separately in Chapters 4 and 5 of this WWMP.

Gravity Sewers and Force Mains. The AC and PVC pipes used for the sewers and most force mains in Madras are both stable materials that can provide a reliable service life of 50 years or more in WW service. AC pipe is vulnerable to attack from hydrogen sulfide in the sewage and aggressive soils that can leach the calcium from cement-based pipe. But these conditions do not appear to pose serious problems in Madras and the AC pipe could potentially last 60 to 70 years.

PVC resists chemical attack, but can degrade over time and become more likely to fail. Plastic pipe is also susceptible to eventual damage from concentrated loads, if the pipe bedding and backfill materials were not installed properly.

The ductile iron pipe that was used for the force main between the "B" St. PS and the NWWTP would have been cement-mortar lined on the interior and asphalt coated on the exterior. These coatings slow the rate of corrosion and extend the life of the pipe. Ductile iron pipe also typically has a thicker wall for pressure service than PVC and is better suited for withstanding pressure surges from pumps cycle on and off over extended periods.

Pipe joints for both the gravity and pressure sewers are often the first part of the assemblies to degrade and begin to leak. When this occurs, gravity sewers experience increases in infiltration and inflow (I/I) from rainfall events and snow melt. Blockages also become more likely due to root intrusion and the accumulation of grease, rags and other solid materials.

Sewer service laterals and manholes are other system components that often experience degradation and can cause problems of high I/I. Proper connection of the laterals to the collector sewers and proper pipe connections to MHs are both critical in preventing I/I or clogging problems.

For planning purposes, we recommend using a conservative service life of 60 years for the AC sewers and ductile iron force main in Madras. We also recommend using a conservative 50-year service life for PVC sewers and force mains. These estimated service lives also extend to the associated service laterals and MHs.

Pump Stations and WWTPs. We have separated PS and WWTP components into the following main categories to assess their conditions:

- structures;
- mechanical, electrical and controls components;
- piping, process valves and appurtenances.

The recommended service lives for these categories are summarized in Table 2-5 and briefly discussed in the following paragraphs.

Table 2-5
Recommended Component Service Lives for Pump Stations and WWTPs

Component Category	Estimated Service Life
CIP Concrete & CMU Structures	50 Years
Precast Concrete Vaults & Wet Wells	50 Years
Metal & Wood Structural Components	30 Years
Roof Decking or Shingles	30 Years
Mechanical, Electrical & Controls Components	25 Years
Exposed Piping & process Valves	30 Years
Buried Piping & Lagoon Liners	50 Years

Cast-in-place concrete and cement masonry unit (CMU) structures can be anticipated to last over 50 years if surfaces receive protective coatings. Since aggressive soil conditions do not appear to be present in Madras, buried concrete should have average to above average service lives. However, deterioration from sewage, biosolids and associated gases can shorten the life of process structures. As a conservative estimate, we recommend planning for a service life of 50 years for cast-in-place concrete and CMU structural components.

The structural framing for the roofs should generally last as long as the building structure. But the City needs to plan to replace shingles or decking on building roofs every 25 to 30 years. Similarly, a service life of 30 years is recommended for metal structural components such as stairs and grating.

Precast concrete vaults and wet wells are generally not as robust as CIP concrete, with thinner wall construction. Additionally, embedded aluminum hatches can experience considerable wear and deterioration over time. Therefore, we recommend using a service life of 40 years for precast concrete vaults and wet well.

Equipment, electrical components, and controls components should last 25 to 30 years, and can last longer. For planning purposes, it is recommended that a 25-year service life be used. Exposed piping, valves and appurtenances should typically last 30 years. Therefore, a 30-year service life is appropriate for these components.

We recommend a 50-year service life for buried yard piping since it should generally last as long as the sewers and force mains. The plastic liners used for lagoons and effluent ponds should also have a similar life as buried plastic piping.

2.3.2. *Conditions of Existing Gravity Sewers and Force Mains*

General Assessment. Indications are the sewers, force mains and appurtenances in the two collection systems are generally in adequate to good condition. The City reports that no sewer failures have occurred in the collection systems and backups are rare. Similarly, flow data indicate the infiltration and inflow (I/I) rates entering the sewers are not excessive, meaning it would not be cost effective to rehabilitate or replace sewers to reduce I/I rates. Also, as reported in Chapter Four, our models of the collection systems under current flows show the sewers and force mains have enough capacity to serve the existing population and a fully-occupied DRCI.

These findings are consistent with what we would anticipate based on local conditions. The oldest sewers and force mains have been in service just over 40 years, groundwater depths in the area are typically below the sewers, and stormwater drainage in the City is generally adequate. Based on our assessment, the City does not need to plan for major replacements of existing sewers and force mains strictly based on condition.

Age Considerations. Since the original AC sewers and the force main to the NWWTP were installed in 1975, these pipes are projected to be at or near the end of their projected 60-year service life at the end of the planning period. Some of the oldest existing PVC pipes may also approach the end of their expected 50-year service life within 20 years.

Based on the age criteria presented in Subsection 2.3.1, it is recommended the City plan to begin a program of inspecting the existing AC pipes and associated MHs in 10 to 15 years, or earlier if clogging or surcharging problems begin to occur. Inspection efforts should primarily be focused on areas where problems are reported. The City should also adopt a schedule for regularly cleaning the sewer pipes in each collection system. Given the lack of reported clogging problems, a cycle of 3 to 5 years may be appropriate.

It is preferable to avoid making repairs to AC pipe due to health concerns associated with exposure to asbestos fibers. Therefore, old AC pipe is typically either lined with cured-in-place pipe (CIPP), if the existing pipe is not too deteriorated, or it is replaced by a separate pipe. After replacement, the AC pipe is then abandoned in place. Since CIPP liner is less costly than full replacement, the City can potentially reduce future costs by proactively cleaning, inspecting and lining AC pipe before it becomes too deteriorated.

Hydrogen Sulfide and Odors. Currently, the AC sewers and concrete MHs do not show signs of accelerated deterioration from sewer gases. But there is the potential for concrete deterioration over time from hydrogen sulfide exposure at key locations. These include the discharge MHs at the ends of the PS force mains and the MHs adjacent to the inverted siphon in the Ashwood Rd. interceptor. The MH in McTaggart Road at the end of the force main from the B South PS is of particular concern since odors have been as issue there.

The City adds calcium nitrate at the B South PS to control hydrogen sulfide and prevent odors at the force-main discharge MH. As long as the chemical addition equipment is working properly and enough chemical is added, this system generally controls odors. Also, the discharge MH does not show signs of accelerated deterioration.

Odor problems have also been a periodic problem at the inverted siphon along Ashwood Rd. that are probably caused by low flows and long detention times in this sewer line. The City and the DRCI have added odor-control products that so far have been unsuccessful at solving the problem.

One maintenance measure the City should take to reduce odors is hire a Contractor to flush and clean the inverted siphon annually or at least every two years. This effort will reduce solids accumulation and potentially reduce hydrogen sulfide general.

Culver Highway Sewer. The sewer line along the Culver Highway has been identified as one area of concern regarding pipe condition and capacity. Observations and electronic monitoring performed by City staff in 2008 revealed periods of unusually high flow depths and brief periods of surcharging in the Culver Highway sewer southwest of 1st Street.

The velocity and depth data collected by the electronic monitoring device indicated these were transient conditions most likely caused by sewer backups due to the accumulation of solids. Some of the monitoring data also appeared to be erroneous. The data do not suggest that the high depths and surcharging were steady-state conditions caused by high peak flows. Records show the Culver Highway sewer was designed with minimum allowable slopes which could promote periodic sediment buildup.

Due to concerns about operating conditions in the Culver Highway sewer, we recommend the City plan to clean this line regularly and complete a video inspection of the pipe. Chapter Four includes additional discussion regarding the capacity of this sewer.

2.3.3. *Conditions of Existing Collection-System Pump Stations*

General Assessment. Table 2-6 provides overall summaries for the conditions of the five collection system pump stations. Condition assessments of the various PS components are provided in Appendix D.

Table 2-6
Summary of PS Condition Assessments

Facility Name	Year Built	Overall Condition	Current Areas of Concern
"B" Street North	1974-75	Poor to Good	Problems with pump clogging and condition of original components from the 1970s.
"B" Street South	2001	Adequate to Good	Corrosion of metal components in valve vault and need for recoating.
"B" St. Genset	1999	Good	Need for recoating exterior wood structural components.
South 97	Not Available	Adequate to Good	Condition of valves and long detention time of sewage in wet well.
Demers	1989-90	Poor to adequate	Condition of valves and piping in valve vault.
Golf Course	1996	Poor to adequate	Age of existing facility, no SCADA unit, and condition of pumps and valves.

The pump stations have the firm capacity to handle peak flows and can reliably serve the tributary sewer systems. Therefore, the main issue is how old some components currently are or will become during the planning period. Some older components are in poor condition and need replacement.

Also, some metal components are corroding and the City will benefit from the adoption of a regular program of coating metal surfaces other than stainless steel. The metal components located in the below-grade wet wells and valve vaults are of primary concern.

"B" Street Pump Stations. The North PS was renovated in 1999 and new pumps were installed in 2014 and 2015. But age remains a concern for the remaining components installed with the original facility. These items include the metal roof, heating and ventilation equipment, three of the accumulators, some valves, and various piping. The condition of the North PS structure is generally good. However, this CMU and concrete structure is not designed to current code and age could become a concern within the next 20 years. The North PS pumps are also susceptible to clogging from common "flushable" items and the City wants to add a screen at the North PS.

Additionally, the South PS is 15 years old and the genset is over 15 years old, therefore age will become a consideration for equipment at these facilities within about 10 years.

Demers PS. The valves and other components in the valve vault are heavily corroded. The vault leaks and provides a damp, corrosive environment. The City should plan to replace components in the valve vault within about 3 to 5 years. The pumps at Demers PS were recently replaced with previously used pumps and are in good shape. However, corrosion is a concern for metal components in the wet well and age is a concern for electrical components.

South 97 PS. The pumps at the South 97 PS only operate infrequently due to low tributary flow and are in good condition. The City should be able to have these pumps rebuilt at least once in the future before planning for their replacement. The valves show signs of corrosion and City should also plan to replace the valves within 10 years.

Golf Course PS. The replacement of the existing Golf Course PS is planned in conjunction with the Willowbrook residential development. However, the timing of this development is unknown. As a result, the City needs to budget for rebuilding the pumps and performing other maintenance work in the next two years. Given its age and condition, full replacement of the PS should be planned in about 10 years in the event the Willowbrook development does not proceed by then.

Portable Generator. The portable power generator the City owns for use at the pump stations does not have the capacity to power either pump at the Demers facility. Currently, the City borrows a portable generator from the DRCI to use at the Demers PS. When the Demers PS is either retrofitted or expanded to accommodate industrial development, the City should plan to either purchase a larger portable generator or have a fixed genset installed at the Demers site.

2.3.4. Conditions of Existing WWTPs

General. Summary descriptions of existing deficiencies at the two WWTPs are presented in the following paragraphs. Assessments for the specific components at each plant are provided in Appendix E. Flow records show that treatment capacity is not an issue for Madras at existing average and peak flows. Therefore, WWTP expansions only need to be addressed with regard to future population growth. Issues relating to the future expansion and associated renovation of the WWTPs are addressed in Chapters 5 and 6.

NWWTP. The overall condition of the NWWTP is adequate-to-poor. Some equipment is in good condition due to recent replacements or repairs; but other equipment is over 20 years old. The original components still remaining at the plant are close to 40 years old.

This facility will require renovation to remain in service at its current design capacity for another 20 years. Some improvements would likely be needed within about 5 years and a major renovation would probably be necessary with about 15 years. Chapters 5 and 6 discuss plans for upgrading the facility and coordinating the upgrade with potential future expansions. Specific issues with regard to the condition of the existing NWWTP are summarized below.

- **No Influent Screening.** The absence of any raw screening allows debris in the WW to accumulate in the Primary Cells and potentially damage aeration equipment.
- **Solids Accumulation in Lagoons.** Over time grit in the influent WW and non-biodegradable solids accumulate in lagoon systems. Typically, solids should be pumped or dredged from lagoons about every 20 years. The accumulation of grit and other solids in the Primary Cells reduces effective volume and treatment capacity.
- **Aerators.** Inadequate aeration can reduce biological treatment capacity and increase odors. The City recently replaced the existing aerators in the two Primary Lagoons with used units that were obtained from Metolius. The replacement of these aerators and their motor starters should be planned in about 5 years.
- **Lagoon Liner.** There is no evidence the liner under the lagoons is leaking. However, the liner will be 50 years old in 10 years. Because of age considerations, the City should plan a complete renovation or replacement of the lagoons in 10-15 years.
- **Lagoon Transfer/Outlet Structures.** The wood walkways to these structures are deteriorating and in need of replacement within 5 years. The concrete structures and the metal components are generally adequate, but the City should plan to replace them in 10-15 years due to their age.
- **DAF Clarifier.** The air compressor, the variable frequency drives for the clarifier, and some controls components have recently been replaced. However, most process components are over 20 years old. The steel structural supports are showing signs of coating failure and corrosion. Overall the process is adequate, but age of the entire system is a concern and ongoing corrective work would be needed to keep it in service.
- **Sandfloat (DAF) Filtration.** The City no longer uses the DAF filter because Class A effluent does not need to be produced for recycling. The filter is in poor condition due to age, equipment condition, and lack of recent operation.
- **Chemical Feed Pump.** This metering pump that feeds coagulant (polyaluminum chlorohydrate) is old and in need of replacement. The City now prefers to use peristaltic pumps for chemical feed applications.
- **Chlorine Residual Analyzer.** The analyzer is adequate, but should be replaced within 5 years. The model at the NWWTP is no longer available.
- **Electrical and Controls Components.** The main electrical service components are nearly 20 years old and should be replaced within 5-10 years. Currently, the controls for the DAF Clarifier are in the process of being upgraded.

- **Coating on Equipment and Structures.** Some coatings on ferrous metal and wood structural components are failing and in need of recoating. Some metal equipment components are also in need of recoating.
- **Seasonal Operation of Clarifier and Disinfection System.** A major limitation of the DAF clarifier and effluent pumping equipment is that their outdoor installations make them subject to freezing. This prevents the City from reliably operating the equipment during cold weather. Lagoon effluent is only sent through the clarifier during the growing season when effluent can be used for irrigation. Outside the growing season, lagoon effluent must be sent to the storage pond. This approach makes irrigation practices dependent on the operation of the clarifier and there is no redundancy in the process equipment.

  Continuous operation of the clarifier and disinfection system all year is a priority for the City because that would allow recycled effluent to be sent to the storage pond when cold and/or wet weather prevents irrigation. The recycled effluent could then be drawn from the storage pond as needed for irrigation without reliance on further treatment.
- **Sludge Drying Bed Capacity.** Although the drying beds are in good condition, they are not enclosed. As a result, cold temperatures and precipitation during the winter reduce evaporation and drainage from the solids. In recent years, the beds have either been nearly or completely filled to capacity. As flows increase, drying bed capacity will need to be expanded and/or the amount of liquid will need to be reduced in the biosolids hauled from the SWWTP.

SWWTP. The overall condition of the SWWTP is good. Since the plant is 15 years old, structural components and yard piping should generally be adequate for the next 20 years and beyond. The age of most equipment components will not become a concern for about 10 years. However, there are specific condition issues with some components that should be addressed within the next 3 years. These components and condition issues are summarized in the following paragraphs.

- **SCADA System.** The control system at the SWWTP provides the required functions. But much of the system hardware and software components are either obsolete or soon becoming obsolete. The system integrator has proposed the phased replacement of most SCADA hardware and software components.
- **SBR Process Building.** Cracking has occurred in the CMU walls of the bldg. and in the concrete wall between the bldg. and the adjacent digester tank. The crack in the concrete would likely require injection grouting to seal. The CMU cracks have been sealed and recoated, but their condition should be monitored to check for any changes.
- **Coating on Equipment.** Some metal equipment components are also in need of recoating.
- **SBR Diffusers.** The fine-bubble, diffuser tubes in the SBR basins are generally expected to last about 10-12 years and become more likely to fail at that point. Also the diffuser tubes lose flexibility over time and become less efficient at diffusing the air into the basins.
- **SBR Effluent Control (Decant) Valves.** The effluent control valves on the decant lines for the two SBR basins do not close tightly and leak. Cost information obtained by the City indicates replacing the valve seals would cost more than half as much as new valves. Therefore, the City should plan to replace the entire valves.
- **Disk Filter Backwash (BW) Pump and Control Valve Actuators.** The BW pump and control valves are located in a below-grade chamber that provides a damp environment during cool and cold weather. The BW pump and skid are heavily corroded. The valves are stainless steel, but the internal parts on the motorized actuators may be subject to corrosion.

Another area of concern for the SWWTP is the operation of the aeration system for the aerobic digesters. The City plans to improve process performance and energy efficiency by installing dissolved oxygen (DO) probes in the digesters and adding a new DO control algorithm to the SCADA System programming.

The SWWTP was designed to accommodate the addition of one more SBR treatment module and the plant may be expanded within the 20-year planning period. If a plant expansion occurs within about 10 years, it may be cost effective to plan a major renovation of existing equipment in conjunction with this future expansion.

2.3.5. Maintenance and Corrective Work Plan

Recommendations for completing major maintenance tasks and corrective work were developed in cooperation with the City. These plans are in outlined in Appendix F. The items covered by the recommended plans are non-routine tasks that typically must be performed by outside contractors or repair shops. Routine preventive maintenance tasks are not included in the recommendations.

Although the recommended tasks have been prioritized and incorporated into a schedule, the timing of the work will depend on how well the affected components continue to function and on the availability of funds. Some corrective work noted in the plans will likely be completed as part of capital improvements either in conjunction with a WWTP expansion or as a major facility overhaul.

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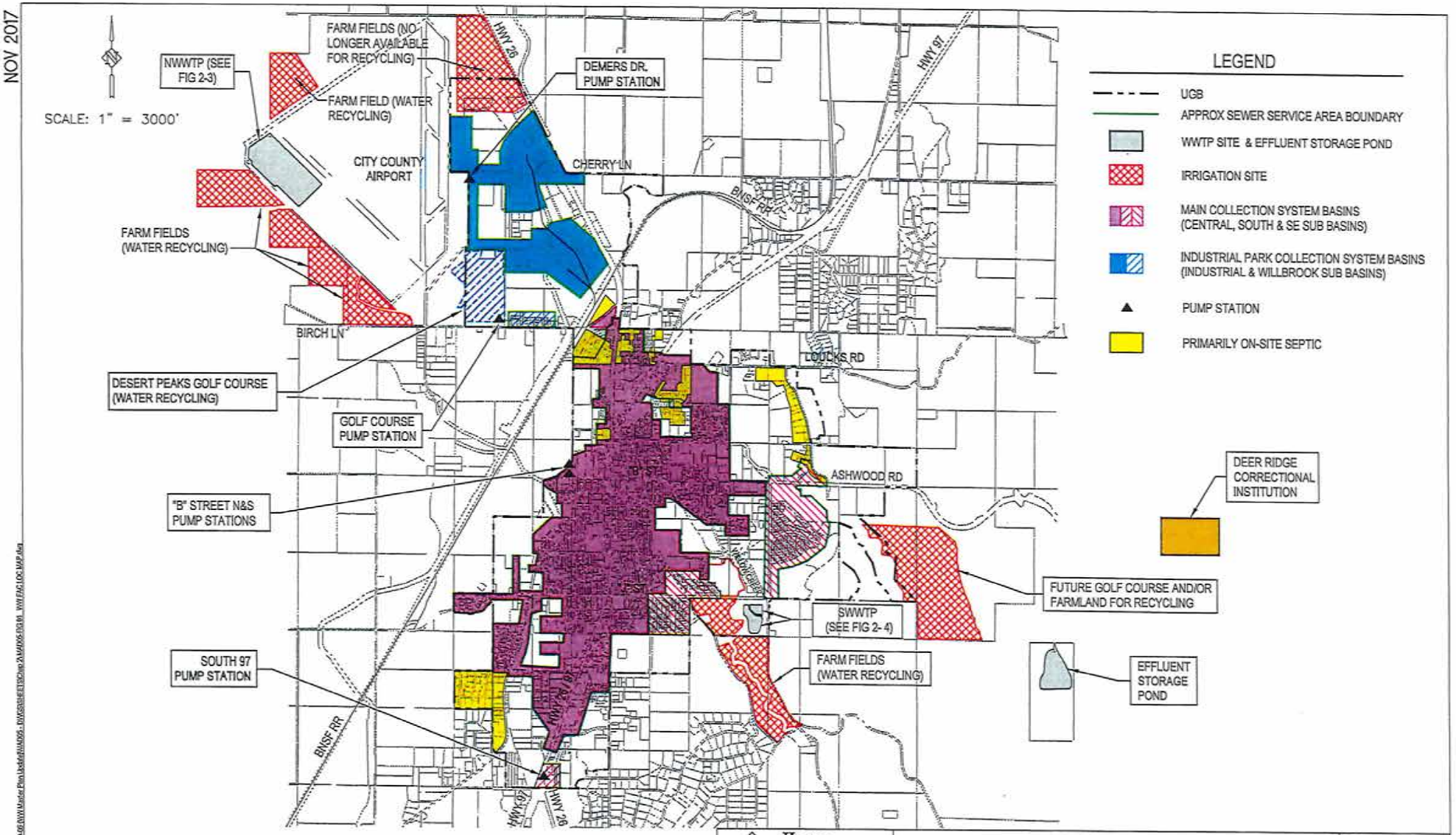

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EXISTING WW FACILITIES MAP

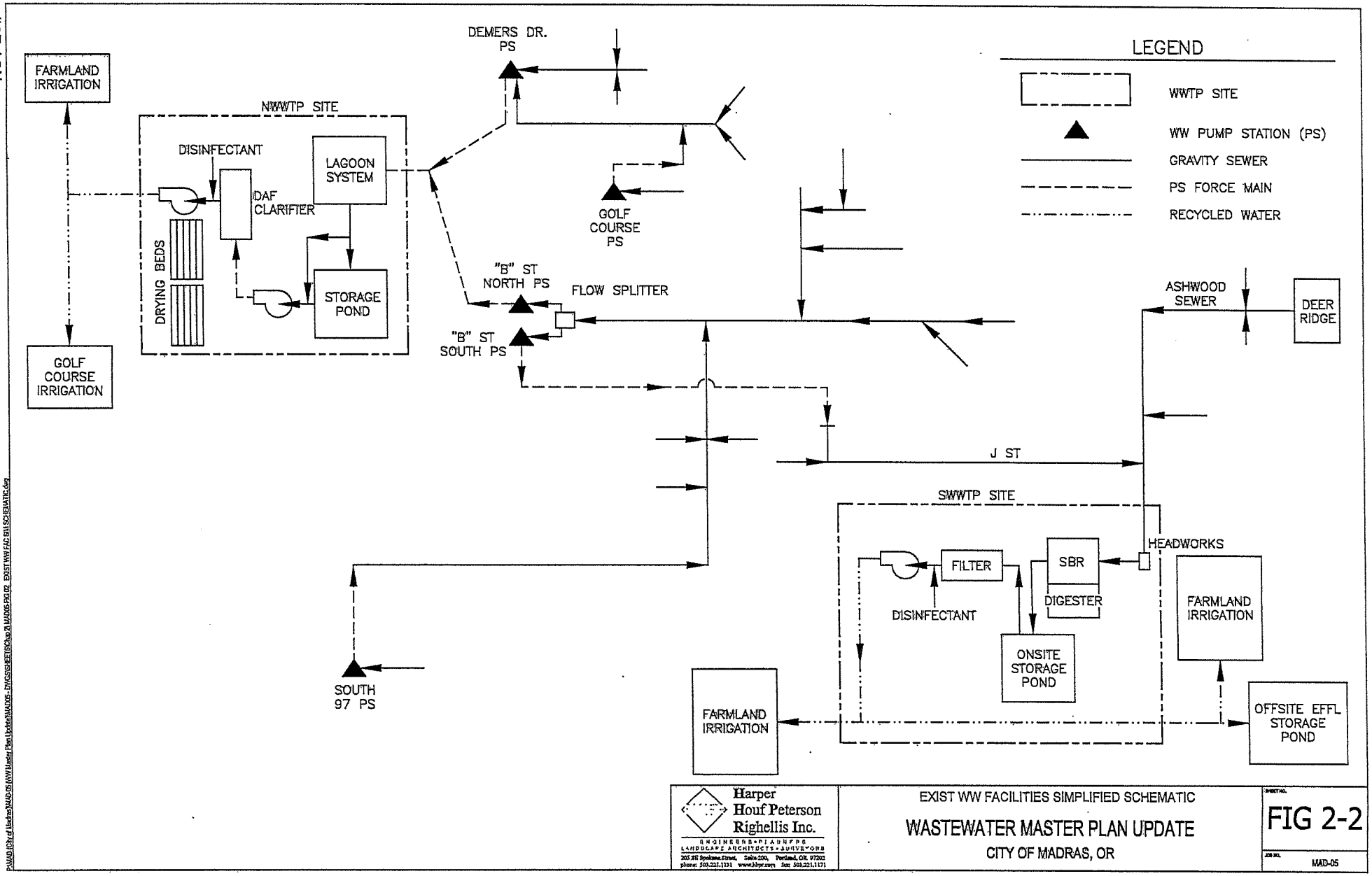
WASTEWATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

FIG 2-1

MAD-05

NOV 2017



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EXIST WW FACILITIES SIMPLIFIED SCHEMATIC

WASTEWATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

FIG 2-2

JOB NO. MAD-05

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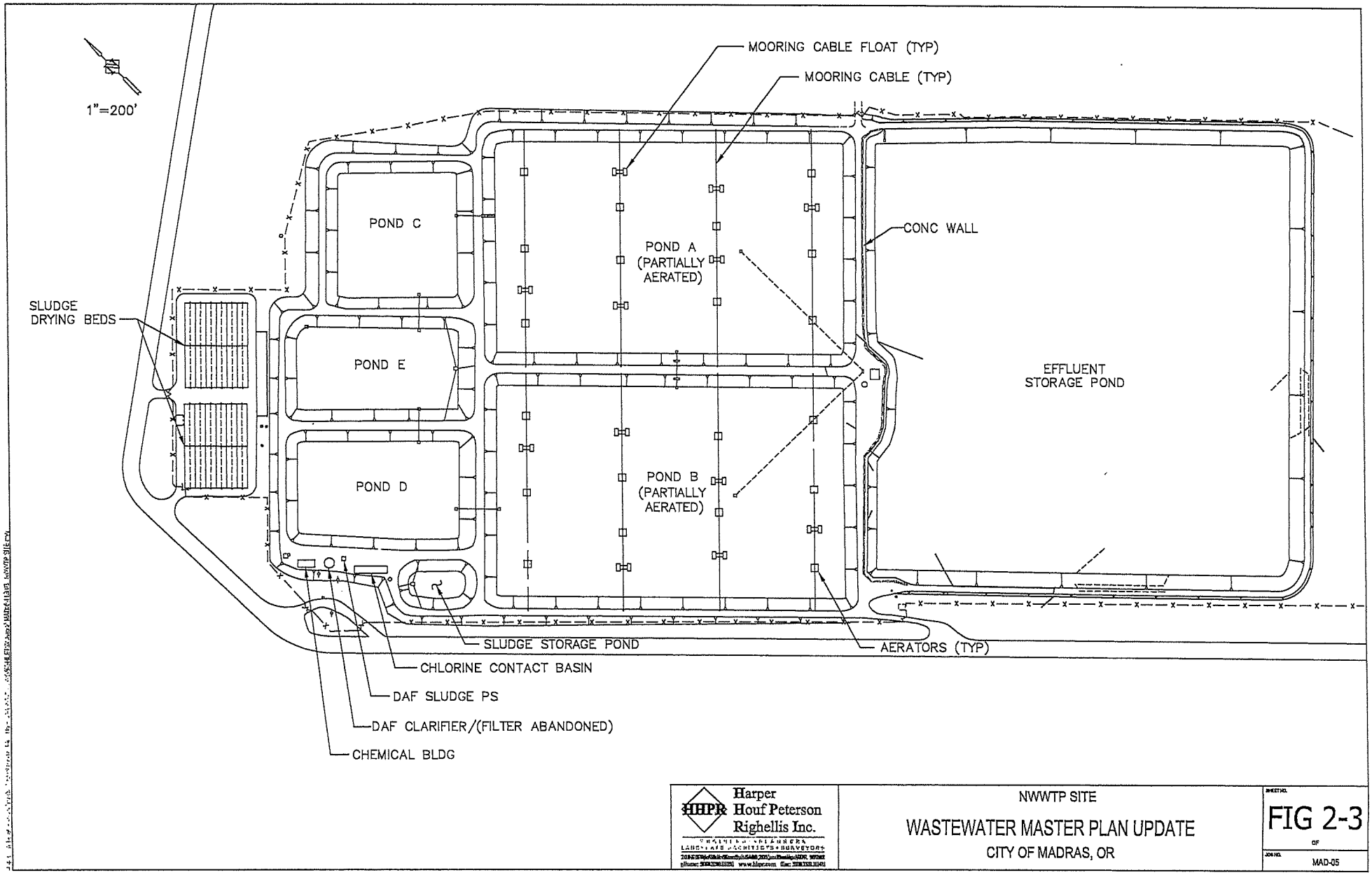

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NWWTP SITE

WASTEWATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

FIG 2-3

MAD-05

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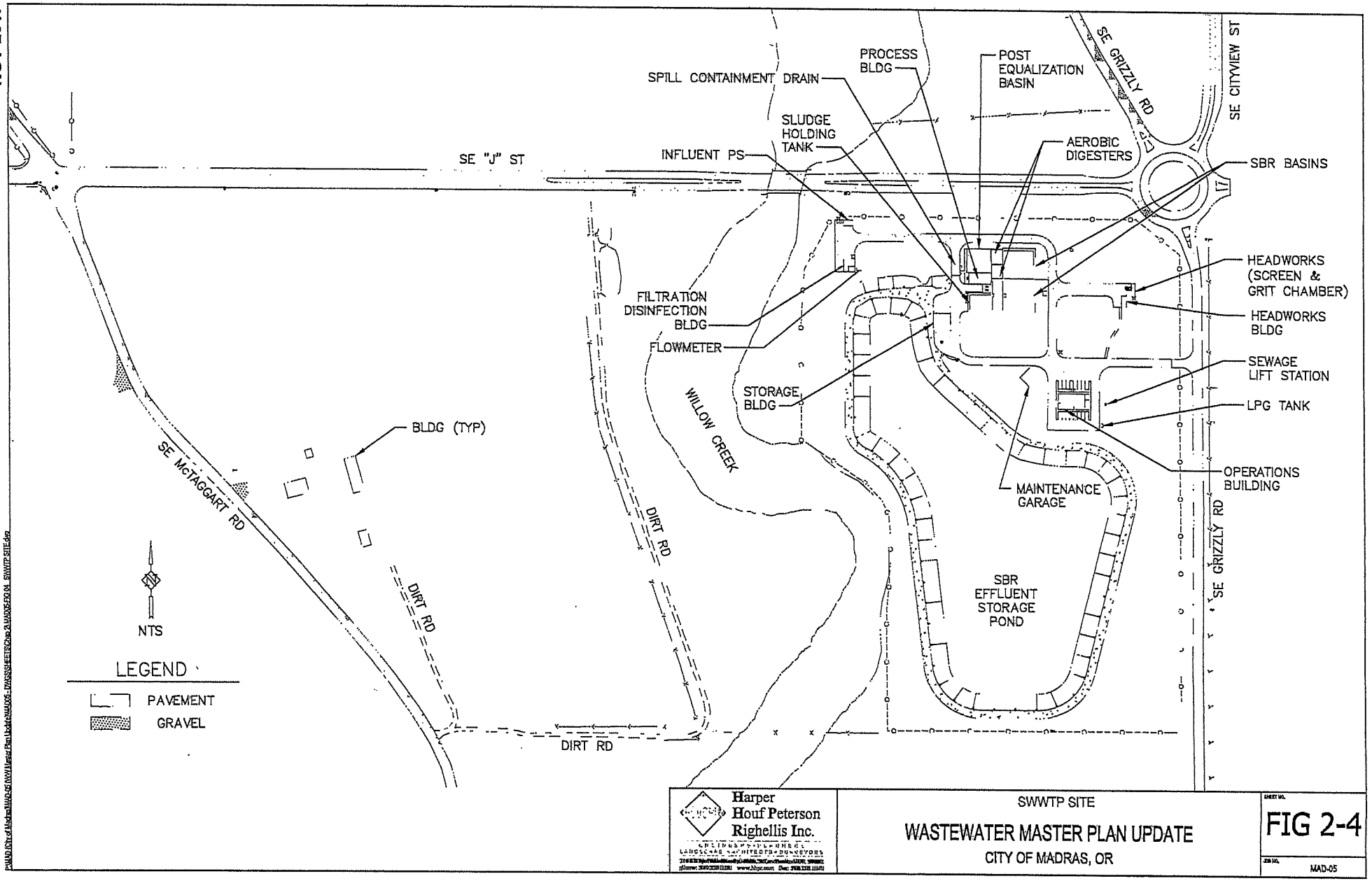

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SWWTP SITE

WASTEWATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

FIG 2-4

MAD-05

CHAPTER 3
BASIS OF PLANNING

3.1 POPULATION AND DEVELOPMENT

3.1.1 Recent Population Trends

Population estimates for the City of Madras over the past 15 years are listed in Table 3-1. Estimates are also shown for the total population within the Madras UGB in the Years 2000, 2010 and 2015. These estimates are prepared annually by the Portland State University Population Research Center (PSU).

Table 3-1
Recent City of Madras Population Estimates

	Population Estimates		Avg. Annual Growth Rate	
Year	Inside City	Within UGB	Inside City	Within UGB
2000	5,130	6,475	---	---
2001	5,200	---	---	---
2002	5,290	---	---	---
2003	5,370	---	---	---
2004	5,430	---	---	---
2005	5,600	---	---	---
2006	6,070	---	---	---
2007	6,585	---	---	---
2008	6,640	---	---	---
2009	6,650	---	---	---
2010	6,050	6,987	1.66% (1)	0.76% (1)
2011	6,225	---	---	---
2012	6,260	---	---	---
2013	6,255	---	---	---
2014	6,260	---	---	---
2015	6,265	7,484	1.34% (1)	0.97% (1)

(1) 10-year AAGR from 2000 to 2010 and 15-year AAGR from 2000 to 2015.

The City's population has increased at an average annual growth rate (AAGR) of 1.34% since the Year 2000, even though growth has fluctuated significantly from year to year depending on economic conditions. By comparison, the 1990 and 2000 U.S. Census data for Madras show an AAGR of about 4.0% over that 10-year period. Also, the PSU population estimates from 2000 to 2008, when the economy was performing better, show an AAGR of 3.3%.

3.1.2 Current Land Use and Dwelling Units

Figure 3-1 shows a current zoning map for Madras. According to the 2007 *Madras Urbanization Report* prepared by ECONorthwest, tax lots made up 86% of the land, or about 3,308 acres, within the UGB in 2005. The remaining 14% of the land, about 540 acres, consists of rights of way.

The Urbanization Report estimated 56% of the land in tax lots was developed in 2005 and about 35% of this land remained available for development. The other 9% was reported to be "constrained" and not developable.

The 2010 U.S. Census reported a total of 2,569 dwelling units (DUs) in the City and 2,970 DUs inside the UGB. The American Community Survey data provided by the Census for 2010-2014 show 2,363 of the units inside the City were occupied households and lists an average unit occupancy of 2.67 people per household (PPH). The PSU 2015 Coordinated Population Forecast for Jefferson County reported an average of about 2.7 PPH in 2010 for all occupied DUs within the Madras UGB. These figures are close to the average of 2.6 PPH used in the 1996 WWMP.

According to the 2007 Urbanization Report the average PPH is expected to decline in the future. Given this projection and the recent Census data, the continued use of 2.6 PPH for average unit occupancy is reasonable.

3.1.3 Population and Dwelling Unit Forecasts

Table 3-2 lists projected populations and the resulting number of occupied DUs within the Madras UGB at 5-year intervals over the next 20 years. The population forecasts were reported in the PSU *2015 Coordinated Population Forecast for Jefferson County* and prepared under the Oregon Population Forecast Program.

Forecasts PSU prepares under this program are to be used for land-use planning according to Oregon state law and Department of Land Conservation and Development policy. Therefore, these data have been used to project WW flows within the existing UGB over the next 20 years. Since the 2015 PSU forecasts also include a 50-year projection, that figure is listed in Table 3-2 as well.

Table 3-2
Madras UGB Forecasts for Population and DUs

Year	Population (1)	Occupied DUs (2)	AAGR (3)
2015	7,484	2,880	---
2020	8,070	3,105	1.52%
2025	8,700	3,345	1.51%
2030	9,268	3,565	1.27%
2035	9,815	3,775	1.15%
2065	12,749	4,905	0.88%

(1) PSU 2015 estimate for entire area within UBG.
(2) Forecasts for occupied DUs based on an average unit occupancy of 2.6 PPH.
(3) AAGR is calculated for each incremental 5-year period to 2035 and for the 30-year period from 2035 to 2065.

The forecasts show the incremental 5-year AAGR inside the UGB steadily declining over the next 50 years. The overall 20-year AAGR from 2015 to 2035 works out to be close to 1.4% and the AAGR over the 30-year period from 2035 to 2065 is forecast to be just under 0.9%.

The controlling parameter for WW flow projections is the population forecast since flow projections are based on average per capita water use and the resulting per capita WW production. At this time there is no basis for forecasting any change in per capita water use. Therefore, a higher or lower average occupancy would not impact projected WW flows because the estimated flow per DU would be raised or lowered proportionally to reflect a consistent per capita WW production.

The projections for DUs are used for sewer modeling since WW flows are input to the model based on tributary equivalent dwelling units (EDUs). The DU forecast provides the basis for projecting a WW flow per EDU described in Subsection 3.2 and also for calibrating the distribution of EDUs in the sewer system model.

3.1.4 Nonresidential Development

Nonresidential Growth. The *2007 Urbanization Report* forecast that employment in Madras would grow in proportion to population growth. To be consistent with that projection, the WW flow projections in this study assume nonresidential flows will increase in proportion to growth in residential flows.

Industrial Development. Projections in the *Urbanization Report* showed more than enough industrial land was available in the City than would be needed over the next 20 years. This forecast should still be current given that no significant development has occurred since 2007 and the PSU population-growth forecast is lower than the projection used in the *Urbanization Report.*

Because the City has available land and industrial development is important to the area's economy, it is essential the City address infrastructure requirements to serve future industrial customers. To support such planning efforts, this study evaluated the WW facilities needed to serve major industrial customers at potential sites in the Industrial Park.

It is not feasible to forecast what type(s) of major industrial users might seek to locate in Madras and how much WW might be generated. Therefore, the evaluations we performed focused on two considerations. First is the question of how much capacity can be made available at the existing NWWTP, without an expansion. Second, is the matter of what improvements would be needed and what it would cost to expand the Industrial Park Collection System and the NWWTP to handle an assumed flow contribution from a major industrial user.

For planning purposes, we assumed a maximum daily flow contribution of 1.0 MGD above the flows from the forecast residential and nonresidential growth. The evaluations of WW service needs for industrial development are included in Chapters 4 and 5.

3.2 WASTEWATER FLOWS

3.2.1 Analysis of Recent Wastewater Flows

Combined monthly WW flow rates to the two WWTPs were analyzed for the period from 2010 through 2014 to establish benchmark WW flows for master planning. These flow rates are reported on the City's monthly Discharge Monitoring Reports (DMRs) that must be submitted to the DEQ as part of their WPCF permit requirements.

Records of the wastewater flow contribution from the prison were also obtained from the City for 2013 and 2014 to identify the net flows contributed by City users without the prison. Monthly average prison flows ranged between 9% and 12.5% of the total monthly wastewater flows. Therefore, to estimate the City's contribution, the total flows reported in the DMRs were reduced by 10% to exclude the prison.

Table 3-3 (following page) summarizes overall average annual WW flows and the resulting average flow per DU for all users other than the prison from 2010 through 2014. The calculation of average flow per DU excludes an estimated 106 homes within the City that have onsite septic systems.

Table 3-3
Total Wastewater Flows from City Users

Year	Average Annual Flow (MGD)	Estimated No. of DUs on Sewers	Average Flow Per DU (gpd) **
2010	0.440	2,220	198.0
2011	0.432	2,288	188.8
2012	0.445	2,302	193.3
2013	0.452	2,300	196.5
2014	0.455	2,302	197.7

** Calculation excludes 106 DUs not connected to sewer (on septic systems).

The flow data over the last five years indicate that 200 gpd/DU is a reasonable approximation of the total, average unit flow from all users. For a conservative estimate of the peak-monthly unit flow, we applied a 20% allowance (or a factor of 1.20) to the average unit flow. The resulting peak-monthly unit flow is 240 gpd/DU. Records show the highest peak monthly flow from 2010 to 2014 (August 2012) was actually about 10% above the average flow for the corresponding year.

To estimate the average WW flow strictly from residential users, we reviewed 2015 water use records. Assuming 82% of the water used in residences becomes WW, the same factor used in the 1996 WWMP, the data indicate residential WW flow to be about 160 gpd/DU. This translates to 61.5 gpd/capita (gpcd) for a residential density of 2.6 people/DU and is consistent with master planning information from other Central Oregon cities.

A peak-monthly residential flow of 192 gpd/DU is estimated based on the peaking factor of 1.2 described in the previous subsection. When this residential portion is subtracted from the total unit flow of 240 gpd, the peak monthly contribution from all other users (commercial, institutional and industrial) besides the prison is 48 gpd/DU or 20% of the total non-prison flow.

Currently, WW flows from the Industrial Park and airport average about 40,000 gpd or about 9% of the total average WW flow. Other nonresidential and non-prison flows are generated by commercial, institutional, and small-scale industrial customers located in the remainder of the City.

3.2.2 Wastewater Flow Projections

Table 3-4 summarizes the projected WW flow rates generated from the unit flows described above and the population forecasts shown in Table 3-2. These flow projections have been used as the basis for planning for this study.

Table 3-4
Wastewater Flow Projections for Madras UGB

Year	Flows (MGD) ** Avg. Annual	Flows (MGD) ** Peak Month	Prison Flows (MGD) ***	Total Flows (MGD) Avg. Annual	Total Flows (MGD) Peak Month
2020	0.55	0.66	0.23	0.78	0.89
2025	0.67	0.80	0.23	0.90	1.03
2030	0.71	0.86	0.23	0.94	1.09
2035	0.76	0.91	0.23	0.99	1.14
2065	0.98	1.18	0.23	1.21	1.41

** Average annual and peak monthly flows based on 200 and 240 gpd/DU, respectively.

*** Prison flow based on dedicated capacity allotted to prison by agreement with ODOC.

To be conservative, the flow projections for the Year 2020 assume sewer service will be extended to 25% of the population outside the City, but inside the UGB. The forecasts for 2025 and beyond assume the entire population within the UGB will be served by sewers. In reality, some existing homes in outlying areas within the UGB probably will not receive sewer service within 20 years. However, that number is projected to be insignificant compared to the total number of DUs.

3.3 WASTEWATER STRENGTHS

3.3.1 Analysis of Recent Wastewater Strength

The strength of the influent WW to a WWTP is characterized by the concentrations of five-day biochemical oxygen demand (BOD) and total suspended solids (TSS). This influent strength is used in conjunction with flow capacity to establish the basis of planning for biological treatment processes and to estimate biosolids production.

Data from 2010 through 2014 for both WWTPs and the prison were used to analyze the WW strengths. Influent BOD and TSS concentrations are measured at each WWTP from composite samples taken once every two weeks. The results are reported in the monthly DMRs according to the WPCF permit. Weekly samples of prison flows are tested separately by ODOC for BOD and TSS concentrations.

The monthly data for BOD and TSS show significant fluctuations in the strength of the WW flowing to each WWTP and being discharged by the prison. Such fluctuations are understandable given the various WW sources, including the prison, the Industrial Park and commercial customers.

Due to infrequent sampling and the variability in the data, our analysis focused on the annual averages of BOD and TSS levels to characterize WW strengths for master planning purposes. These annual averages for the WWTP influents and the prison are summarized in Table 3-5 (following page).

Table 3-5
Annual Average Influent
BOD and TSS Concentrations (mg/L)

	NWWTP		SWWTP		Prison	
Year	BOD	TSS	BOD	TSS	BOD	TSS
2010	292	298	324	303	293	246
2011	336	301	290	304	344	384
2012	300	310	264	284	310	325
2013	324	260	258	268	294	273
2014	322	256	318	285	332	250
5-Yr. Avg.	315	286	291	289	315	296

At this time most of the flow to both WWTPs is pumped from the two pump stations at "B" Street and, in general, the strength of the WW pumped from these two pump stations will be equal. Also, since the flow to "B" Street is primarily domestic WW from residences, the BOD and TSS concentrations will typically be less than those found in the WW from the prison and Industrial Park. Our analysis bears this out, although at this time the prison is not producing WW at the strengths originally anticipated during design of the SWWTP expansion for the prison.

3.3.2 *SWWTP Wastewater Strength*

Data on average flows from 2013 and 2014 indicate about 27% of the SWWTP influent comes from the prison, with the rest coming from City users. Most of the City flows are pumped from the "B" Street South PS. The current SWWTP design is based on BOD and TSS concentrations of 750 mg/L in the prison flows and 250 mg/L in the flows from City users.

Although prison WW strength is thus far lower than anticipated, waste concentrations will likely increase once the facility is used at or near capacity due to improved operating efficiencies. Therefore, at this time the same design BOD and TSS concentration of 750 mg/L should be used along with the design flow of 0.23 MGD to plan for prison WW contributions.

Based on the average BOD and TSS concentrations reported for the SWWTP and the prison, the average concentrations from City users are calculated to be about 280 mg/L for BOD and 285 mg/L for TSS. These values are 12-15% higher than the 250 mg/L BOD and TSS concentration previously used for SWWTP design.

It is reasonable to expect that WW strength has become more concentrated over the last 15 to 20 years, given the increased use of low-water use plumbing fixtures and appliances, particularly in commercial enterprises. However, at this time we recommend the continued use of 250 mg/L for average BOD and TSS levels in City WW as the basis of planning. Our reasons for this approach are described below.

- Our projections for flows per EDU are conservative enough to account for WW flows that are only 12 to 15% higher in waste strength than previous designs.
- An under-loaded WWTP is less efficient to operate and prison flows may not become as concentrated as previously thought.
- Residential flows from the east side of the City are expected to make up a higher proportion of future City flows to the SWWTP. That domestic WW without significant commercial flows may tend to be less concentrated.

Table 3-6 summarizes the recommended basis of planning for influent BOD and TSS concentrations to the SWWTP. These WW strengths should be reevaluated during the preliminary design of any future SWWTP expansions.

3.3.3 *NWWTP Wastewater Strength*

Based on the data from 2010 through 2014 and the reasons described below, we recommend the use of 300 mg/L for the average influent BOD and TSS at the NWWTP (see Table 3-6).

Table 3-6
Average Influent BOD and TSS Concentrations

Description	Avg. Design Concentration (mg/L)
A. South WWTP Influent BOD & TSS	
Municipal Flows	250
Prison Flows (0.23 MGD)	750
B. North WWTP Influent BOD & TSS	
Total Combined Flows	300

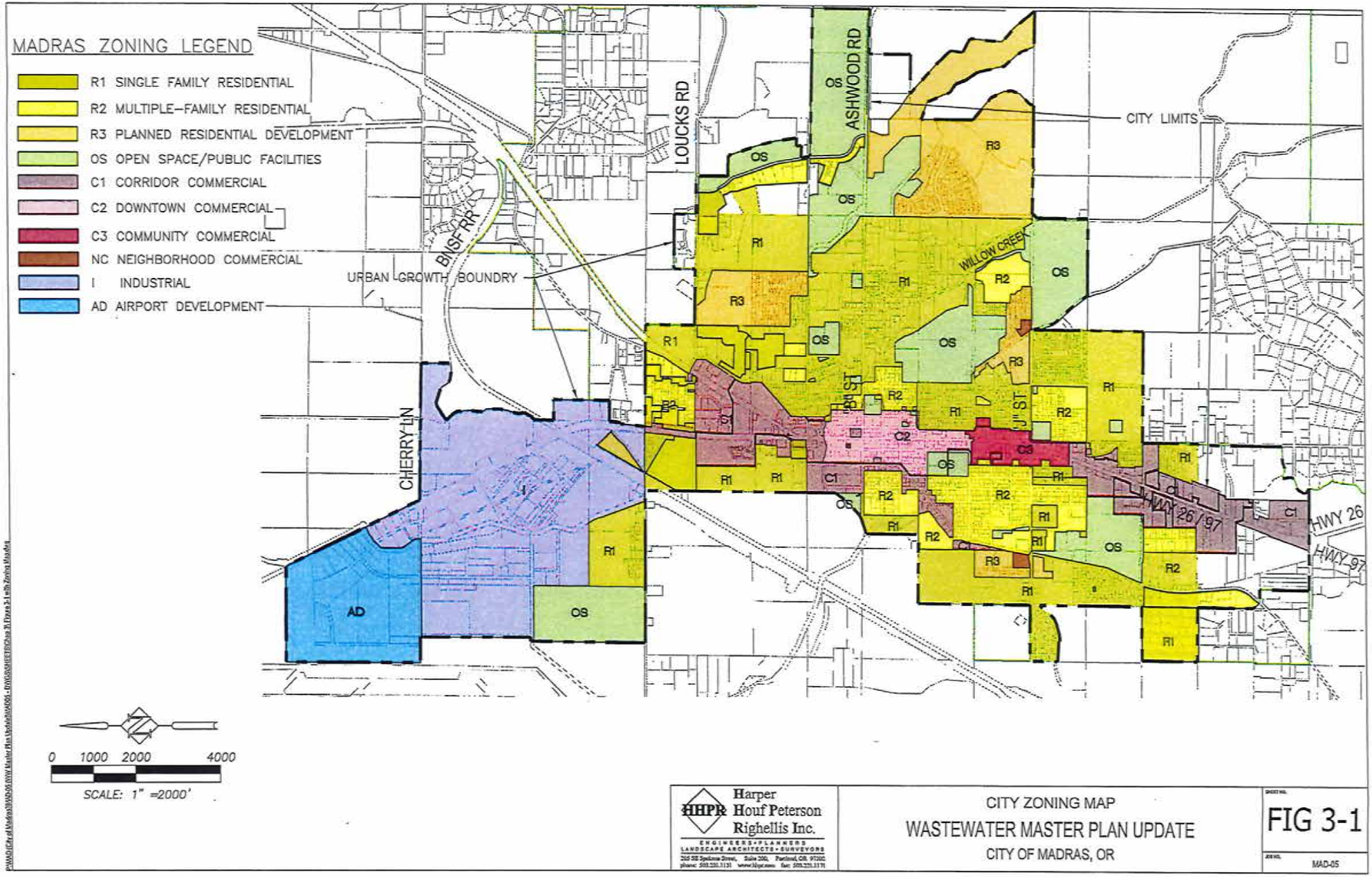
All WW from the two "B" Street pump stations is expected have the same strength. On the other hand, the Demers PS serves the Industrial Park and currently receives very little residential flow. Our analysis indicates existing flows pumped from the Demers PS have highly variable BOD and TSS concentrations, with the overall average concentrations close to 550 mg/L.

Data on average flows from 2013 and 2014 indicate 85% to 90% of the NWWTP influent comes from the "B" Street North PS, with the rest coming from the Demers PS. Although development in the Industrial Park will result in more flow from Demers relative to "B" Street, we anticipate WW strength from the Industrial Park will decline as overall flows increase.

The development of business parks and other commercial users in particular will tend to produce less concentrated WW than industrial users. Also, large industrial users will have a strong incentive to limit WW strength in order to avoid surcharges on their sewer bill from high waste loads.

The strength of the WW from Demers will need to be evaluated in more detail during the preliminary design of an expansion or upgrade to the NWWTP. Further evaluation may be warranted sooner, if development in the North Area is sufficient to force a significant reduction in flows pumped from "B" Street.

NOV 2017



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CITY ZONING MAP
WASTEWATER MASTER PLAN UPDATE
CITY OF MADRAS, OR

FIG 3-1

MAD-05

CHAPTER 4
COLLECTION SYSTEM EVALUATION

4.1 EVALUATION OF SEWER MODELING SOFTWARE

4.1.1 Background

The hydraulic analysis we performed for the 1995 Wastewater Master Plan (WWMP) used Eagle Point software to model the existing sewer system and proposed improvements. Eagle Point stopped supporting this sewer-modeling software by 2010. Their modeling software allowed users to export data on gravity sewers to spreadsheets. The software also provided both a stand-alone graphical user interface (GUI) and a GUI through AutoCAD.

As part of this project, we have evaluated new sewer modeling software to replace the software that we previously used in the 1996 WWMP. To complete this evaluation, we took the following steps.

- Identified the key considerations in evaluating and selecting the software;
- Developed a list of suitable software and evaluated the software characteristics; and
- Selected the recommended software for use on the project.

4.1.2 Key Considerations for Evaluating/Selecting Sewer Modeling Software

The key factors we addressed in our software evaluation are described in the following paragraphs.

Longevity/Stability. One objective is to select modeling software that we believe should have a lasting presence in the industry. We identified software that had a sufficient market share of users to demonstrate stability. Although it is difficult to project what developments may occur, a company whose product has a large number of users is more likely to have the resources to adapt and stay ahead of software changes in the field. Any software in widespread use for various modeling applications also provides a wider pool of experienced users.

Adaptability. The software should be capable of efficiently importing and exporting data in a format that both allows the use of data from previous studies and supports continued use of the data in the future. The software also needs to have the flexibility to model scenarios for changes that occur in projected patterns of development and flow.

Functionality. The software needs to provide the functions needed for modeling the sewer system. Some software is better suited for modeling stormwater rather than sewer systems. Stormwater and sewer systems experience differing hydraulic conditions and modelers tend to use different units.

Graphical User Interface (GUI). There are four common methods used to display sewer systems in conjunction with other features such as streets and utilities. The three most common methods use AutoCAD, Microstation, or ArcMap.

AutoCAD and Microstation are widely used and provide the ability to print plans, profiles and other graphical displays. ArcMap is the main software for Geographical Information Systems (GIS) and is used by many government agencies to record and map data for infrastructure and developments. The fourth GUI method is the use of a stand-alone GUI that is typically part of a proprietary software and may not offer the ability to import and export data from other GUI systems.

Simulation Options. It is useful to identify software that meets the City's needs and offers adequate flexibility, but is not overly complex. Different models can be executed in different ways and various features are available. Different assumptions, equations, and time-based calculations are used. Alternative methods are also used to calculate infiltration and inflow (I/I) and changes from open-channel to surcharged pipe conditions. Another factor in simulation is the ability to calibrate flows and hydraulic grade lines (flow depths) so they reflect actual sewer conditions.

Education and Support. Sewer modeling and GUI software are complex and require training for efficient use. The level of support for each software is specific to the manufacturer, their distributors, and the character of the market they have developed. Some software suppliers sell expensive training or a support package for assistance. Other software is so widely used that online training is available through the software supplier's website, user groups, You Tube videos, and other educational websites.

Cost. We compared initial costs to verify competitiveness in the marketplace.

4.1.3 Listing and Initial Screening of Sewer Modeling Software

The following is a list of the software we reviewed for the City of Madras Wastewater Master Plan:

Software Name	Vendor
Autodesk Storm and Sanitary Analysis	Autodesk
Eagle Point	Eagle Point
EPA-SWMM	USEPA
H2OMap SWMM/ InfoSWMM	Innovyze
Mike Urban	DHI
SewerCAD/SewerGEMS	Bentley

We eliminated the following products through an initial screening process.

- Eagle Point Software was ruled out because they no longer provide support for the product.
- EPA-SWMM was ruled out because the GUI interface is standalone and the software is not user friendly.
- H2OMap SWMM was ruled out due to its limited functionality relative to InfoSWMM.
- Mike Urban was ruled out because the software did not support the latest form of the GUI.

4.1.4 Shortlist and Evaluation of Sewer Modeling Software

The following paragraphs summarize our evaluations of the products that remained after screening. Appendix G provides a comparison of the features of all the modeling software.

Autodesk Storm and Sanitary Analysis. This program is a separate Autodesk module that allows users to develop a Pipe Network in Autodesk Civil 3D (C3D) software and export it to the module. The module uses a standalone GUI to represent the model in the software.

Distributors for Autodesk software told us a software consultant would be required to convert the 1995 WWMP data into a format we could import into either C3D or Storm and Sanitary Analysis. Alternatively, we could import the 1995 data by redrawing the entire system as a C3D Pipe Network.

The drawings from the 1995 WWMP were in Civil 2D and had only the locations of the sewers and manholes. The data on manhole rim elevations and pipe inverts was in a separate spreadsheet that would have required a time-consuming process to import into C3D.

As part of our evaluation of the Autodesk software, we put together a small C3D Pipe Network with pipes, manholes and an outlet. We did import the data into the Storm and Sanitary Sewer Analysis module; but we had difficulties exporting data back to C3D when changes were made. We found it would require changes to the way the programs identified the various components during importing and exporting to allow the software to properly model the components.

Based on all of the above considerations, Autodesk Storm and Sanitary Analysis software were considered too inefficient and cost prohibitive for the Madras WWMP model.

InfoSWMM. This program is a commonly-used, commercially-available variation of the EPA SWMM program and HHPR has a version available for use on the WWMP project. Table 4-1 provides a partial list of Oregon Cities and Agencies that have used InfoSWMM.

Table 4-1
List of Cities and Agencies
Using InfoSWMM in the State of Oregon

Ashland	Klamath Falls
Bend	Medford
Clean Water Services	Milwaukee
Corvallis	Newberg
Dallas	Oregon City
Eugene Water & Electric Board	Portland
Grants Pass	Prineville
Gresham	The Dalles
Hermiston	Tualatin
Hood River	Wilsonville

InfoSWMM has more functionality than H2OMap SWMM and is capable of doing stormwater systems alone or with combined sewer systems. InfoSWMM also provides simulations that allow modeling of pipe surcharging where the conditions are known to occur.

InfoSWMM uses the ArcMap GUI, which is also used by Jefferson County. The City has said they can work with the County to map the City's sewer system. The data from the 1995 WWMP can be imported and drawn up by InfoSWMM software in ArcMap format. The additional data for changes to the collection system since 1995 can be easily added to the model and its maps.

Data can be exported from the InfoSWMM software into a Microsoft Excel spreadsheet that can be used by the City. The data can also be imported and exported easily into C3D in a 2D format. This feature is useful for providing a sewer map the City can view using AutoCAD Lite along with maps of zoning and future developments. The software also allows data to be exported as a "kml" file that can be viewed on free software like Google Earth. Reports are output in HTML and so can be viewed with any web browser.

SewerCAD and SewerGEMS. Bentley, the maker of Microstation and InRoads, supplies these software products. Bentley supplies different versions of these programs with varying costs and functionality.

In its simplest form, the academic SewerCAD is offered with a book on collection system modeling for $195. This version of SewerCAD functions with a standalone GUI. More advanced forms of SewerCAD can operate with AutoCAD, Civil 3D, Microstation, and Inroads.

SewerCAD has a proprietary hydraulics simulation engine acquired from Haestead Methods that can perform steady state and extended period simulations. It is also capable of capacity, backwater and automatic constraint-based analyses. Other features of SewerCAD include:

- the ability to do polyline to pipe conversion from "dxf" and "dwg" files;
- the ability to import and export data from spreadsheets, databases, shapefiles and OLE DB; and
- the ability to extract elevations from contours, point, shape files, CAD drawings and surfaces.

SewerGEMS is a superset of SewerCAD, including all its functionality, plus additional features. This program has the highest functionality and interoperability of any of the software we reviewed, but also has the highest price.

4.1.5 Selected Sewer Modeling Software

InfoSWMM has been selected as the sewer modeling software for this Master Plan Update based on the following reasons.

- The software is widely used for sewer modeling which suggests the potential for longevity in the wastewater industry.
- The software has a high level of functionality for modeling sewer systems.
- The data from the 1995 Wastewater Master Plan can be imported to InfoSWMM for system modeling and mapping.
- The additional data for the system changes since 1995 could be readily input to the model.
- The ArcMap GUI that InfoSWMM uses in also used by the County for GIS data. This allows the City to work in conjunction with the County to update the sewer system data and mapping.
- Data can be exported from the software into Microsoft Excel spreadsheets, which is the format used by the City.
- The data could be imported and exported readily into Civil 3D in a 2D format. This allows the City to view maps with AutoCAD Lite.

4.2 MODEL OF EXISTING CONDITIONS

4.2.1 Sewer Data Input

The sewer model was developed in two segments to analyze the gravity sewers in the two existing collection systems, the main system and the Industrial Park system. Chapter 2 includes general descriptions of these two collection systems.

The starting point for the new model was the sewer data from the 1995 WWMP model. These data were imported directly from data spreadsheets. We then input data from available records for sewer installations that occurred since the 1995 modeling effort. Table 4-2 (following page) lists the sewer projects and developments constructed from 1995 through 2015 with the number of new dwelling units (DUs) and/or commercial equivalent dwelling units (EDUs) associated with each.

Any gaps or inconsistencies in available records and in the 1995 model were filled through field investigations and surveys performed by either City staff or HHPR surveyors. The result is a backbone sewer model that represents to the extent feasible actual characteristics (sizes, lengths, lines and grades) of the sewer systems.

Figures 4-1A to 4-1D provide an overall map showing the two existing collection systems that were modeled. Appendix C includes a tabulation of the pipe and MH data for the existing sewer segments in the two collection system models.

Table 4-2
Previous Sewer Projects and Developments from 1995-2015

File No.	Project Name	Residential Units	Commercial EDUs
1	Berg Drive & Related Improvements		6
3	10th Street		
4	Buff St		
5	Lincoln Heights	12	
6	Sunnyside Estates Phase 1	29	
7	Ashwood Rd FM & San Sewer		
8	Cherry Lane		2
9-10	Chestnut Sewer Phases 1 - 2	9	3
16	Jefferson Park Business Center Phase 1A		2
17	Jefferson St. Sewer	14	1
18	Madras Hotel Crosskeys		
19-21	Morning Crest Phases 1 - 6	87	
23	Fourth, Oak to Poplar		
24-25	Oak St, 4th to Hwy 26 & 6th to 7th		
26	Poplar and Hwy 26		
28	Park Place Phase 1 (1996/1999)	37	
30	Polk Street		
31	Lee Street to Tops and B St PS to North Wye Sewer		
32	Sunrise Estates	87	1
34	South 97 Sewer		2
35	Strawberry Heights Sub Phase IV	127	1
36-36A	The Pines Phases 1 - 2	83	
37A	City View Street Intersections (Yarrow)		
37B	Yarrow City View RAB	15	2
37-38	Yarrow Phases 1 - 2		
41	Bi Mart Sewer June 1998		4
42	Buff Estates [18 Lots 1999]	21	2
43	H & Marshall Apt Sewer Extension		
44	Kinkade Crossing (50 Lots 2006)	8	
46	Juniper Crest	101	
47	Sage Hill Addition		
48	Wagon Wheel	28	
49	J Street - City View Improvements		
50	Madras 1B		
51	Madras Eff Pump Main and Pond		
52	Oak Terrace	3	
53	Bean Drive 2nd Addition	1	2
54	S&P Estates (sewer built but no development)		
55	Madras Aquatic Center		
56	Fairway Estates	41	2
Total EDUs		**703**	**30**

4.2.2 *Existing Wastewater Flow Inputs*

Main Collection System. Existing WW flows were input to the model by developing estimates of the current DUs tributary to each sewer segment. We then applied the average daily flow per DU previously reported in Chapter 3 to estimate the average flow contributions throughout the collection systems. The model produced a total average flow of 0.50 MGD in the main collection system, which compares well to recent flow data for the system (see Chart 4-1).

A diurnal curve is used to model peak flows throughout the system and address their impacts on the sewers. This curve represents the flow variations that occur over the course of a typical day. Sewage flows tend to drop overnight and then rise during the daytime with flow spikes occurring in the morning and evening. The highest peak flows in Madras generally occur in late morning around 10:00 AM.

The ratio of the peak flow to the average daily flow is termed the peaking factor. The 1995 study applied a peaking factor of 2.6 to establish a peak flow for the model. Our analysis of recent flow data found that a peaking factor near 3.1 better characterized the current ratio of peak to average flows. The diurnal curve we developed for the model was based on this higher peaking factor.

Industrial Park Collection System. Existing WW flows in the Industrial Park Collection System consist of contributions from businesses and a few residences in the Industrial Park plus the output from the Golf Course PS. Since the WW reaching the Golf Course PS is all residential flow, the same average daily flow per DU and peaking factor described above were used to estimate flows the tributary flows.

Water use records were analyzed to estimate flows from users in the Industrial Park. A factor was applied to the metered water use to estimate the proportion of the water that becomes wastewater. This factor is based on overall water use and wastewater treatment plant (WWTP) flows in the City.

4.2.3 *Calibration of Wastewater Flow Inputs*

Main Collection System. The model for the Main Collection System was calibrated by comparing the depth predicted from the execution of the model to the actual flow depth measured by Madras Public Works. The actual depth was measured in the 18-inch interceptor near the "B" Street PS (MH I-1). A comparison of the depth predicted by the model simulation to the actual depth measured in the field found the model was sufficiently accurate in its representation of flow conditions.

We also calibrated our model of the Culver Highway sewer using velocity and depth data collected along that line in 2008 by a temporary monitoring device. Our analysis of the 2008 data indicates peak flows in that sewer may be higher than our initial estimates. Therefore, we used a higher peaking factor of 4.0 for the Culver Highway sewer in the model. The data also suggest the condition of this sewer warrants the use of a higher Roughness Coefficient than we used for the other sewers. As a result we used a coefficient of 0.015 for the line along Culver Highway, instead of the 0.013 coefficient we input for the other sewers.

Industrial Park Collection System. We used estimated WW outputs from the Demers PS to check the accuracy of the modeled flows for the Industrial Park. Estimates of PS output were generated from data on Demers pump run times and the design pump output. Since the pumps at the Demers PS were recently rebuilt, the pump output was assumed to be equal to the rated capacity of 290 gpm at the design total dynamic head (discharge pressure). The outputs estimated from pump run times were consistent with the WW flow rates developed in the model from factored water uses.

4.2.4 Modeling Results for Existing Conditions

The model found no surcharging conditions under existing peak flows for any gravity sewer pipes in both the Main and Industrial Park Collection Systems. These results indicate the existing gravity sewers should have adequate capacity for existing flows. Additionally, our analysis shows the existing pump stations have adequate capacities to pump the estimated peak flows.

4.3 MODEL OF PROJECTED FLOW CONDITIONS

4.3.1 Modeling Future Developments

To estimate the locations and amounts of future WW flows entering existing sewers, projections were generated of a probable distribution of future developments in the City. For modeling purposes, the projected DUs from these developments were translated into flow contributions entering existing sewer MHs.

City records were used to identify all proposed development projects along with the proposed numbers of DUs and EDUs associated with each. Records show the total number of DUs in proposed developments, plus build-out of existing developments, is more than twice the number of DUs forecast to be built over the next 20 years by Portland State University (PSU). In fact, the proposed developments are close to equaling the 50-year growth forecast from PSU.

To generate a development distribution more consistent with growth forecasts, proposed developments that were most likely to proceed within the next 20 years had to be identified. In support of this effort, the City performed an analysis that estimated relative development timing based on infrastructure needs and divided proposed developments into separate timing categories. The City generated these estimates based on an analysis of the relative street and sewer improvements required for each project. Other infrastructure elements did not appear to be significant factors in development timing. A planning memo that describes the City's analysis is included in Appendix H.

The City's development-timing estimates were based only on infrastructure considerations and did not address the socio-economic issues PSU uses to generate population forecasts. The infrastructure requirements for the proposed developments are estimated to have less of an impact on development than economic and demographic factors. The result is the PSU forecasts show less development occurring over the next 20 years than the City's timing estimates.

Our sewer analysis under future conditions is based on a more gradual development rate than shown in the City's analysis to correlate more closely with the PSU forecasts used as the basis of planning. To be conservative, our analysis includes approximately 5% more DUs than are forecast by PSU. We also focused on areas where developments would have the greatest impact on existing sewers.

Table 4-3 (following page) lists the proposed development projects identified for this study with associated DUs and EDUs. The developments are divided into four development-timing categories to address incremental impacts on the sewers in the near term, mid term and long term. The DUs and EDUs in developments listed under Categories 1 through 3, plus EDUs resulting from full build-out of ongoing developments, were included in the model of projected conditions in 20 years.

Table 4-3 also identifies the existing sewer MH that would receive the WW flows from each proposed development. All these developments, except the planned Willowbrook Subdivision, will be tributary to the Main Collection System and are shown in Figures 4-2A through 4-2C.

Table 4-3
Estimated Timing for Proposed Developments

File No.	Project Name	DUs	EDUs	Existing MH Receiving Flow
Category 1 – Near-Term Planning Forecast (0-5 years)				
6	Kinkade Heights	5		A.17-1.1
12	Parkside Manor	8		A.14-5
14	Sonrise View Estates	8		E12
20 & 21	Yarrow Phases 1 & 2	150		CV-14 & CV-08
26	Lincoln Heights	5		M3.1
29	Morning Crest	33		SP-11
30	Kinkade Crossing	15		A.15-3
Subtotal – Near Term		**224**		
Category 2 – Mid-Term Planning Forecast (5-10 years)				
7	Meridian Park (Partial)	79		MH-02
9	Mule Deer Estates (Partial)	27		MH-06
11	Park Place (Partial)	21		N.2
15	Sunridge	75		B-10
40	Jefferson Street Area	38		JS-8A
Subtotal – Mid Term		**240**		
Category 3 – Long-Term Planning Forecast (10-20 years)				
1	Ashwood Heights	30		CV-26
7	Meridian Park (Partial)	79		MH-02
9	Mule Deer Estates (Partial)	27		MH-06
11	Park Place (Partial)	20		N.2
13	Roadrunner	23		MH-01
15	Sunridge	75		B-10
16	Sunset View	30		MH-01
19	Willowbrook (Partial)	77		IA-12
22 & 23	Yarrow Phase 4	65		CV-03
25	Strawberry Heights	48		SH-3
Subtotal – Long Term		**474**		
Category 4 – Beyond Planning Period (20-50 years)				
1	Ashwood Heights	30		CV-26
2	Cascade View Estates	230		SP.12-3
3	Eldorado Estates	133		SH-17
4A	Fairgrounds Estates	48		M13
5	Grizzly Estates	41		MH-01
7	Meridian Park (Partial)	80		MH-02
8	Miller Crossing	50		M5-5
10	Belmont Basin	17		M5-3
17	The Ridge	149		SH-17
18	Willow Heights	39		MH-01
19	Willowbrook (Partial)	76		IA-12
22 & 23	Yarrow Phase 3	65		CV-03
24	S&P Estates	147		SP-5
25	Strawberry Heights	48		SH-3
27	Sunnyside Estates	30		M5-12
32	South Town Center	90	160	M13
Subtotal – Category 4		**1,273**		
Total Proposed DUs		**2,211**		---

The development projects show a future growth pattern that differs significantly from the projections used in the 1996 WWMP. The proposed projects more closely coincide with the layout of the existing Main Collection System than the 19996 WWMP showed. The result is no new pump stations have been identified to meet projected needs. Instead future flows are projected to either be tributary to existing collection system pump stations or, in the case of the SE sewer basin, be conveyed by gravity to the South WWTP site.

4.3.2 *Service Extensions to Existing Residences With Onsite Disposal Systems*

Areas inside the UGB with existing homes not served by sewers were identified from available records. Based on input from the City, the unsewered areas projected to receive sewer service within 20 years were also identified and incorporated into the sewer model for future conditions. Table 4-4 (Page 4-9) lists these unsewered areas that were added to the model along with the receiving MH and interceptor in the existing sewer system that would handle the flows from each.

Table 4-4
Projected Sewer Service Timing for Currently Unsewered Areas

File No.	Unsewered Area	Projected DUs	Projected Timing (Yrs.)	Existing MH Receiving Flow
34	Bean 2nd Addition	21	0-5	CV-26
35	Bel Air	30	0-5	A.4-16
36	Cedar Heights	4	0-5	A.4-18
37	Herzberg Heights	32	0-5	A.4-18
38	Manathiela Heights	30	6-10	G-10
39	Mountain View	74	6-10	LS-11
40	North Unit	55	6-10	JS-8A
41	Sky Ridge	24	6-10	LS-14
42	Watts Addition	4	11-20	A.4.5-1
N/A	Juniper Heights (Burns Dr.)	30	16-20	M13
Total DUs		**304**		

Other unsewered areas within the UGB are not considered a high-priority for sewer extensions due to their distance from existing sewers and the lack of reported problem areas. It is anticipated these other areas will only be brought into the City limits and receive sewer service if plans for redevelopment are proposed. Given the current 20-year forecast for growth and the availability of developable land in the City, such redevelopment is not expected to occur within 20 years. Therefore, sewer extensions to these area were not evaluated or modeled in this study.

4.3.3 *Modeling Results for Main Collection System*

General. The model of the Main Collection System was executed with projected flows from developments and unsewered areas as described above to identify future deficiencies. Appendix I includes an example printout of the modeling results for a maximum-flow, buildout scenario incorporating all the projected developments identified in Tables 4-3 and 4-4.

Projected Sewer Deficiencies. Modeling of projected conditions in the Main Collection System shows two existing sewer sections lack the capacity needed to handle projected peak flows. These sewer deficiencies are described in the following paragraphs.

1. **North Wye Sewer.** Our model shows projected sewer connections in the north part of the Main Collection System will cause surcharging in the 8-inch sewer from the intersection of U.S. 97 and Cedar Street down to the intersection of 4th and Maple Streets. At that point the pipe size increases to 18-inch.

   The area tributary to this North Wye sewer is projected to have 294 additional DUs connected within 20 years and a total of 671 DUs after full development. These consist of an estimated 223 existing houses in unsewered areas and 448 DUs that are proposed as future developments.

   The unsewered areas tributary to the North Wye sewer consist of the following:

   - East of U.S. 97 – Belair, Cedar Heights and Herzberg Heights (66 DUs)
   - West of U.S. 26 – Mountain View, Sky Ridge and Watts Addition (102)
   - Between U.S. 26 and U.S. 97 – North Unit (55 DUs)

   The future developments that will contribute to this total include the following:

   - Morning Crest and Jefferson Street Area (71 DUs within 10 years)
   - Cascade View Estates and S&P Estates (377 DUs beyond 20 years)

2. **Culver Highway Sewer.** Modeling results following the calibration described in Section 4.2.3 show projected flow increases in the Culver Highway Sewer would exceed the pipe capacity. The capacity shortfall is projected to occur in the 8-inch sewer along Marshall Street, Culver Hwy. and 1st Street, between "G" and "B" Streets. This sewer connects to an 18-inch interceptor at 1st and "B" Streets.

   The following developments proposed for the south and west sides of the City are forecast to add 591 tributary DUs/EDUs.

   - Lincoln Heights, Park Place, and Sunridge (196 DUs projected within 20 years).
   - Fairgrounds Estates, Miller Crossing, Belmont Basin, Sunnyside Estates and Madras South Town Center (235 DUs and 160 EDUs projected beyond 20 years).

   We also estimate there are 30 houses in the unsewered, Juniper Heights area that would be tributary to this sewer.

Table 4-5 summarizes our estimates of the current and projected conditions for the North Wye and Culver Highway sewer sections where our model shows capacity deficiencies. The pipe capacities are listed for the sewer sections in each interceptor with the mildest slopes. We have listed available capacities and projected tributary growth both in terms of peak flow rates and EDUs.

Table 4-5
Existing Sewer Capacities – North Wye & Culver Hwy. Interceptors

	Model Results for Existing Conditions		Estimated Available Capacities		Projected Tributary Developments	
Existing Sewer	Pipe Capacity (MGD)	Peak Flow (MGD)	Peak Flow (MGD)	No. of EDUs	Peak Flow (MGD)	Total No. of EDUs
8-inch North Wye	0.47	0.17	0.30	400	0.67	677
8-inch Culver Hwy	0.43	0.17	0.26	265	0.64	591

Our analysis shows projected, 20-year growth tributary to each interceptor may not exceed available capacity. However, we project that available capacity would be exceeded well before proposed developments are fully constructed. Since it is impossible to accurately predict the pattern and pace of developments in each tributary area, the City should plan to address both sewer deficiencies within the planning period.

Projected Sewer Extensions. New public sewers would need to be extended in a few locations to connect proposed developments to the existing system. Each location that would require a sewer extension is described in the following paragraphs and the recommended improvements to address these projected needs are described in Subsection 4-4.

1. **Madras South Town Center Sewer Extension.** The development of Madras South Town Center and Fairgrounds Estates will add a proposed 250 DUs and EDUs. A sewer extension will be required to connect these developments to the existing Main Collection System.

2. **Eldorado Estates and The Ridge Extension Sewer.** These two developments propose the construction of 282 DUs and will require a sewer extension to connect to the existing system.

3. **Willow Creek North Sewer.** The area on the west side of SE City View Street between "B" and "J" Streets slopes down toward Willow Creek and gravity service cannot be provided by the sewer in City View. The following four developments with a total of 133 DUs are proposed for this area.

   - Roadrunner and Sunset View (53 DUs projected within 20 years)
   - Grizzly Estates and Willow Heights (80 DUs projected beyond 20 years)

4.3.4 Modeling Results for Industrial Park Collection System

General. The model of future conditions in the Industrial Park Collection System was first executed with projected flows from the planned Willowbrook development to identify deficiencies. Additional modeling runs were then executed to address potential future need from major industrial users. The modeling results of future conditions are discussed below. Appendix I includes an example printout of the modeling results for buildout conditions at Willowbrook.

Willowbrook Subdivision. The only planned residential development that will be tributary to the Industrial Park sewers is the Willowbrook Subdivision (153 DUs projected). The capacity of the existing Golf Course PS must be expanded to pump the projected peak flows from Willowbrook to the Industrial Park and a replacement PS is planned for the development.

Results show no surcharging will result in the existing Industrial-Park sewers and flows to the Demers PS will be below the existing pumping capacity when Willowbrook reaches buildout.

Industrial Development. Currently, there are no major industrial developments proposed for the Industrial Park that would provide a basis for estimating future WW contributions. Given this limitation, it is typical practice to model future industrial flows by identifying a per-acre flow factor and multiplying this factor by the approximate area tributary of each MH. The per-acre flow is commonly based on current flows from existing industrial users.

The model shows the existing sewers and Demers PS are adequate for the development of the Industrial Park with future users that contribute similar WW flows as the existing users. However, it is a priority for the City to prepare for major industrial users that could potentially produce high peak WW flows not represented by a general flow factor.

To address sewer needs for major commercial/industrial developments, we estimated available capacities in each existing interceptor in the Industrial Park. These estimates were identified by subtracting the estimated, existing peak flow from the calculated sewer capacity in each segment with the mildest slope. Table 4-6 (following page) shows the results we calculated for each of the Industrial Park interceptors.

Since flows in the Industrial Park are currently quite low, most of the interceptor capacity remains available for developments. Each of the three interceptors can accept additional peak flows of 0.73 to 0.77 MGD at their upstream end without surcharging. This translates to average design flows of about 0.25 MGD, assuming a design peaking factor of 3.1.

Table 4-6
Existing Sewer Capacities – Industrial Park Interceptors

Existing Interceptor	Pipe Size (inches)	Min. Slope (%)	Design Depth (d/D) *	Pipe Capacity (MGD)	Available Peak Flow Capacity (MGD) **
Berg Drive	10	0.25	0.90	0.75	0.73
Cherry Lane	8	0.40	0.90	0.79	0.77
Demers Drive	10	0.29	0.90	0.80	0.74

* d/D = allowed ratio of flow depth (d) to pipe diameter (D) per City Standards.
** Available capacity = calculated capacity minus estimated existing peak flow.

Major Industrial Flow Contributions. An additional analysis was performed to address the impacts of major industrial developments on the collection system. This analysis applied a conservative flow at upstream manholes in the system to model flows from large-scale contributors and adjacent developments. For planning purposes, we applied a 1.0 MGD average flow with a peaking factor of 3.5 to model the combined future flows from major users and adjacent developments.

The locations chosen for applying the WW flow were selected where adjacent areas have large parcels of land available for major developments. These sites, labeled as the North, South and East Industrial Areas, are shown in Figure 4-2A. The North Area would be tributary to the Berg Drive sewer and the South Area would be tributary to the Demers Drive sewer, or directly to the Demers PS. We investigated alternatives alignments for serving the East Area, across U.S. 26, either along Cherry Lane or along Hesse Road, Adler Street and Demers Drive.

As Table 4-6 indicates, the existing sewers do not have available capacities sufficient to convey the future peak industrial flow applied to model major users. The sewer improvements required to handle the flows are discussed in Subsection 4-4.

Land along the northwest side of the airport is identified in the 2010 Airport Master Plan Update as a future redevelopment area. Because of the topography of the airport property, potential developments in this area could not be served by gravity sewers tributary to the Industrial Park Collection System. The area would require a PS and a force main, most-likely extending directly to the North WWTP. Therefore, development of this area would not impact the existing sewers and Demers PS.

4.4 SEWER IMPROVEMENTS

4.4.1 Alternative Installation Technologies for Sewers

Capacity problems in existing sewers can be addressed either by installing a second, parallel sewer to increase capacity or a replacement sewer with larger diameter. A parallel sewer is more cost effective if the existing sewer can be anticipated to have at least 20 years left in its service life and there is adequate space in the right of way for a second pipe. The interceptor sewers in the Industrial Park are less than 30 years old and parallel sewers are likely to be more cost effective for capacity upgrades proposed within the next 20 years.

It is often more cost effective to augment the capacity of an older sewer through replacement. A replacement sewer can either be installed using open-trench or trenchless methods. Trenchless technologies for sewer installations generally include pipe lining, pipe bursting, horizontal directional drilling (HDD), and pipe boring and jacking.

The trenchless options that have the most potential of being cost effective for replacement applications in Madras are pipe lining and pipe bursting. Boring and jacking or HDD would typically be considered for crossings under railroads or highways when pipe lining or bursting is not feabible.

Lining an existing pipe is considerably less costly than open-trench installation of a new pipe. But lining is suitable only when no increase in pipe capacity is required and the existing pipe is in adequate condition to support the lining. Alternatively, pipe bursting is a practice that allows an increase in sewer size by bursting the existing pipe and pulling a larger pipe through the opening.

Pipe bursting can be less costly than open-trench installation in congested, high-traffic areas and in other circumstances. Key considerations in evaluating pipe bursting are described below.

- Pipe size increase – the incremental increase in pipe diameter that pipe bursting can accomplish is limited.
- Existing pipe material – certain materials, such as asbestos cement, are better suited to bursting.
- Soil conditions – pipe bursting can be limited by soil type or the presence of rock adjacent to the pipe trench.
- Pipe depth – adequate depth is required to prevent surface heaving.
- Proximity of existing utilities and structures – depending on the method used and soil conditions, pipe bursting can impact nearby facilities.

4.4.2 Sewer Improvements in Main Collection System

General. The sewer improvements required for the Main Collection System to convey projected flows and extend service to unsewered areas are summarized in the following paragraphs. The locations of these improvements are shown in Figure 4-2B or Figure 4-2C. The timing of the installations will depend on the actual pace of development.

North Wye Sewer. The developer for Cascade View Estates previously designed a pipe-size increase to 12 inches for the North Wye Sewer by pipe bursting. Our model confirms a 12-inch pipe will have the capacity to carry the projected tributary flows from the north-northeast portion of the Main Collection System.

Current forecasts suggest the North Wye sewer improvement might not be necessary within the next 20 years. However, if developments in the tributary area occur sooner than anticipated, the sewer improvement would need to be implemented within the planning period.

The feasibility of pipe bursting for the North Wye Sewer should be confirmed by a detailed analysis of existing subsurface conditions and pipe material. The designer of the sewer replacement should document in-situ conditions during project development.

Culver Highway Sewer. The model shows a parallel, 10-inch sewer in Marshall Street, Culver Hwy. and 1st Street will be needed to allow all projected flows to be conveyed to the interceptor in "B" Street. A portion of this parallel sewer has previously been designed by a developer.

Since the existing sewer between "G" and "B" Streets is over 40 years old and the timing of future developments is uncertain, the City should give consideration to the replacement of the existing pipe instead of a parallel line. A replacement pipe would need to have a 15-inch diameter to handle all projected flows from existing and future developments.

We recommend the City complete a video inspection of the existing pipe prior to project development to assess its condition and help determine if replacement would be more cost effective than a parallel pipe. If the existing line is in adequate condition, future lining of this pipe may be feasible. Therefore, a parallel sewer and pipe lining at a later date may be the preferred option.

Madras South Town Center Sewer Extension. Due to existing topography, most of the sewer connections at the Madras South Town Center site would flow to the northwest. Therefore, development of the Town Center and the Fairgrounds Estates will require an extension of the sewer system. The model shows an 8-inch pipe that will connect to the Main Collection System at the intersection of Culver Hwy. and Fairgrounds Road (MH M13) will be adequate.

The model assumes WW from the east side of the site will discharge to existing sewers along Highway 26/97. Further investigation will be needed during project development to determine the actual layout of sewer extensions and distribution of WW flows. Current forecasts indicate these projects and the associated sewer extension may occur beyond the 20-year planning period.

Eldorado Estates and The Ridge Extension Sewer. The development of these properties will require a gravity sewer that would extend north and connect to the existing system at MH SH-17. The model shows an 8-inch pipe will be adequate for the proposed developments and the developers have included the sewer extension in their proposed plans. Current forecasts indicate these projects and the associated sewer extension may occur beyond the 20-year planning period.

Willow Creek North Sewer. Proposed developments between Willow Creek and City View Street will require a sewer service extension. Given the sizes and locations of the proposed developments, an 8-inch gravity sewer extending along Willow Creek south to "J" Street would be adequate. Proposed plans submitted by the developers have followed this concept. The alignment of the extension and the need for easements will require coordination between development plans.

Service Extensions to Unsewered. The City plans to extend sewer service to most unsewered areas that have existing residences within the next 20 years (see Table 4-4). At full development, these unsewered areas can be served by 8-inch gravity sewers. The timing of these sewer extensions will depend on the availability of funds.

4.4.3 Sewer Improvements in Industrial Park Collection System

North and South Industrial Areas. Modeling results show an 18-inch parallel sewer would be needed to supplement the existing capacity of either the Berg Drive or Demers Drive sewer to handle an average-flow increase of 1.0 MGD. The proximity of the South Area to Demers PS might allow a parallel sewer along Demers Drive to be shorter than a parallel line in Berg Drive.

However, to be conservative, our analysis assumed the Demers Drive parallel sewer would extend south to Adler Street.

East Industrial Area. Modeling results show an 18-inch parallel sewer would be needed to supplement available capacity if the East Area were served by the Demers Drive sewer. Alternatively, a 15-inch parallel sewer would be needed to supplement available capacity in the Cherry Lane sewer. Also, the parallel line along Cherry Lane would be shorter than the Demers Drive alignment. Therefore, it is recommended the City plan to continue serving most of the East Area from Cherry Lane.

Service Extensions to Unsewered Areas. Two 8-inch sewer extensions are planned in the Industrial Park Collection System. One line would extend along Mill Street and the second would extend along Hesse Street and across U.S. Highway 26. These extensions would provide service to a small number of current developments that are currently using onsite disposal systems and support infill development within these parts of the Industrial Park.

Undeveloped Airport Property. Due to topography, potential developments along the northwest side of the airport would require a separate WW collection system with a separate PS and force main. Figure 4-2A illustrates a potential system layout. The actual alignments and sizing of the gravity sewers serving the area would depend on the patterns and service needs of the developments that occur. These sewers would generally be constructed as part of individual developments.

It may be feasible to serve the land immediately northeast of the airport with a gravity sewer extending west along Dogwood Lane. However, if gravity service to the northwest side of the airport is not feasible, another PS would be needed for the northeast area.

4.5 COLLECTION SYSTEM PUMP STATION IMPROVEMENTS

4.5.1 Pump Stations in Main Collection System

"B" Street Pump Stations. Based on conversations with operating staff, the addition of influent screening is warranted at the "B" St. North PS due to an increase in plastic fabrics such as flushable wipes that tend to clog pumps. Because this problem is a priority, our estimate of probable costs includes a separate project for the addition of a mechanically-cleaned screen in a new concrete channel. Future NWWTP upgrades and expansions should be coordinated with the installation of screening equipment at the PS.

The condition assessment in Chapter 2 also recommended the City renovate the "B" St. North PS in 11 to 15 years. This renovation would include electrical, instrumentation and controls components that serve both the North and South pumping systems.

The "B" St. South PS is generally in adequate to good condition and should not require a major overhaul. But the PS will need to be expanded when the South WWTP is expanded (see Chapter 5). Due to age and wear, the City will need to replace some other components during the planning period. Consequently, a PS expansion and partial renovation is listed as a capital improvement.

The generator set and associated equipment will be in need of a major overhaul or replacement in 11 to 15 years. Some renovation work on the Generator Building would also likely be due at that time. To be conservative, we have included the replacement of the genset and related work as a capital improvement.

South 97 PS. The City should plan a renovation of this PS in 6 to 10 years. Because of the small size and limited amount of equipment at this PS, we have considered this work to be part of ongoing maintenance and have not included it as a capital improvement.

4.5.2 Pump Stations in Industrial Park Collection System

Golf Course PS. The Golf Course PS will need to be replaced when the Willowbrook subdivision development proceeds. But the timing of that development cannot be predicted. Therefore, as noted in Chapter 2 (Subsection 2.3.3), the City should plan to replace the existing PS within 10 years due to its age and condition.

Demers PS and Force Main. The existing capacity of the Demers PS is 0.42 MGD and the net available capacity for future developments is estimated to be 0.14 MGD after full development of Willowbrook. Given the condition of this PS, the City should plan to renovate much of the facility in 3 to 5 years. Due to the age of the overall facility, the City should plan to fully replace the entire PS in 16 to 20 years, or sooner if a capacity expansion is needed to serve industrial development. The replacement PS would be designed with space for an additional pump, and also for larger pumps, to accommodate phased expansions as development necessitates.

Future expansions of the Demers PS will require an increase in the size of the PS force main to accommodate the higher pumping rate. We have included a future replacement of the Demers force-main with an 8-inch pipe as a recommended PS improvement project. A second 8-inch pipe could be installed parallel to this replacement pipe when a further PS expansion is required.

The timing of the future PS expansions, force main replacement and second, parallel force main would depend on the pace of industrial development and their actual WW contributions.

Northwest Airport Area PS and Force Main. As mentioned in Section 4.4.3 and illustrated in Figure 4-2A, a separate PS and force main would be needed to extend service to land along the northwest side of the airport. The actual sizing and location of the PS would depend on the service needs of the future users who locate to the area. For industrial site readiness planning we have assumed the PS would have the same capacity as the future Demers PS replacement.

A more detailed study into the most cost effective way to extend sewer service to undeveloped airport property will be required during the early stages of site development. A key consideration in siting the PS will be the shallow depth to rock in the airport area.

It may be feasible to serve the land immediately northeast of the airport with a gravity sewer extending to the potential PS site shown in Figure 4-2A. However, if gravity service to the northwest PS site is not feasible, another PS would be needed for the northeast area.

4.6 ESTIMATES OF PROBABLE PROJECT COSTS

Tables 4-7 and 4-8 present planning-level estimates of probable costs for the sewer system and PS improvements, respectively. These estimates are current to December 2016 (Engineering News-Record Construction Cost Index = 10,530). Chapter 8 provides additional information on the basis of these estimates. *The capital improvements plan presented in Chapter 8 lists updated probable costs that are current to December 2017.*

Table 4-7
Estimates of Probable Costs for Sewer Improvements (December 2016 Dollars)

Project Description	Pipe Size (inches)	Approx. Length (ft.)	Probable Construction Cost [1]	Probable Project Cost [2]
A. Industrial Park Collection System Sewer Extensions				
1. Hess Street Sewer	8	1,670	$250,000	$338,000
2. Mill Street Sewer	8	1,430	$215,000	$290,000
Subtotal for Industrial Park Sewer Extensions			**$465,000**	**$628,000**
B. Potential Alternative Sewers for Major Users [3]				
1. East Area Parallel Sewer – Cherry Ln.	15	4,800	$1,200,000	$1,620,000
2. South Area Parallel Sewer – Demers Dr.	18	2,400	$720,000	$972,000
3. North Area Parallel Sewer – Berg Drive	18	2,240	$673,000	$909,000
C. Main Collection System Sewer Improvements				
1. North Wye Sewer Replacement (By Pipe Bursting)	12	2,060	$631,000	$852,000
2. Culver Hwy. Parallel Sewer	10	3,100	$543,000	$733,000
3. Bel Air/Herzberg Heights [4]	8	5,100	$829,000	$1,120,000
4. Jefferson Street/North Unit [4]	8	2,900	$399,000	$539,000
5. Mountain View/Sky Ridge Sewer Extensions [4]	8	4,500	$844,000	$1,139,000
6. Juniper Heights Sewer Extension [4]	8	5,350	$1,003,000	$1,354,000
7. Willow Creek North Sewer Extension	8	2,500	$406,000	$548,000
8. Madras South Town Center Sewer Extension [5]	8	2,420	$454,000	$613,000
9. Eldorado Estates/The Ridge Sewer Extension [5]	8	1,800	$338,000	$456,000
Subtotal for Main Collection System Sewers			**$5,447,000**	**$7,354,000**

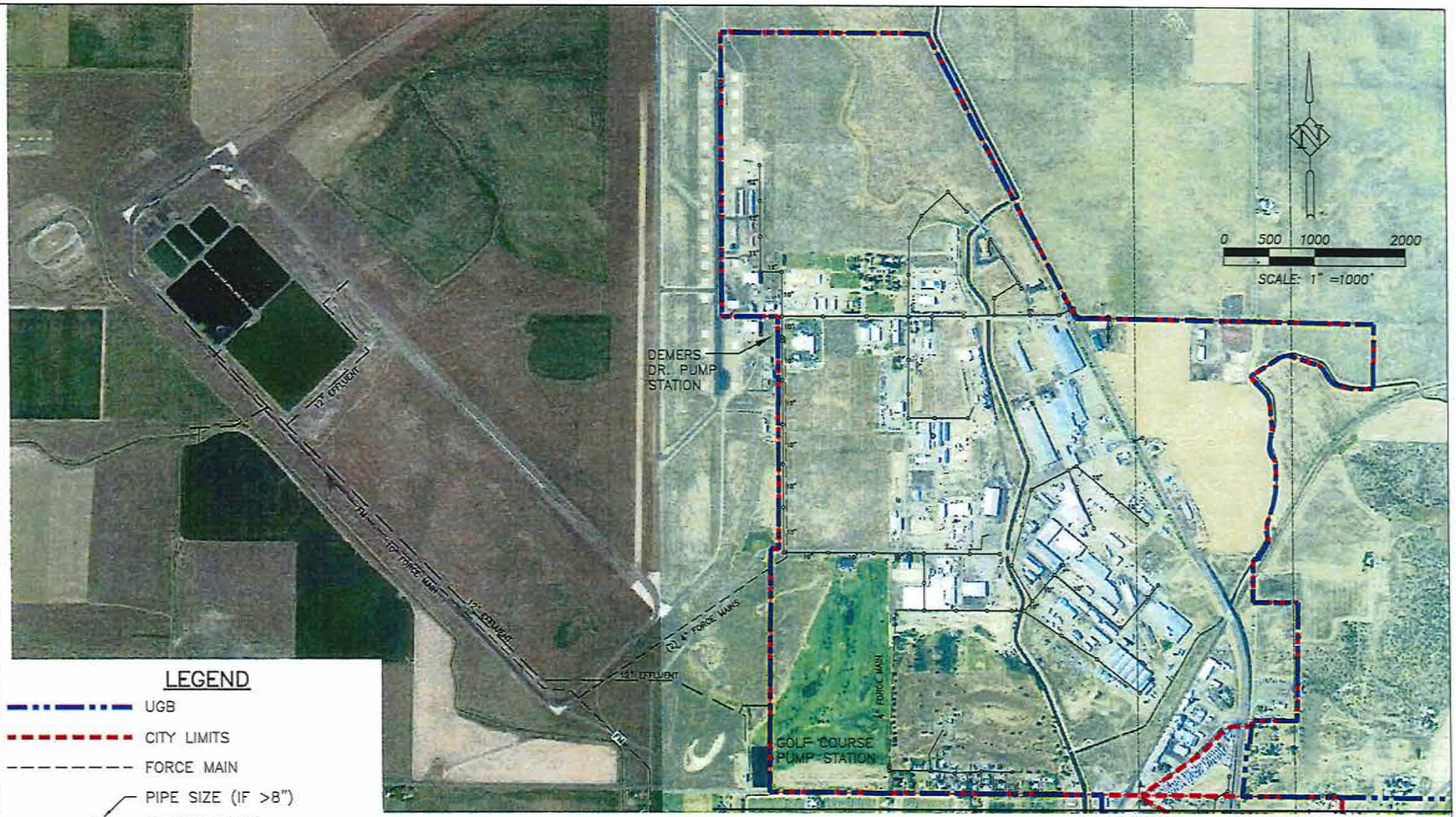
(1) Construction cost includes a 25% construction contingency.
(2) Project cost includes a 35% allowance for nonconstruction costs (engineering and administrative).
(3) Potential improvements shown for planning industrial site readiness. Timing dependent on developments for major users. Required sewer projects for major user(s) must be reevaluated based on actual development proposal(s).
(4) Projects for unsewered areas with current development.
(5) Projects would not be required within 20 years based on current population projections and anticipated development timing. Listed for information in case developments are proposed within planning period.

Table 4-8
Estimates of Probable Costs for Pump Station Improvements (December 2016 Dollars)

Project Description	Current Capacity (MGD)	Planned Capacity (MGD)	Probable Construction Cost [1]	Probable Project Cost [2]
A. Industrial Park Collection System (North Area)				
1. Golf Course PS Replacement – Expanded Capacity	N/A	0.21	$350,000	$475,000
2. Demers PS Renovation – Major maintenance and repair	0.42	--	-----	$200,000
3. Demers PS Replacement – Expanded Capacity	0.42	1.33	$1,285,000	$1,735,000
4. Demers Force Main Replacement – 8" Pipe [3]	--	1.33	$1,137,000	$1,535,000
5. Potential PS & Force Main for NW Airport Area [3]	--	1.33	$1,680,000	$2,270,000
Subtotal – Pump Stations in North Area				**$6,215,000**
B. Main Collection System Pump Stations				
1. Influent Screen at "B" Street North PS – No expansion	1.11	1.11	$334,000	$450,000
2. Renovation of "B" Street North PS – No expansion	1.11	1.11	$438,000	$590,000
3. "B" Street South PS Expansion & Renovation	1.33	2.66	$525,000	$710,000
4. "B" Street North & South Generator Set Replacement	N/A	N/A	$175,000	$235,000
5. South U.S. 97 PS Renovation – No expansion	0.06	0.06	$44,000	$60,000
Subtotal – Pump Stations in Main Collection System				**$2,045,000**
Total – Pump Stations & Force Mains				**$8,260,000**

(1) Construction cost includes a 25% construction contingency.
(2) Project cost includes a 35% allowance for nonconstruction costs (engineering and administrative).
(3) Potential improvement shown for planning industrial site readiness. Timing dependent on developments for major users. Required pump station and force main projects for major user(s) must be reevaluated based on actual development proposal(s).

NOV 2017



MATCHLINE – SEE FIGURE 4–1B

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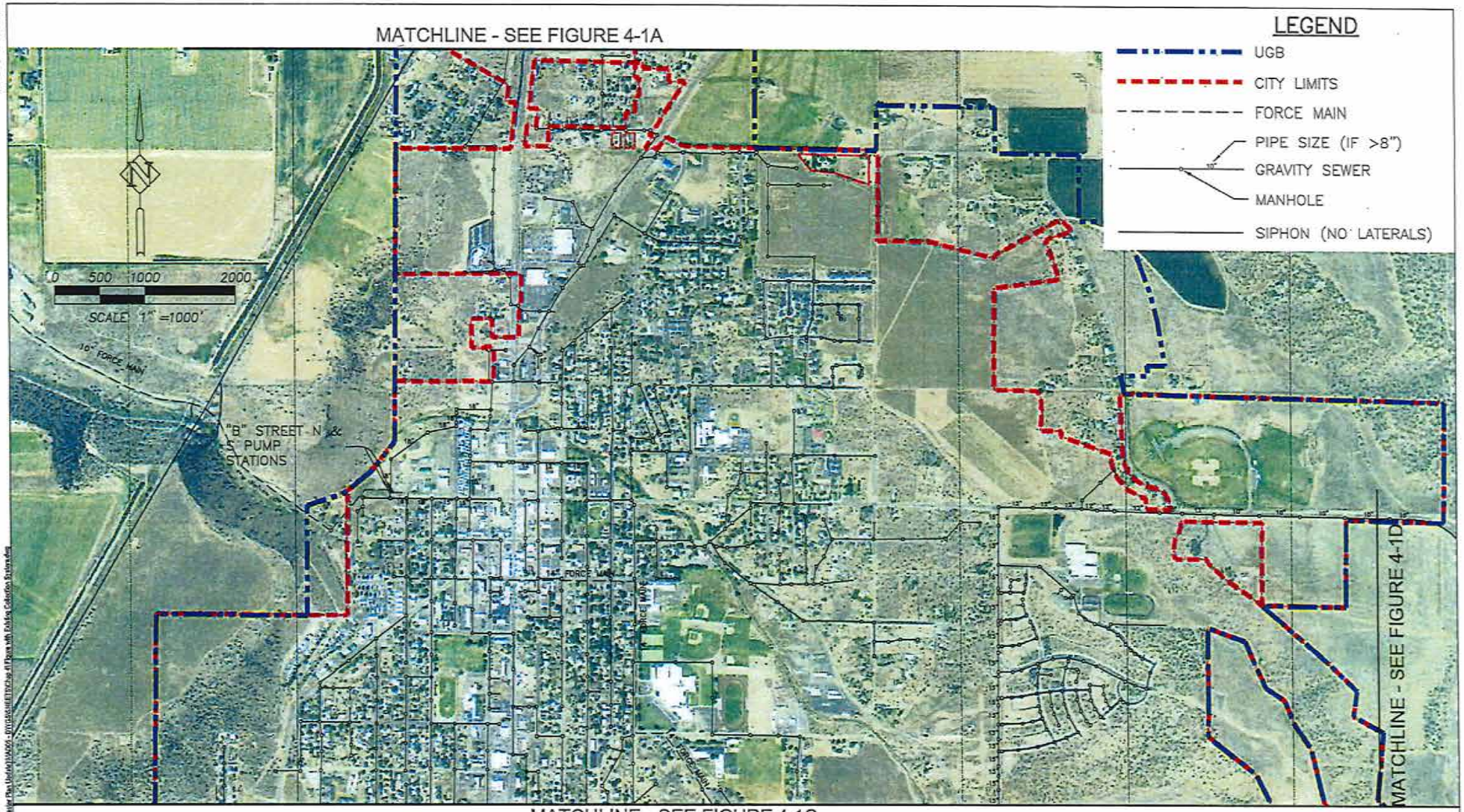
EXISTING WW COLLECTION SYSTEMS - NORTH AREA
WASTEWATER MASTER PLAN UPDATE
CITY OF MADRAS, OR

FIG 4-1A

MAD-05

NOV 2017

MATCHLINE - SEE FIGURE 4-1A



MATCHLINE - SEE FIGURE 4-1C

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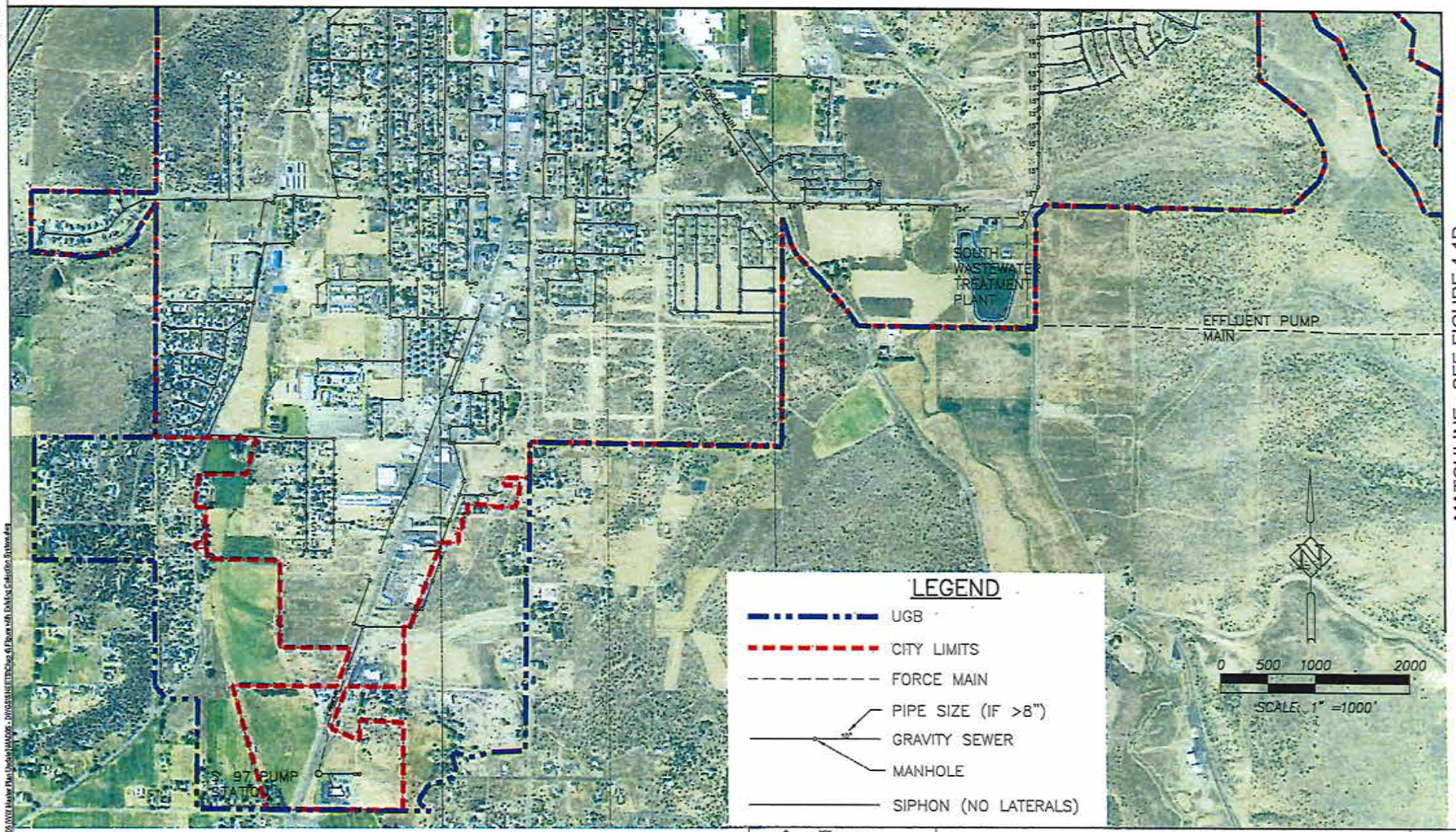
EXISTING WW COLLECTION SYSTEMS - CENTRAL AREA
WASTE WATER MASTER PLAN UPDATE
CITY OF MADRAS, OR

SHEET NO.
FIG 4-1B

JOB NO.
MAD-05

NOV 2017

MATCHLINE - SEE FIGURE 4-1B



MATCHLINE - SEE FIGURE 4-1D

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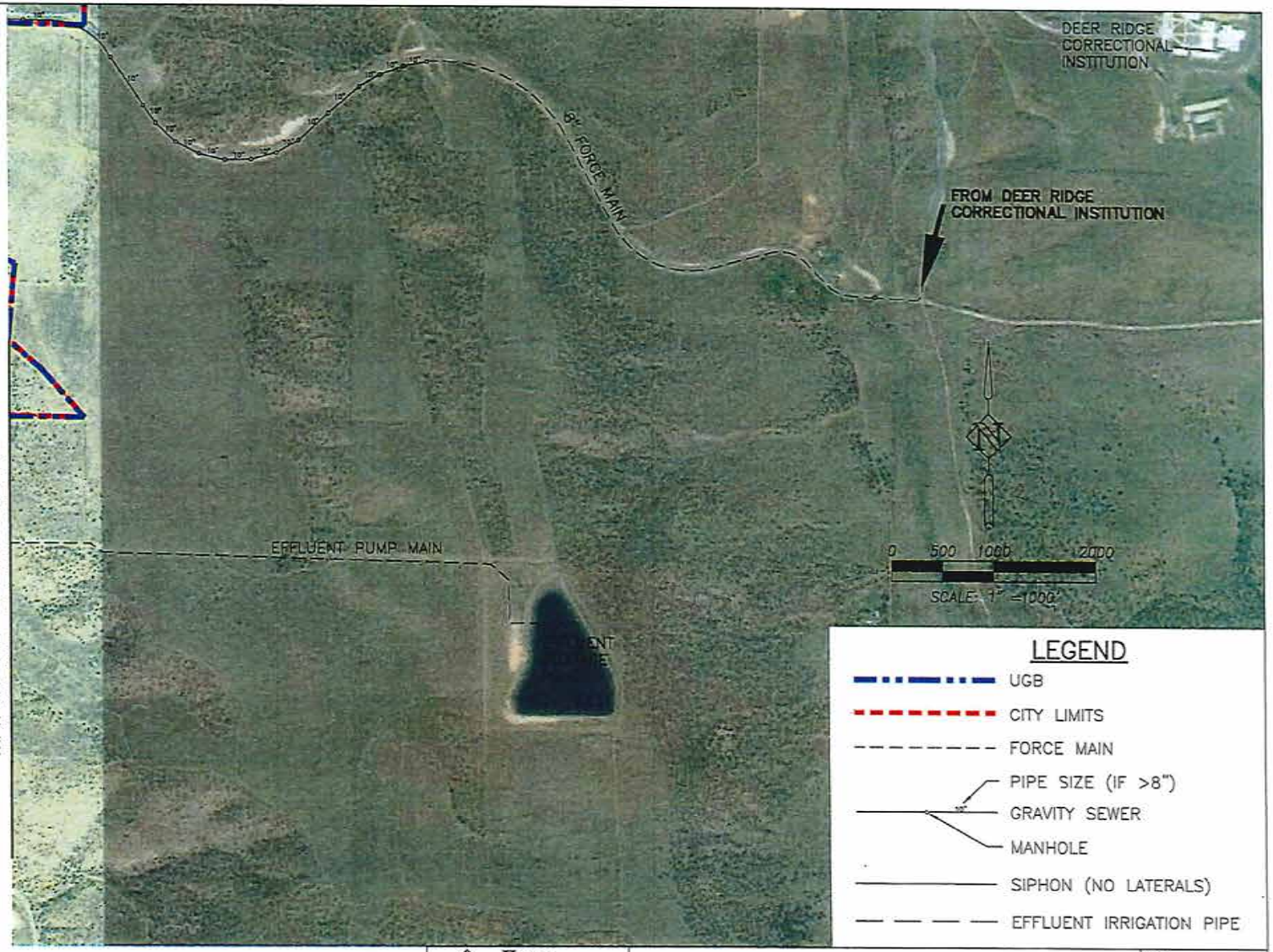
EXISTING WW COLLECTION SYSTEMS - SOUTH AREA
WASTE WATER MASTER PLAN UPDATE
CITY OF MADRAS, OR

FIG 4-1C

MAD-05

NOV 2017



MATCHLINE - SEE FIGURE 4-1C

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EXISTING WW COLLECTION SYSTEMS - EAST AREA
WASTE WATER MASTER PLAN UPDATE
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FIG 4-1D

MAD-05

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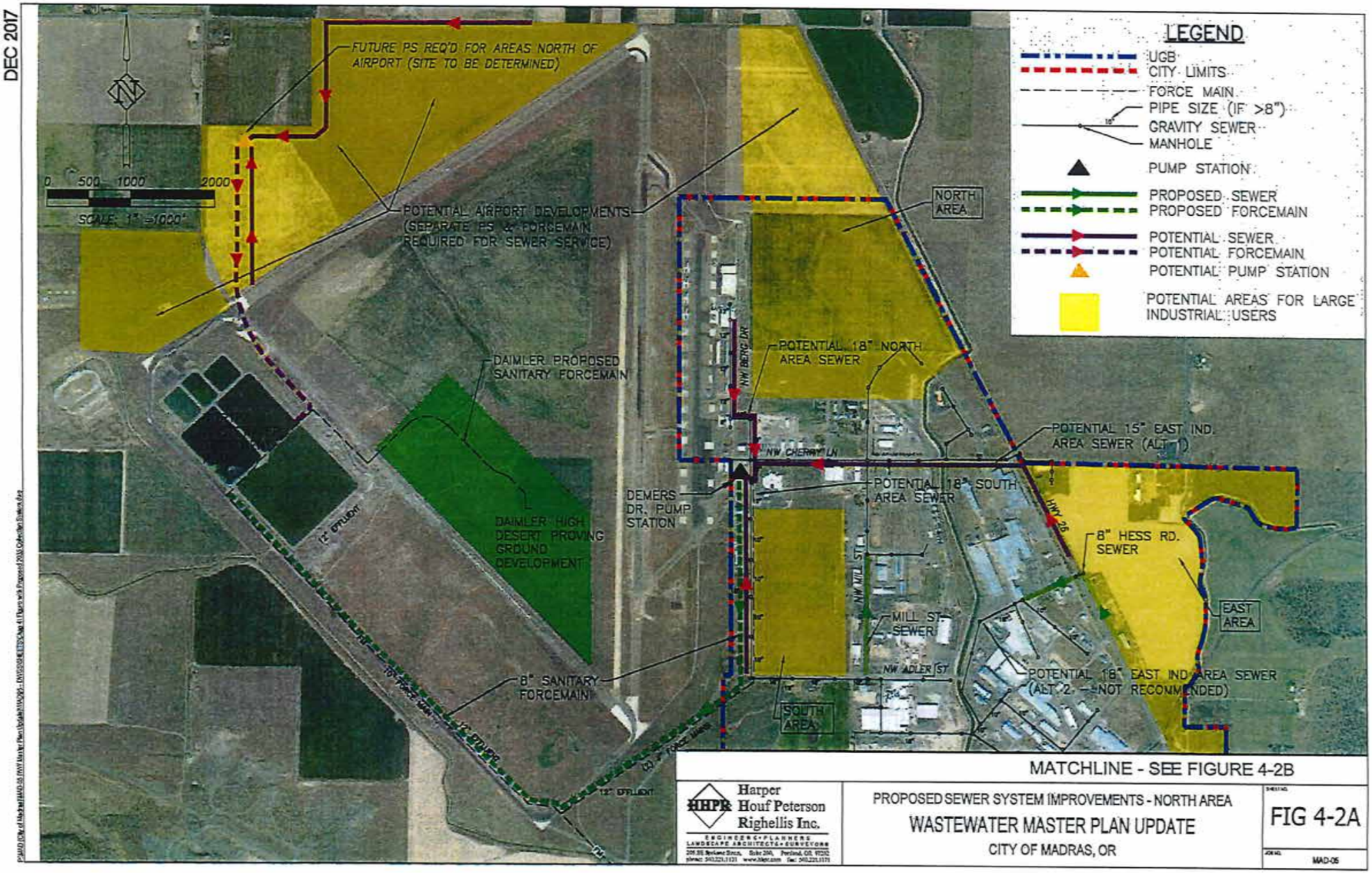

MATCHLINE - SEE FIGURE 4-2B

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PROPOSED SEWER SYSTEM IMPROVEMENTS - NORTH AREA

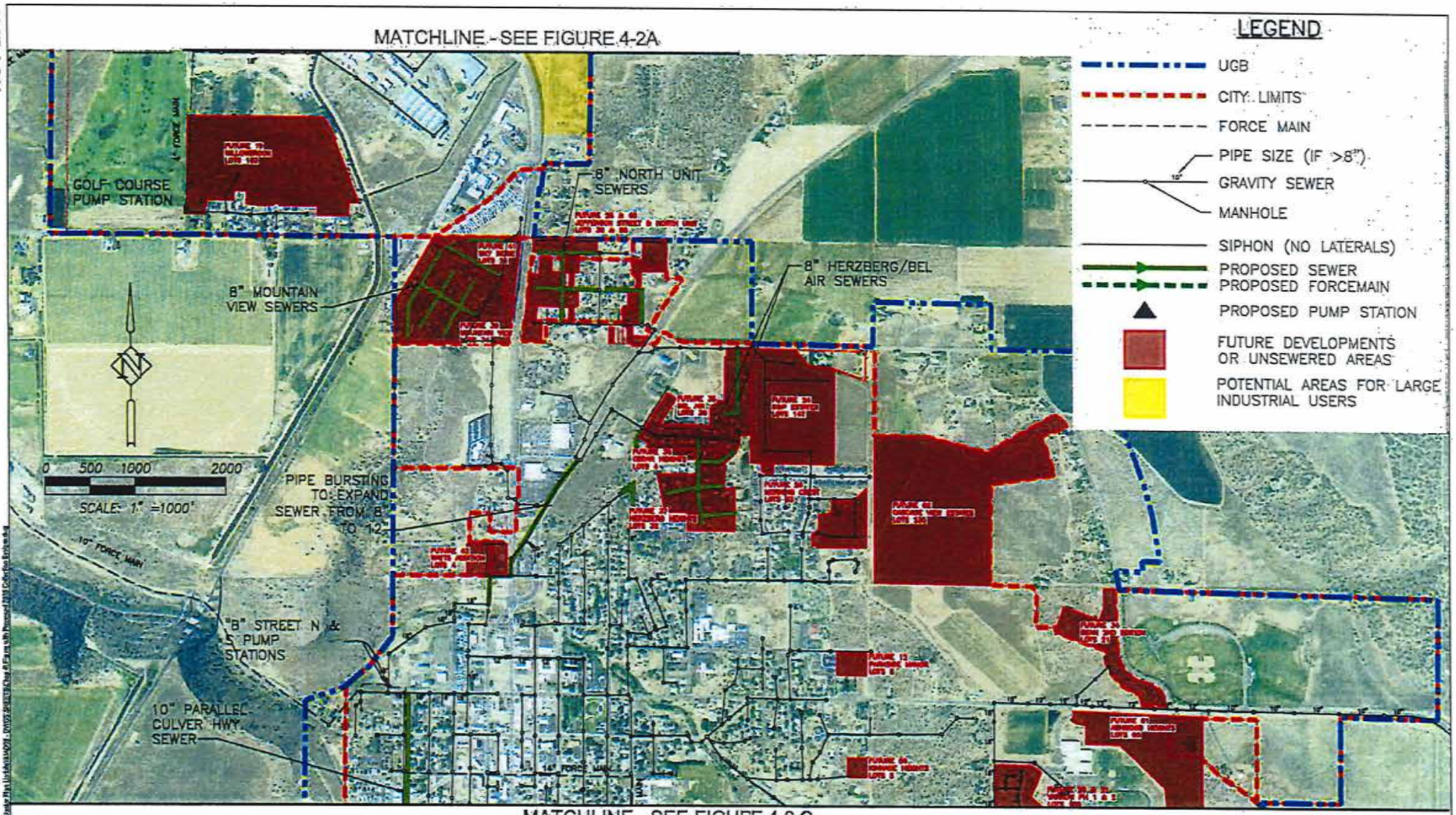
WASTEWATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

FIG 4-2A

MAD-05

NOV 2017



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PROPOSED SEWER SYSTEM IMPROVEMENTS - CENTRAL AREA
WASTEWATER MASTER PLAN UPDATE
CITY OF MADRAS, OR

FIG 4-2B

MAD-05

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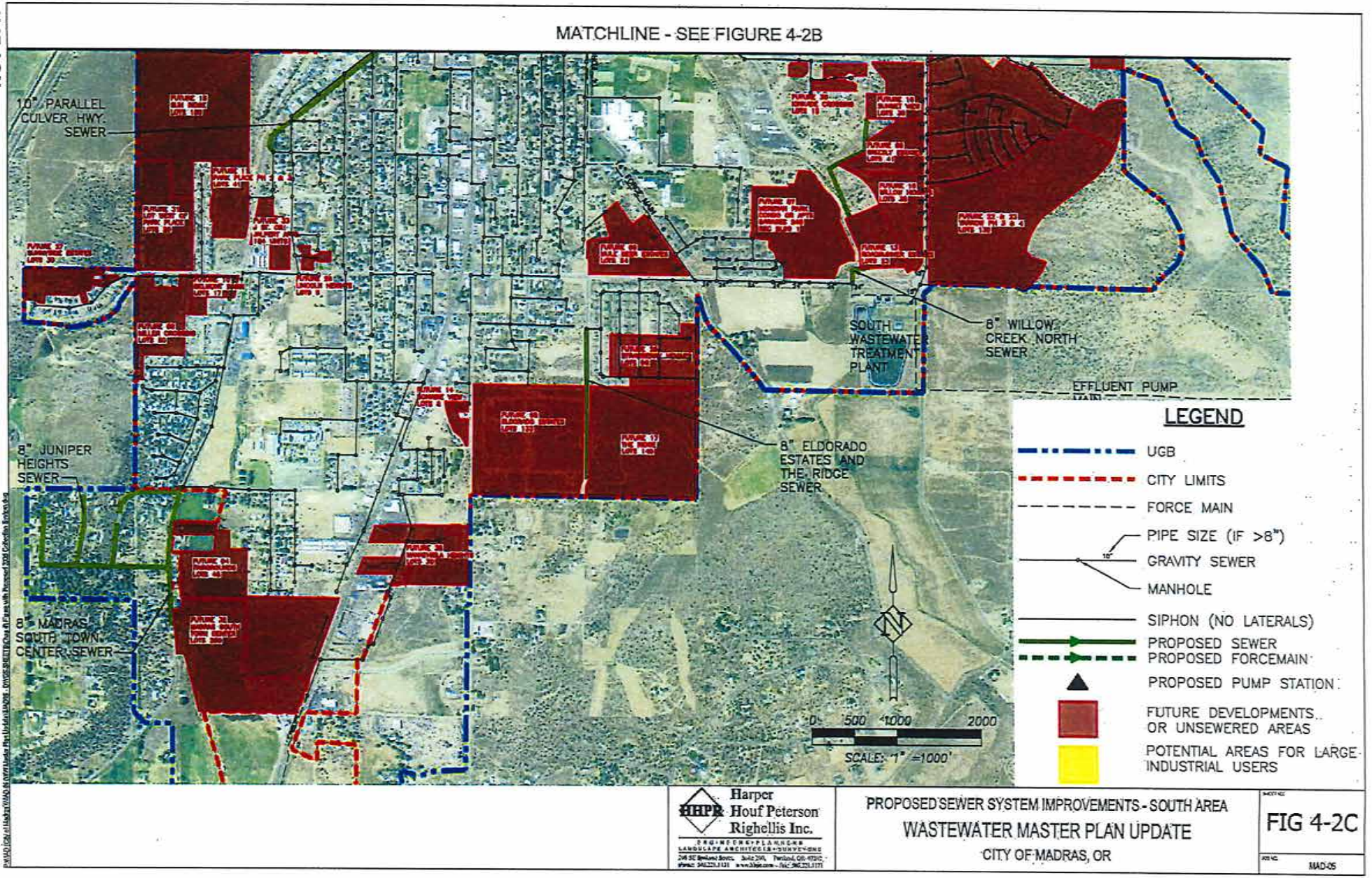

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PROPOSED SEWER SYSTEM IMPROVEMENTS - SOUTH AREA

WASTEWATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

FIG 4-2C

MAD-05

CHAPTER 5
TREATMENT ALTERNATIVES DEVELOPMENT AND SCREENING

5.1 INTRODUCTION

This chapter discusses wastewater (WW) treatment alternatives and identifies those alternatives that are recommended for further consideration. The main elements of this chapter are listed below.

1. Background Information – establishes the framework for developing treatment alternatives.
2. Basis of Alternatives Development – identifies the required Wastewater Treatment Plant (WWTP) capacity and treatment level.
3. Overall Treatment Scenarios – identifies and screens overall treatment scenarios based on projected service needs.
4. Treatment Process Alternatives – identify liquid-stream and solids-stream treatment process alternatives that have the potential to cost effectively meet the City's needs.
5. Identify alternatives screening criteria and present the results of the screening effort.

5.2 BACKGROUND FOR ALTERNATIVES DEVELOPMENT

5.2.1 Existing Liquid-Stream Treatment Facilities

NWWTP. A focus of this WWMP is to support industrial site readiness by evaluating alternatives for serving Industrial Park developments, including alternatives for upgrading and expanding the existing NWWTP. The facility offers the following key advantages.

- The lagoon system provides an inexpensive biological treatment process.
- The facility is located close to the existing Industrial Park as well as irrigable land for effluent recycling.

Other key considerations in developing alternatives for the NWWTP are described below.

- The NWWTP requires significant corrective work to keep the facility operating reliably for another 20 years and some of this work should be completed within 5 years.
- Land-use guidance from the Federal Aviation Administration (FAA) identifies WWTPs as potential wildlife attractants. This guidance recommends 10,000 feet of separation between wildlife attractants and airports serving turbine-powered planes. The NWWTP is well within this separation distance.

  Wildlife biologists from the U.S. Department of Agriculture (USDA) have conducted site visits to the NWWTP in the past on behalf of the FAA. Correspondence from the USDA has recommended the airport implement mitigation measures to remove wildlife hazards at the site.
- The shallow depth to underlying rock at the NWWTP site impacts the cost of excavations. To limit rock excavation, lagoons and basins must be shallow and/or built mostly above grade.

SWWTP. The 1996 WWMP established the cost effectiveness of the SWWTP to provide service for most of the City. The facility offers the following main advantages.

- The plant has significant useful service life remaining and should provide reliable service for 20 years with routine maintenance, scheduled replacements, and other planned corrective work.
- The facilities are designed to accommodate another expansion with common-wall construction.
- The site accommodates gravity flow from sewers in the east and southeast parts of the City.

The only disadvantage to keeping the SWWTP in operation is the relatively higher operations and maintenance (O&M) cost of a mechanical plant relative to a plant using a lagoon system such as the existing NWWTP. However, the offset to the higher O&M cost is that far less land is required for the mechanical plant than for a lagoon system.

5.2.2 WWTP Effluent Uses

Recycling. Chapter 1 outlines the regulations that govern effluent recycling and Chapter 2 briefly describes the City's current recycling practices. As described in Chapter 1, the Department of Environmental Quality (DEQ) generally encourages effluent recycling as a beneficial use. The DEQ considers the treated effluent as a resource because it supports water conservation and/or a reduction in fertilizer use.

The City began recycling treated effluent as irrigation water after the NWWTP was constructed and never obtained an operating permit for a surface-water discharge. The 1996 WWMP evaluated a discharge to Willow Creek as an alternative for a new WWTP. However, that report recommended effluent recycling through irrigation for the proposed SWWTP, as well as the continuation of this practice at the NWWTP.

Surface-Water Discharge. At the time we prepared the WWMP scope, a key assumption was that the City would continue effluent recycling throughout the planning period. Therefore, the WWMP scope only included an evaluation of treatment alternatives for effluent recycling and no detailed study was conducted of alternatives for other effluent disposal methods.

However, the cost of pond(s) to store effluent between growing seasons and the costs of irrigation systems for recycling provide an impetus to consider other options. DEQ's recent approval of a year-round discharge from constructed wetlands in the City of Prineville has also raised questions regarding the potential application of a similar approach in Madras.

Because of these cost considerations, we briefly examined the main issues relating to a surface-water discharge as part of this study. Our examination included a review of current WQS, consideration of discharge options, a brief analysis of WW treatment requirements, and initial communications with DEQ (see Appendix J). The following paragraphs summarize key issues our preliminary investigation identified regarding the pursuit of a permit for a surface-water discharge.

Regulation of Discharges. As described in Chapter 1, DEQ regulates surface water discharges in Oregon to maintain compliance with published water quality standards (WQS) for receiving water bodies. Since Willow Creek and the Deschutes River are the only potential receiving streams near Madras, the WQS that pertain to the Deschutes Basin would be used to regulate a discharge. Chapter 1 lists the key WQS governing treatment requirements for such a discharge.

Key Water Quality Considerations.

1. DEQ lists Willow Creek, Simtustus Lake and the lower Deschutes as water-quality impaired because they do not meet WQS for the following parameters.
   - Willow Creek is listed as being water quality impaired for water temperature.
   - The Deschutes River, above and below Pelton Dam is listed as being water quality impaired for dissolved oxygen and pH level.
   - Lake Simtustus is listed as water quality impaired for dissolved oxygen and chlorophyll-a (phytoplankton growth).

Because these water bodies are water-quality impaired, the DEQ must issue Total Maximum Daily Loads (TMDLs) for the parameters that do not meet WQS. The TMDLs would be used to determine discharge limitations from a permitted facility. To date DEQ has not yet published proposed TMDLs for the Deschutes Basin and there is no schedule for their development. Input from DEQ suggests issuing these TMDLs is not a priority.

2. In general, Lake Simtustus is characterized as eutrophic and nutrient loads (nitrogen and phosphorus) are a concern. Nitrogen in the form of nitrates is also a concern in the Willow Creek basin. These issues could impact permit limitations for nitrogen and phosphorus on any Willow Creek discharge.
3. Willow Creek commonly runs dry from July to December and stream flows can be very low during winter and spring.
    - The WQS include a criterion for dilution of organic material that effectively requires some background flow for the approval of a discharge. The dilution criterion requires the concentration of biochemical oxygen demand (BOD) in a discharge to be no greater than a dilution factor.
    - With no background flow present, the dilution factor becomes zero and the discharge of measurable BOD levels is effectively prohibited. Therefore, the absence of background flows in Willow Creek might serve as the basis for an outright denial of a discharge permit, at least for most of the year.
    - Even during winter, low flows are common in Willow Creek which means there would be very little mixing and dilution of any WWTP discharge. This lack of dilution would result in stricter discharge limitations and higher treatment costs.
4. The published WQS include an antidegradation policy (OAR 240-041-0004) that is intended to prevent the further degradation of water quality from new or increased pollution sources. This policy could be used as the basis for denying a discharge permit, unless the City could provide an analysis showing a discharge to Willow Creek would not degrade water quality. The City might need to request an exemption from the antidegradation WQS and submit the analysis as supporting data.

Discharge Options. Approved (permitted) discharges to a surface water body can be either seasonal or for the entire year and also either direct or indirect. These options are briefly described below.

1. Seasonal Discharge. Discharges from November 1 through March 31 are sometimes permitted in Oregon because stream flows are higher during these months and WQS are less stringent. Higher stream flows provide more dilution for the effluent and, when combined with less stringent WQS, this can result in less-costly treatment requirements. If Madras were issued a seasonal discharge permit, all effluent produced during spring, summer and part of autumn would need to be recycled. Also, some effluent storage may be required.
2. Year Round Discharge. A discharge all year typically requires a receiving stream that has flow all the time for mixing and dilution. Even with year-round flow, treatment requirements are commonly more stringent in summer due to lower stream flows. An indirect discharge may be regulated differently than a direct discharge, as discussed below.
3. Direct Willow Creek Discharge. A direct discharge to Willow Creek would be subject to strict WQS and might be denied. If permitted, a direct discharge would probably require advanced treatment that would increase costs relative to current treatment requirements.

4. Indirect Willow Creek Discharge
    - This approach involves releasing treated WW into intermediate facilities such as constructed wetlands. The effluent then seeps into the ground and enters a water body indirectly. The intermediate facilities are designed to provide additional treatment.
    - DEQ has stated that their guidance for indirect discharges is currently in flux. As a result, there is uncertainty as to the regulatory requirements for this type of discharge.
    - Due to the complexity of treatment mechanisms in wetlands, DEQ would probably require detailed analyses into the fate of pollutants through these pathways.
5. Outfall Pipeline for Direct Deschutes River Discharge
    - The relatively-high flows of the Deschutes River would provide good dilution and mixing for a direct discharge to that receiving stream. As a result, such a discharge may be more feasible in terms of treatment requirements for meeting WQS, particularly downstream of Pelton Dam.
    - A discharge to the Deschutes River from the NWWTP would require a gravity pipeline of more than 4 miles extending to Lake Simtustus or further south to the river just below the Pelton Dam. A discharge from the SWWTP to the Deschutes River would likely require effluent pumping across town, through a force main, and then gravity flow through a pipeline to Lake Simtustus or the river.
    - Construction of an outfall pipe to the river would face major technical, environmental, financial and political obstacles. A discharge to the Deschutes River would also probably not qualify as a beneficial use.

Summary of Options for Effluent Uses. Incentives for the City to continue effluent recycling are as follows:

- a successful track record with the practice;
- the local availability of irrigable farmland;
- the recommendations of the 1996 WWMP;
- a favorable regulatory climate; and
- less uncertainty regarding future rules affecting effluent recycling.

Regulations for effluent recycling are generally less strict and subject to fewer revisions than the regulations that govern surface-water discharges. Chapter 7 provides projections for the effluent storage capacity and farmland needed to continue recycling all effluent for the next 20 years.

The City may want to further investigate the feasibility of a discharge to Willow Creek and pursue a permit from the DEQ before undertaking any major WWTP upgrades or expansions. However, the City would face significant regulatory hurdles in pursuing a discharge permit. A direct discharge may not gain approval or be feasible due to water quality issues and technological constraints. The DEQ may not permit an indirect discharge for similar reasons or only permit an indirect discharge during the winter season, which means effluent recycling during the spring and summer would still be necessary.

The main benefit to a creek discharge in winter would be to reduce the amount of effluent storage capacity needed when recycling cannot occur. To evaluate the cost effectiveness of this approach, the City would need to compare the savings of reduced storage capacity to the added costs associated with more stringent treatment requirements.

Feasibility Study for Surface-Water Discharge. To investigate a surface-water discharge, the City would need to conduct a feasibility study that would generally include the following elements.

1. Perform an initial evaluation of the impacts that WQS and related issues would have on a discharge-permit application.
2. Develop concept-level discharge options and screen out options that do not appear feasible based on input from DEQ and site-specific factors.
3. Investigate the permit limitations that would be established for remaining discharge options and the resulting treatment requirements.
4. Consider the potential differences in permit limitations, treatment requirements for seasonal and year-round discharges.
5. Evaluate the potential benefits of an indirect discharge through constructed wetlands.
6. Identify the probable scope of the water quality modeling and study that would be required to address the fate of potential pollutants and show no adverse water quality impacts would result.
7. Provide concept-level estimates of probable costs for discharge options that appear feasible.

5.2.3 Biosolids Handling

The 1996 WWMP evaluated alternatives for biosolids handling and recommended the construction of aerobic digesters at the SWWTP and sludge drying beds at the NWWTP. Both these facilities were constructed and subsequently expanded. The aerobic digesters stabilize the waste activated sludge (WAS) produced in the sequencing batch reactor (SBR) process and the City then hauls the stabilized biosolids by tank truck to the drying beds. Solids removed in the dissolved air flotation (DAF) clarifier at the NWWTP are pumped to a sludge storage pond where the material dries during warm-weather months.

The City spreads the dried solids as Class B biosolids on City-owned farmland according to the City's Biosolids Management Plan. The aerobic digesters at the SWWTP are designed to accommodate future expansion along with the SBR process.

The existing digesters and drying beds have adequate capacity to handle the biosolids currently being produced and these facilities are generally in good condition. Continued operation of these facilities and land application of dried Class B biosolids should remain cost effective as long as the existing WWTPs remain in service and regulations do not change. However, the capacity of the drying beds is barely adequate to handle current volumes of biosolids being hauled from the SWWTP. Therefore, either the drying beds will need to be expanded to accommodate flow increases, or the water content of the biosolids will need to be reduced before hauling.

5.3 BASIS OF ALTERNATIVES DEVELOPMENT

5.3.1 Required Treatment Capacity

Table 5-1 (following page) lists the maximum-monthly, influent flow projections identified from the basis of planning presented in Chapter 3. This maximum-monthly flow is typically used to establish the total ADF capacity required for secondary WW treatment. The net available ADF capacity listed in Table 5-1 is the difference between the projected maximum-monthly flows and the existing combined ADF flow capacity of 1.04 MGD. Maximum-month flows are projected to reach existing WWTP capacity in 10 to 12 years. Table 5-1 also shows the projected peak-hourly flow used to establish the required overall WWTP hydraulic capacity. The peak-hourly flows are based on an estimated peaking factor of 2.67.

Table 5-1
Wastewater Treatment Capacity Requirements

Year	Projected Total Flows (MGD) [1]		Net Available ADF Capacity [2]
	Maximum Monthly	Peak Hourly	
2020	0.89	2.43	0.15
2025	1.03	2.75	0.01
2030	1.09	2.91	−0.05
2035	1.14	3.04	−0.10
2065 (build-out)	1.41	3.76	−0.37

(1) Flow projections assume full occupancy of the DRCI and nonresidential flows will increase in proportion with projected growth in residential flows.

(2) Based on the existing total ADF capacity of 1.04 MGD.

5.3.2 Required Treatment Level and Storage

Liquid Stream. As long as the City continues the practice of effluent recycling, the required treatment level depends on how the treated effluent is recycled. These minimum treatment requirements are established by the DEQ regulations for recycling and are divided into effluent Classes A through D (refer to Table 1-1). Current opportunities for irrigation readily accommodate recycling with Class B effluent and the additional treatment required to produce Class A effluent is not necessary. Therefore, this study evaluates treatment alternatives for continuing the practice of recycling Class B effluent.

Both WWTPs readily produce Class B effluent through the operation of a biological process, solids removal equipment and a disinfection system. This approach provides good effluent quality, which limits chlorine demand for disinfection and lowers the potential for fouling of irrigation components. Class B effluent also carries less-strict conditions of use for irrigation practices than Class C and Class D effluent.

As discussed in Subsection 5.2.2, there is uncertainty regarding the treatment requirements for a surface-water discharge and further study is required to address options for a discharge. Such a study is beyond the scope of this WWMP Update.

Effluent Storage. Water recycling for irrigation purposes in Madras can occur only during the growing season, usually from early-to-mid April until early-to-mid October. As a result, without a seasonal discharge to Willow Creek, effluent must be stored for 6 to 7 months annually. The effluent storage capacity needed for each 0.5-MGD of treatment capacity would require a gross area of about 30 acres, assuming one pond with a water depth of 10 feet when full. Chapter 7 provides further information on the requirements for effluent storage.

The alternatives developed herein would all require effectively the same effluent storage capacity to address this seasonal limitation for recycling. Therefore, each alternative would include the same space requirements and costs for effluent storage capacity. Since effluent storage costs are equal for all alternatives, they are not included in the cost comparison.

Solids Handling. Given the local availability of farmland and the conditions of existing biosolids handling facilities, the continued practice of land applying Class B biosolids is the best option at this time. Therefore, biosolids handling alternatives were developed based on current treatment requirements to produce Class B biosolids.

The FAA would need to agree that expansions to the sludge drying beds would be compatible with airport operations and mitigation measures would likely be required to deter wildlife attraction.

5.3.3 *Summary of Projected Treatment Requirements*

Table 5-2 summarizes the influent WW characteristics that the WWTPs must be designed to treat to meet the projected 20-year needs. These characteristics were used to develop preliminary process sizing for the alternatives evaluation.

Table 5-2
Influent Wastewater Characteristics

WW Parameter	Value	
A. Flow Rates (1)		
Average Daily Flow	0.99	MGD
Maximum Monthly Flow	1.14	MGD
Peak Hourly Flow	3.04	MGD
B. Average BOD_5 & TSS Concentrations		
Municipal Flows (to SWWTP)	250	mg/L
DRCI Flows (to SWWTP)	750	mg/L
Combined Industrial & Municipal Flows to NWWTP	300	mg/L
C. Influent Temperature		
Average Winter Design	10	deg. C

(1) Includes 0.23 MGD design flow from DRCI

5.4 OVERALL TREATMENT SCENARIOS

5.4.1 *General Descriptions*

Technically-feasible WW treatment scenarios the City could potentially implement over the next 20 years are summarized in Table 5-3 and evaluated in the following paragraphs.

Table 5-3
General Treatment Scenarios

Scenario One:	No WWTP expansions. Renovate, maintain and operate both WWTPs to provide the current 1.04 MGD capacity for the planning period.
Scenario Two:	Abandon both existing plants. Construct one or two new plants to treat all flows at an existing site or alternate sites.
Scenario Three:	Abandon one WWTP. Expand the other to treat all flows.
Scenario Four:	Maintain one WWTP at its current capacity and provide the necessary repairs. Replace or expand the other WWTP to treat the remaining flows.
Scenario Five:	Implement modifications to both WWTPs to expand the capacity of each.

5.4.2 Evaluation and Initial Screening of Scenarios

Scenario One – No-Expansion. According to projections, the City will begin to experience a small, capacity shortfall in about 10 years. Since the City must plan to treat all projected WW flows, the only way to avoid planning for a capacity expansion would be to implement water conservation measures and/or reduce I/I rates.

Current estimates of per capita WW production indicate there is little potential for water-use reductions through conservation. Similarly, influent flow records show I/I rates are not significant. As a result, the City should plan for a treatment capacity expansion to meet projected needs and no further evaluation of this scenario is warranted.

Scenarios Two and Three – Abandonment of One WWTP or Both WWTPs. No scenarios that involve abandoning one or both of the WWTPs have been evaluated for this study due to the following considerations.

- **NWWTP.** It is important for the City to plan for increased WW flows from Industrial-Park developments as part of maintaining industrial site readiness. Because of this factor, maintaining a WWTP near the Industrial Park provides a key benefit.

  Service needs can vary widely for industrial users and planning efforts for site readiness need to incorporate flexibility by accommodating phased expansions. Since the existing NWWTP is located near the Industrial Park, this site reduces the technical complexities and costs of implementing a phased plan. Therefore, this study has only evaluated alternatives that continue providing treatment at the NWWTP site.

- **SWWTP.** The SWWTP is in fair-to-good condition and is strategically located to serve projected growth in the east and southeast parts of the City. As a result, all alternatives developed for this study include maintaining this plant in service for the next 20 years.

Scenarios Four and Five – Expand Either or Both WWTPs. Expansions to either or both plants are technically feasible and potentially cost effective. Therefore, we have developed alternatives incorporating these scenarios. Key factors in developing the treatment alternatives include:

- the small size of the projected capacity shortfall;
- the need for the SWWTP to treat all gravity flows entering the plant from the east and southeast parts of the City, including the DRCI;
- the need for near-term renovations at the existing NWWTP to maintain current capacity;
- the amount of land needed for seasonal effluent storage and effluent recycling by irrigation;
- the importance of addressing Industrial Park site readiness; and
- impacts on the "B" Street pump stations.

All scenarios we evaluated include an expansion of the SWWTP because of the flexibility this would provide. Expanding the SWWTP capacity would free up capacity at the NWWTP to treat flows from North-Area developments and also offer greater flexibility for providing service to the entire Main Collection System, including gravity service to east-side developments.

5.4.3 *Summary of Overall Scenario Screening Results*

The remaining overall scenarios used to develop treatment alternatives selected for further evaluation are described in Table 5-4. The two scenarios maintain both WWTPs in service and allow for future expansions to the NWWTP as needed to serve developments in the North Area.

Table 5-4
Remaining Overall Treatment Scenarios

Option A – Expand SWWTP to Treat Projected Flows; Dedicate NWWTP to Serve North Area
1. Phased improvements to the SWWTP (see Figure 5-1). • Phase 1. Modify the plant to provide a small increase in capacity to 0.65-MGD and renovate the existing facilities as needed to maintain reliable service. • Phase 2. If necessary, construct the additional 0.5-MGD treatment module for which the SWWTP is designed to provide a total 1.14-MGD ADF capacity. This second phase would free up capacity at the NWWTP to serve industrial developments. 2. Renovate, retrofit, or replace the existing NWWTP to maintain the 0.5-MGD capacity. After SWWTP expansions, the NWWTP would be dedicated to serving the North Area and would be expanded as necessary to serve Industrial Park developments.
Option B – Expand SWWTP; Use Both WWTPs to Treat Projected 20-Year Flows
1. Construct the additional 0.5-MGD treatment module for which the SWWTP is designed to provide a 1.04-MGD ADF capacity at that plant. 2. Renovate/retrofit/replace the NWWTP to maintain the 0.5-MGD capacity. Operate the plant to treat projected WW flows above the SWWTP capacity and additional flows from the North Area (expand the plant as needed to serve Industrial Park developments).

We propose Option A as the primary option because the Phase 1 SWWTP expansion would provide an overall treatment capacity that meets the 20-year flow projections. Under current projections, the Phase 2 SWWTP expansion would free-up the entire capacity of the NWWTP to serve the North Area. This second expansion would only be recommended if additional capacity is needed above current projections and expansions to the NWWTP are heavily constrained by the need to mitigate impacts on the airport. Otherwise, Phase 2 for the SWWTP would not be justified.

Option B would be a fallback plan if development accelerates above the forecast growth rate. The smaller Phase 1 SWWTP expansion would not make sense under such conditions.

5.4.4 *Improvements to Existing NWWTP*

An upgrade of the NWWTP is part of the overall treatment scenario because improvements must be made within the planning period to maintain reliable service. The plant could be renovated to keep existing treatment processes in service, retrofitted to modify existing treatment processes, or replaced with a new facility.

Potential approaches for upgrading the existing NWWTP lagoon system are summarized in the following paragraphs. Upgrades and/or replacements of the clarification and disinfection systems would be part of each upgrade described below.

1. **Full Renovation.** Renovate the existing lagoons to maintain the current capacity in the existing footprint. A future expansion would require the construction of a treatment module and an effluent storage pond on adjacent land.
2. **Partial Renovation.** Renovate half the lagoon system to provide a 0.25-MGD and construct adjacent treatment facilities to maintain or expand current capacity. The other half of the lagoon system could be replaced with an effluent storage pond as part of a future expansion.
3. **Retrofit to Maintain Capacity and Reduce Footprint.** Retrofit half the existing lagoon system with a new, higher-rate lagoon system to maintain a 0.5-MGD capacity within half the existing lagoon footprint. The other half of the existing lagoons could then be replaced with a second-phase lagoon retrofit or an effluent storage pond as part of a future expansion.
4. **Complete Replacement.** The City could construct a new 0.5-MGD WWTP adjacent to the existing facility and abandon all existing components. When an expansion of the replacement plant is needed, the existing lagoon footprint could then be converted to effluent storage.

Chapter 6 evaluates each of these alternative approaches to upgrading the NWWTP in coordination with alternatives for future expansions intended to provide industrial site readiness. This coordinated evaluation also considers potential impacts the alternative NWWTP upgrades and expansions might have on the airport and adjacent farmland used for effluent recycling.

Modifications to the NWWTP must address FAA constraints on the siting of wildlife attractants near airports. Plans for any modifications would need to be submitted to FAA for review and, if costly mitigation measures are mandated, the City may need to investigate alternative sites.

5.5 ALTERNATIVE TREATMENT PROCESSES

5.5.1 General

A review of treatment processes was conducted to identify technically-feasible alternatives that should be considered in the evaluation of improvements to the NWWTP. This review identified alternative liquid-stream and solids-stream processes as a first step in determining the most cost-effective approach to upgrading and expanding the plant.

Our review effort considered the guiding principles described in Table 5-5. The technologies selected for evaluation have generally been found to be suitable for the plant size and treatment level required in Madras.

Table 5-5
Principles Used for Identifying Suitable Treatment Processes

Regulations:	The processes produce Class B effluent for water recycling and Class B biosolids for land application.
Affordability:	The process costs (capital, operating and maintenance) have the potential to be within the City's financial reach.
Operability:	The process complexity and O&M requirements are appropriate for locally-available labor and support.
Reliability:	The process uses technology proven to be reliable.
Compatibility:	The process is compatible with local conditions and constraints.

5.5.2 *Liquid-Stream Treatment*

The following paragraphs describe the main treatment categories commonly provided at WWTPs and Table 5-6 lists by category the liquid-stream processes we included in the screening effort.

1. **Preliminary Treatment.** Preliminary treatment is provided at the headworks of a WWTP to screen out coarse materials and settle out grit particles. The City should plan to provide screening and grit removal processes upstream of all secondary treatment alternatives to protect the downstream equipment from damage and prevent grit accumulation in tanks or lagoons.

2. **Primary Treatment.** Primary clarifiers are used to reduce the size and cost of the downstream secondary treatment process. But for smaller plants the incremental cost of constructing and operating primary clarifiers is generally more than the potential savings in the secondary process. Therefore, primary clarifiers were not evaluated for this study.

3. **Secondary Treatment.** Secondary treatment consists of a biological process that oxidizes and stabilizes the WW. This level of treatment is required to produce Class B effluent for recycling. Biological processes promote the growth of microorganisms that consume organic matter and, as a byproduct, generate biosolids. These processes require some type of solids separation as part of the overall process to clarify secondary effluent prior to further treatment.

4. **Advanced Treatment.** Advanced treatment processes are provided for further removal of suspended solids, nitrogen and phosphorus to meet strict treatment requirements. Common advanced treatment processes include filtration, polishing lagoons, and constructed wetlands. Since the City does not currently need to meet such strict requirements, our evaluation does not address advanced treatment. The City could add advanced treatment should future conditions warrant. The WWTP layouts we developed allot space for the addition of filters, if necessary.

5. **Disinfection.** Disinfection destroys or inactivates a high proportion of the microorganisms present in the treated WW, particularly pathogens (disease-causing organisms). The disinfection requirements for Class B effluent are established by limitations on total-coliform levels published in the DEQ regulations for water recycling (see Table 1-1).

Table 5-6
Liquid-Stream Treatment Alternatives Included in Screening Effort

Preliminary Treatment (1)	Secondary Treatment (2)	Disinfection
1. Influent Screening • Manually-cleaned bar racks • Mechanically-Cleaned screens 2. Grit Removal • Vortex Grit Chamber • Aerated Grit Chambers • Horizontal Grit Channels	1. Lagoons Systems • Facultative • Partially-Aerated/ Facultative • Aerated/Partially-Mixed 2. Extended Aeration • Earthen Basins • Oxidation Ditch • Compact Configuration • SBR Process	1. Sodium Hypochlorite Bulk Storage & Feed (3) 2. Tablet Chlorinator (3) 3. Ultraviolet Light w/Low-Pressure Lamps 4. Onsite Hypochlorite Generation and Feed (3) 5. Onsite Chlorine Dioxide Generation and Feed (3)

(1) New NWWTP screening and grit removal included for all secondary treatment alternatives.
(2) Clarification included with all biological treatment alternatives for solids removal.
(3) Requires chlorine contact tank.

Appendix K provides brief descriptions and summarizes key advantages and disadvantages of the liquid-stream alternatives we screened. Appendix K also identifies other liquid-stream processes we reviewed but discarded prior to screening because they are not suitable for this application.

5.5.3 Biosolids Handling

The following paragraphs describe the main categories of biosolids handling processes considered for this study.

1. **Stabilization.** Biosolids from a biological process must be stabilized to meet current requirements for Class B land application. Therefore, a stabilization process must be included with each secondary treatment alternative that produces waste activated sludge not already stabilized in a lagoon system. The existing aerobic digesters at the SWWTP will be maintained in service and expanded along with that plant's future 0.5-MGD expansion.

2. **Thickening.** Thickening equipment separates water from biosolids to reduce the volume that must be processed and, therefore, reduce the size and cost of other biosolids processes. A thickener can produce biosolids with 5.0% solids content by weight and would reduce the volume of biosolids that must be hauled from the SWWTP and emptied onto the drying beds at the NWWTP.

   The City has space in an existing storage building on the SWWTP site to house the thickening equipment for freeze protection. Therefore, the key issue is whether the life-cycle costs associated with thickening equipment would be offset by savings in hauling costs and capital costs for drying bed expansions.

   Similar savings would not be available at the NWWTP because liquid biosolids can be pumped directly to the drying beds and a new building would be needed to house the equipment. Additionally, if a lagoon system is recommended as the secondary process for NWWTP expansions, biosolids production would be lower than at the SWWTP. Therefore, it is less likely adding a mechanical thickener as part of NWWTP expansions would be cost effective.

3. **Dewatering.** Dewatering biosolids would be another alternative to either continuing the practice of hauling dilute biosolids or adding only a thickener. A dewatering process further reduces the volume of material that must be handled and produces a cake that is handled as a solid. Dewatered biosolids help mitigate potential vector and wildlife-attraction issues associated with handling and land applying liquid biosolids.

   Dewatering equipment could be installed at the SWWTP to further reduce the volume of biosolids that must be hauled and emptied onto the drying beds. The drying beds would still be necessary to remove additional moisture for land application and to store biosolids when fields are not accessible.

   It is unlikely dewatering equipment would be cost effective as part of NWWTP expansions for the same reasons described above for a thickener. Liquid biosolids can be pumped directly to the drying beds and a new building would be needed to house the equipment.

4. **Drying.** The existing drying beds at the NWWTP are in good condition, and have proven effective. As a result, there is no need to consider their abandonment. However, the drying beds are currently used to capacity when the winter is colder and wetter than average. Therefore, drying bed expansions must be addressed in the evaluations of biosolids handling alternatives. Space is available for drying-bed expansions at the NWWTP site.

The drying beds serve a dual purpose. In addition to drying the solids to facilitate spreading on farmland, they store the solids when fields are not accessible. It is this latter purpose that impacts the relative cost effectiveness of thickening and dewatering processes. Less water in the biosolids hauled to the beds results in the need for less storage volume during the winter.

We screened out the construction of drying beds at the SWWTP due to concerns over land use compatibility. The City prefers not to locate open-air drying beds at the SWWTP because of potential adverse impacts on residential developments planned for the immediate vicinity.

Table 5-7 lists by category the biosolids handling processes identified as suitable alternatives for evaluation in this study.

Table 5-7
Summary of Solids-Stream Process Alternatives

Biosolids Stabilization	Thickening Process	Dewatering Process	Drying Process
1. Aerobic Digestion 2. Sludge Lagoon 3. Composting 4. Lime Stabilization	Mechanical thickener	Mechanical Screw Press	Sludge Drying Beds

Appendix K provides brief descriptions and summarizes key advantages and disadvantages of the solids-stream alternatives we screened. Appendix K also identifies other solids-stream processes we reviewed but discarded prior to screening because they are not suitable for this application. Evaluation of specific thickening or dewatering equipment can be performed early in design, if such equipment is recommended as part of a WWTP improvements project. (see Chapter 6).

5.6 SCREENING OF ALTERNATIVE PROCESSES

5.6.1 Criteria for Alternatives Screening

Initial screening of each alternative listed in Tables 5-6 and 5-7 was performed by evaluating and comparing the processes with regard to the criteria summarized in Table 5-8. These criteria were used to eliminate processes that do not fit this application well based on key management and site-specific considerations. The remaining alternatives were evaluated using more specific criteria as part of the cost-effectiveness analysis described in Chapter 6.

Table 5-8
Summary of Alternatives Screening Criteria

O&M Considerations:	Operational complexity and equipment O&M requirements affecting long-term maintenance management.
Treatment Reliability:	Effluent quality produced and consistency of effluent quality.
Safety Considerations:	Potential hazards to staff and public.
Siting Constraints:	System is compatible with local land uses and has potential for fitting within framework of existing WW facilities.

5.6.2 Alternatives Screening

Preliminary Treatment Alternatives. Based on initial screening, all alternatives for the NWWTP will include a headworks structure with a mechanically-cleaned screen and low-energy, vortex grit chamber. Manually-cleaned screens (bar racks) were eliminated from further evaluation as the primary method of screening due to poor treatment reliability and safety issues.

Grit removal processes other than low-energy vortex chambers were eliminated due to site compatibility issues, lower reliability, and/or O&M concerns. The 0.5-MGD expansion to the SWWTP would include the addition of a second low-energy vortex grit chamber matching the capacity of the existing chamber. The existing influent screen at the SWWTP has adequate capacity for the potential expansions.

Secondary Treatment Alternatives. Aerated lagoons have the potential of being a cost effective alternative for expansions. But facultative lagoons and partially-aerated/facultative lagoons were eliminated as alternatives for NWWTP expansions due to land requirements and potential compatibility issues with the airport.

Renovation of the existing partially-aerated/facultative lagoon system is an option that would be cost effective only if there is no acceleration in North-Area developments. Otherwise, it would be more appropriate to retrofit the existing NWWTP with a more intensive, aerated lagoon system.

The extended aeration processes using concrete tanks (oxidation ditch, compact configuration, and SBR) are suitable for the area adjacent to the NWWTP site. But an extended aeration system using lined, earthen aeration basins was eliminated as an alternative for NWWTP expansion due to site compatibility issues relating to the shallow depth to underlying basalt.

Disinfection Alternatives. The screening effort concluded that bulk storage and feed of sodium hypochlorite, onsite sodium hypochlorite generation, and tablet chlorination (calcium hypochlorite) equipment are potentially cost effective alternatives. Ultraviolet (UV) light and onsite chlorine dioxide (ClO2) generation were eliminated as alternatives for NWWTP expansions due to O&M considerations.

Biosolids Handling Alternatives. Alternative processes for biosolids stabilization must be evaluated in conjunction with options for expanding the NWWTP. The screening effort eliminated stabilization processes other than aerobic digesters because of site compatibility issues. Expansions to the SWWTP would include improvements or expansions to the existing aerobic digesters.

We evaluated thickening and dewatering processes for the SWWTP to reduce the biosolids volume that must be hauled and emptied onto drying beds. The evaluation included the following three alternatives:

1. The continued practice of hauling dilute, liquid biosolids from the SWWTP to the sludge drying beds at the NWWTP and the expansion of the drying beds.
2. The addition of only thickening equipment to reduce biosolids volume for liquid hauling and drying combined with a smaller expansion of the drying beds relative to the first alternative.
3. The addition of dewatering equipment to further reduce biosolids volume and hauling as solid material a dump truck.

Evaluations of thickening and dewatering equipment at the NWWTP as biosolids handling alternatives are not warranted at this time for the reasons discussed above in Subsections 5.2.3 and 5.5.3. The costs and maintenance requirements associated with these processes would not be justified.

If space constraints in the future limit opportunities for drying bed expansions, the City can revisit the potential cost effectiveness of thickening or dewatering equipment at the NWWTP.

5.6.3 Summary of Screening Results

Table 5-9 lists the treatment processes that have been identified through the initial screening as potentially cost-effective alternatives for upgrades and expansions to the NWWTP. Appendix K provides additional descriptions of the screening results. Chapter 6 describes the cost-effectiveness analysis we performed to evaluate the remaining alternatives.

Table 5-9
NWWTP Expansions – Alternatives Recommended for Further Evaluation

1. Preliminary Treatment at Headworks: Mechanically-Cleaned Screen and Low-Energy, Vortex Grit Chamber
2. Secondary Treatment a. Renovation of existing Partially-Aerated, Facultative Lagoon System (no stabilization) b. Aerated/Partially Mixed Lagoon System – retrofit and expansion (no stabilization) c. Oxidation Ditch Extended Aeration d. Compact Extended Aeration Process Configuration e. SBR Extended Aeration
3. Disinfection a. Sodium Hypochlorite Bulk Storage and Feed b. Onsite Sodium Hypochlorite Generation and Feed c. Tablet Chlorination (Calcium Hypochlorite) Equipment
4. Biosolids Stabilization: Aerobic Digestion
5. Biosolids Dewatering/Drying: Sludge Drying Beds

Alternatives for expanding the SWWTP involve expansions or modifications to the existing treatment processes, plus the potential addition of biosolids thickening or dewatering equipment.

5.7 PROPOSED OVERALL SCENARIO FOR TREATMENT IMPROVEMENTS

Table 5-10 (following page) summarizes the overall improvements and potential process alternatives that could be incorporated into the proposed WWTP scenario identified in Table 5-4 (Option A).

Table 5-10
Summary of Improvements and Alternatives for WWTP Scenario

A. SWWTP Expansion, Phase 1 – Retrofit and upgrade SWWTP to increase capacity from 0.54 MGD to 0.65 MGD (Projected Timing – Complete within 10 years).

- Increase pumping capacity at "B" St. South PS and Influent PS.
- Renovate existing headworks (replace/repair preliminary treatment equipment).
- Upgrade the SBR aeration system and other SBR components to expand capacity.
- Convert lower pond to effluent storage pond.
- If determined to be cost effective, add a mechanical thickening process or a mechanical dewatering process.
- Expand sludge drying beds at NWWTP to handle biosolids from SWWTP (size of expansion depends on biosolids handling alternative selected for SWWTP.
- Replace other components as necessary to increase capacity or address deficiencies.

B. Phased NWWTP renovation, retrofit, or replacement (Complete within 15 years).

- Construct headworks with mechanical screening and grit removal.
- Renovate existing lagoons; retrofit the lagoons with aerated lagoon system; or replace the lagoon system with a new secondary treatment process (see Table 5-9 for alternatives).
- Replace DAF clarifier, disinfection system, pumps, and other components, as necessary.

C. SWWTP Expansion, Phase 2 – Construct additional 0.50-MGD treatment module. (1)

- Add pumping capacity at "B" St. South PS and Influent PS.
- Expand headworks to provide sufficient grit removal capacity.
- Construct a third SBR aeration system with all internal components.
- Construct a second post-equalization tank.
- Construct additional effluent storage pond to expand storage capacity.
- Expand aerobic digester capacity.
- If determined to be cost effective, expand the mechanical thickening process or dewatering process.
- Expand sludge drying beds at NWWTP.

D. NWWTP Expansion(s) – Future phases to serve Industrial-Park developments. (2)

- Expand influent screening and grit removal processes at headworks.
- Construct selected secondary treatment process w/clarifier (see Table 5-9 for alternatives).
- Provide selected disinfection process (see Table 5-9 for alternatives).
- Expand effluent storage capacity.
- Provide selected biosolids stabilization process (see Table 5-9 for alternatives).
- Expand sludge drying beds.

(1) Phase 2 SWWTP expansion would be required when total City-wide flows reach the 20-year (2035) projected flow of 1.14 MGD, if the NWWTP capacity must be dedicated to serving the Industrial Park.

(2) Timing of NWWTP expansions would be driven by Industrial-Park developments and any NWWTP expansion would be contingent on acceptance from the FAA.

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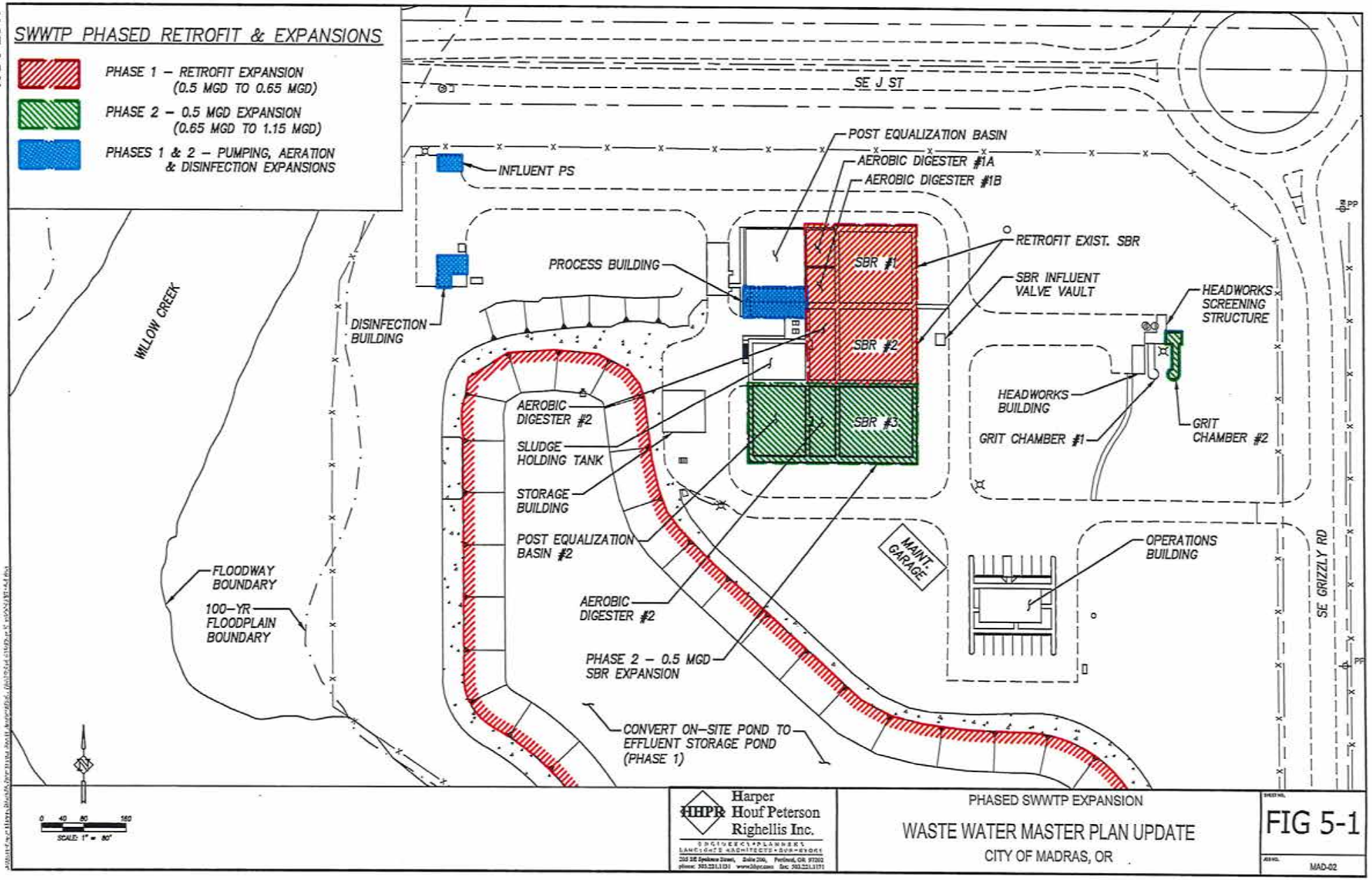

Harper Houf Peterson Righellis Inc.

PHASED SWWTP EXPANSION

WASTE WATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

FIG 5-1

MAD-02

CHAPTER 6
TREATMENT ALTERNATIVES EVALUATION

6.1 OVERVIEW OF ALTERNATIVES EVALUATION

6.1.1 General

This chapter presents the results of the multi-attribute, cost-effectiveness analysis we used to identify a recommended plan for wastewater (WW) treatment over the next 20 years. For the North Wastewater Treatment Plant (NWWTP), we completed a two-stage evaluation of alternatives to address condition issues and industrial site readiness. First, we evaluated alternative processes that remained after the screening effort (Chapter 5) to identify a recommended set of processes for NWWTP expansions. Then we evaluated alternatives for renovating, retrofitting or replacing the NWWTP in coordination with future expansions.

A separate alternatives evaluation was also performed for the South Wastewater Treatment Plant (SWWTP) to determine whether biosolids thickening or dewatering facilities could be cost effective additions.

6.1.2 Criteria for Evaluating Alternatives

Table 6-1 summarizes the attributes that were used as the criteria to rank the relative cost effectiveness of the alternatives being evaluated. These criteria were chosen as a means for fully considering the relative financial, social, and environmental impacts of each alternative.

Table 6-1
Summary of Criteria for Alternatives Ranking

Present Worth Cost:	relative probable life-cycle costs (construction cost, operation and maintenance (O&M) cost, and salvage value).
O & M Requirements:	relative operation and maintenance requirements and process complexity.
Land Use Impacts:	relative land requirements, future expandability, and impacts on airport and other existing land uses.
Treatment Reliability:	relative process stability (sensitivity to changed conditions and potential risk of process upsets or failures).
Operating Flexibility:	relative flexibility in process control.
Sustainability:	relative energy consumption, conservation opportunities, and other environmental issues.

We generated a ranking matrix to compare the relative scores of the alternatives using the criteria presented above. The alternative with the highest ranking for a specific criterion was assigned a score of one. The second-highest ranked alternative was assigned a score of two, and so on. If our evaluation did not identify a significant difference between alternatives for a certain criterion, these alternatives were assigned the same score. Using this procedure, the alternative with the overall lowest point total is the alternative with the highest overall ranking.

The initial ranking assigned all criteria an equal level of importance, meaning we did not assign differing weights to the scoring based on a relative importance for a criterion. This approach was followed to prevent the evaluation from becoming unnecessarily complex and overly subjective.

Even though the relative present-worth cost may be viewed as the bottom line for determining the preferred alternative, other factors such as lower O&M costs and greater reliability may be sufficient to offset a higher overall cost. Once the initial rankings were established, any alternatives that scored close the top were evaluated in more detail to better characterize their relative cost effectiveness.

6.1.3 Estimates of Probable Costs

General. Preliminary estimates of probable, life-cycle costs over a 20-year period were generated for each alternative. These probable life-cycle costs include estimates of construction costs and the present worth of both annual O&M costs and salvage values at the end of 20 years. Although major wastewater treatment plant (WWTP) upgrades or expansions are not currently needed, our cost estimates are based on 2016 dollars to establish a consistent basis for comparisons.

The estimates are based on the alternative descriptions provided in this study and from information available at the time this evaluation was performed. The estimates exclude both construction and O&M costs for components that are effectively the same for all the alternatives. Examples of such items are main influent and effluent pipelines to and from the WWTP, effluent pumps and storage ponds, water recycling components, a site access road, and other common site work.

Construction Costs. The probable construction costs developed for this study are planning-level estimates. Chapter 8 provides additional information on the basis of these estimates. The information used to generate the cost estimates has been updated to December 2016 using the Engineering News-Record Construction Cost Index of 10,530. *Chapter 8 lists estimates of probable project costs for the recommended WWTP improvements updated to December 2017.*

Allowances for contractor overhead and profit, mobilization/demobilization, and construction contingencies are included to provide conservative estimate of the probable construction costs. However, since the estimates are provided for comparison purposes, nonconstruction costs for project planning, engineering, and administration have been excluded. At this stage, these costs would be estimated as a percentage of construction cost and would increase each alternative by a common percentage.

O&M Costs. Annual O & M costs generally result from power consumption, labor, repair/replacement parts, and biosolids hauling. Estimates of probable O&M costs were generated from information provided by equipment vendors, City of Madras operating personnel, prior HHPR studies and available literature.

Estimates of horsepower requirements and an average cost of $0.10 per kilowatt-hour (kW-Hr) provided the basis for power costs. This unit cost includes a contingency factor for the NWWTP since bills from the Central Electric Cooperative, the utility serving that facility, showed an average cost of about $0.07/kW-Hr in 2016. An average hourly rate of $40 was used for labor costs to include allowances for benefits, payroll costs, and direct overhead. We used a discount rate of 1.5 percent to calculate the present worth of probable, annual O&M costs for each alternative.

6.2 DEVELOPMENT OF SECONDARY PROCESS ALTERNATIVES

6.2.1. General

This section describes the secondary treatment alternatives we evaluated for expansions to the NWWTP (Table 5-9). Preliminary process sizing, configurations, and site layouts were developed for these alternatives to provide a basis for estimating probable life-cycle costs and identifying space requirements.

The secondary process configurations are based on one treatment module with an average daily flow (ADF) capacity of 0.5-MGD. The influent WW characteristics and treatment requirements previously reported in Section 5.3 were used to establish the preliminary sizing criteria for key process parameters.

Secondary systems for extended aeration processes were developed assuming dual-basin configurations for each 0.5-MGD expansion module to provide operating flexibility. The lagoon systems would consist of multiple cells for the same reason. Sufficient redundancy would be provided with pumping equipment to allow operation with one unit out of service.

We assumed outdoor process tanks or basins, other than earthen lagoons, would be constructed of concrete. Tanks or basins can be constructed of steel to reduce initial capital costs and construction time. However, the life-cycle cost of steel tanks would be about the same as concrete due to the need for periodic recoating and the potential for a shorter service life due to corrosion. DAF clarifiers would be steel tanks housed in a building.

Additional facilities that would be required with each of the secondary processes are listed below. These facilities are included in the evaluation because they would differ in some ways between the alternatives. Brief descriptions of these facilities are provided at the end of this section.

- a headworks for preliminary treatment;
- secondary clarifiers for biosolids separation and removal;
- aerobic digesters for biosolids stabilization;
- building to house accessory equipment and process controls; and
- sludge drying beds for biosolids dewatering and land application of Class B biosolids.

6.2.2. *Aerated/Partially-Mixed Lagoon System*

Aerated lagoons would consist of lined, earthen cells with sloped sides and would be configured to operate in series. Table 6-2 lists the preliminary sizing criteria used for the aerated lagoons alternative and Figure 6-1 shows a preliminary layout of the main system components.

Table 6-2
Preliminary Sizing Criteria – Aerated/Partially-Mixed Lagoon System

Process Parameter	Criterion	
1. Hydraulic Retention Time @ ADF	30	days
2. Total System Volume	15.0	MG
3. No. of Lagoons	3	Cells
4. Design Cell Side Water Depth	8	feet
5. Design Cell Side Slope	3:1	Horizontal to Vertical
6. Design Surface-Area BOD_5 Loading Rate	220	lbs./day/acre
7. Oxygen Feed Requirements	1.5	lbs. oxygen/lb. BOD applied

Each lagoon cell would be aerated to supply oxygen for biological activity. Aeration could be provided by mechanical aerators, air diffusers with blowers, or possibly a combination of these two. We have included a small blower building with this alternative to accommodate the blowers required with a diffused-air system.

Clarifiers would be provided either as an integral part of the last lagoon cell or as separate tanks. For this study, we have assumed separate, concrete clarifiers would be constructed to be both conservative and because this would provide greater operating flexibility. Waste activated sludge (WAS) pumps are needed to remove settled sludge from the clarifiers and pump it to aerobic digester. No return activated sludge (RAS) pumps are required with lagoons. The sizing and layout of secondary clarifiers and aerobic digesters are described later in this subsection.

6.2.3. *Oxidation Ditch Extended Aeration*

The oxidation ditch process is typified by aeration basins with "racetrack" configurations followed by clarifiers for solids separation. Table 6-3 lists the preliminary sizing criteria used for the oxidation ditch alternative and Figure 6-2 shows a preliminary layout of the process components.

Table 6-3
Preliminary Sizing Criteria
Oxidation Ditch and Compact Extended Aeration

Process Parameter	Criterion	
1. Design Volumetric BOD_5 Loading Rate	25	lbs./day/1,000 c.f.
2. Hydraulic Retention Time @ ADF	18	hours
3. Design MCRT	20	days
4. Design MLSS Concentration	4,000–4,500	mg/L
5. Design MLSS Volatile Solids Content	80	pct. volatile
6. Total Reactor Volume	0.38	MG
7. No. of Reactor Basins	2	MG
8. Design Basin Side Water Depth	14	feet

The contents of each oxidation ditch, termed mixed liquor suspended solids (MLSS), are forced around the basin and kept in suspension by mechanical aerators and/or mixers. The agitation and mixing produced by mechanical aerators also introduces the oxygen required to keep the microbes in the MLSS active.

Oxygen is sometimes added by mounting air diffusers in the oxidation ditches and providing blowers in a separate building. However, we based our analysis on mechanical aerators for this application because the basins will be at the shallow end of the typical range of depths for oxidation ditches. Air diffusers become less efficient at shallower depths. Therefore, no air blowers are included with this alternative.

RAS pumps are needed to recycle settled solids from the clarifiers back to the oxidation ditches. Since microbes multiply as they consume organic matter, WAS pumps must use provided to periodically transfer a portion of the settled solids in the clarifiers to digesters. Secondary clarifiers and aerobic digesters are described later in this subsection.

6.2.4. *Compact Extended Aeration*

The compact extended aeration alternative utilizes a concentric configuration with common-wall construction for the separate tanks. A circular clarifier is located in the center of the structure and is surrounded by a doughnut-shaped section that contains the aeration basin and an aerobic digester tank. Typically, fine-bubble air diffusers are mounted near the bottom of each aeration basin to provide the required oxygen and mixing. Air blowers are housed in a separate blower building.

RAS and WAS pumps are required similar to the oxidation ditch alternative, except that the concentric configuration often results in the pumps being mounted above the clarifier. The sizing of the clarifiers and aerobic digesters would be the same as it would be for the oxidation ditches.

The preliminary sizing criteria used for the compact extended aeration are the same as those used for the oxidation ditches and listed above in Table 6-3. Figure 6-3 shows a preliminary layout of the main process components.

6.2.5. *SBR Extended Aeration*

The SBR alternative is a fill-and-draw process that operates with time-based cycles. Deeper basins are needed than the aeration basins for other secondary alternatives to accommodate the fill-and-draw cycles.

Table 6-4 lists the preliminary sizing criteria used for the SBR alternative. The layout for the entire SBR system would be similar to the existing SWWTP with common wall construction for the SBR, post equalization, and aerobic digester basins (see Figure 5-1).

Table 6-4
Preliminary Sizing Criteria
SBR Extended Aeration

	Process Parameter	Criterion	
1.	Design Volumetric BOD_5 Loading Rate	17	lbs./day/1,000 c.f.
2.	Hydraulic Retention Time @ ADF	27	hours
3.	Design MCRT	16	days
4.	Design MLSS Concentration	4,000–4,500	mg/L
5.	Design MLSS Volatile Solids Content	80	pct. volatile
6.	Total Reactor Volume (at average depth)	0.56	MG
7.	No. of Reactor Basins	2	MG
8.	Max. Design Basin Side Water Depth	19	feet

SBR basins function as aeration basins during aeration and mixing phases during each operating cycle and then serve as clarifiers during the settling and decanting phases of each cycle. By combining these functions in the SBR tanks, separate clarifiers and RAS pumps are eliminated. WAS pumps are required similar to the other alternatives. A post equalization basin must also be included in the SBR alternative to avoid increasing the capacity of downstream components.

The type of SBR process installed at the South WWTP (SWWTP) uses fine bubble air diffusers to introduce the required oxygen and separate mixers to provide complete mixing. Other configurations with combined aeration and mixing equipment are also available.

6.2.6. *Associated Support Facilities*

Headworks. We included headworks with screening and grit removal for preliminary treatment as part of each secondary alternative. The NWWTP headworks would need to be constructed with the structure almost entirely above grade to allow gravity flow to the secondary reactor basins. The height of this structure would vary for the different secondary alternatives because basin depths vary for the secondary alternatives.

Initially, the headworks structure would contain a single, mechanical screen with a bypass bar rack and a single vortex grit chamber. A second grit chamber would be added when the plant ADF capacity is expanded from 1.0 MGD to 1.5 MGD. Figure 6-4 shows a preliminary layout of the headworks with approximate dimensions.

The sizing and configuration of the proposed headworks for the NWWTP was based in part on the headworks at the existing South WWTP. Although the overall configuration was modified to better fit the planned site. Our cost estimates were based on using the same type of screening and grit removal equipment as is currently in use at the SWWTP.

Secondary Clarifiers. Clarifiers are required with all the secondary processes, except SBRs. Layouts and cost estimates are based on the construction of circular clarifiers for the oxidation ditch and compact extended-aeration alternatives. The preliminary sizing criteria used for the secondary clarifiers are listed in Table 6-5.

Table 6-5
Preliminary Sizing Criteria – Secondary Clarifiers

Process Parameter	Criterion	
1. Total Surface Area (both tanks)	1,400	square feet
2. Tank Side Water Depth	12	feet
3. Length of Overflow Weir (both tanks)	175	feet
4. Peak Design Surface Overflow Rate	950	gpd/sq. ft.
5. Peak Weir Loading Rate	7,600	gpd/lineal ft.

Circular tanks allow for more efficient collection and pumping of the RAS back to the aeration basins. Rectangular clarifiers are included with the aerated lagoons since no RAS system is required with this alternative and less WAS would be produced. An allowance for polymer feed to enhance solids settling was also included with the aerated lagoon alternative.

Aerobic Digesters. Each of the secondary alternative requires aerobic digesters for biosolids stabilization. The digesters would be concrete tanks with aeration provided by diffused air systems. Coarse-bubble diffusers would be installed in the digester tanks and blower equipment would be installed in the process building. The digesters would also include decanting devices to allow some thickening of the tank contents through supernatant withdrawal.

The digester tanks have been sized to provide 60 days of solids retention time assuming an average solids content of 1.0 percent. Smaller aerobic digesters would be provided for the aerated lagoons because fewer biosolids would be produced and the biosolids would be partially stabilized in the lagoons. The aerobic digester capacity would be the same for each extended aeration alternative.

Secondary Process Building. Pumps, aeration blowers, valves, polymer feed equipment, instrumentation, process controls, and electrical equipment for the secondary alternatives would be housed in a building. The building sizes vary for the different alternatives based primarily on different requirements for pumps, blowers and valves. Estimates of the probable construction costs for the buildings are based on structures with concrete floor slabs, cement masonry unit (CMU) walls, and wood-frame roofs with metal, roof decking. The layouts are based on common-wall construction with adjacent process tanks where feasible.

Process-Specific Piping and Valves. The cost estimates for each alternative include allowances for piping, valves and associated components that would be specific to each alternative.

Other Facilities. Additional facilities common to all secondary alternatives have been excluded from the cost comparisons because they would not differ significantly between alternatives. Such facilities include main pipelines to and from the WWTP, effluent pumps and storage ponds, water recycling components, potable water service, a site access road, and other common site work.

6.3 SECONDARY ALTERNATIVES COMPARISON AND RANKING

6.3.1 Estimates of Probable Present-Worth Costs for Secondary Alternatives

Table 6-6 summarizes the preliminary estimates of probable costs for each secondary alternative. These present worth cost estimates are based on a 20-year planning period. The scope of each estimate is based on the alternative descriptions provided in Section 6.2. Breakdowns of the preliminary estimates for secondary process alternatives are presented in Appendix L.

Table 6-6
Estimates of Probable Costs – Secondary Alternatives

Secondary Alternative	Present Worth Costs (in millions – Dec. 2016)				
	Capital (1)	O&M (2)	Salvage Value (2)	Total Life Cycle	Rank
1. Aerated Lagoons	$ 4.92	$ 1.99	$ 1.31	$ 5.60	1
2. Oxidation Ditches	$ 4.90	$ 2.61	$ 1.17	$ 6.34	4
3. Compact Extended Aeration	$ 4.74	$ 2.64	$ 1.11	$ 6.27	3
4. Sequencing Batch Reactors	$ 4.56	$ 2.54	$ 1.14	$ 5.96	2

(1) Capital costs are probable construction costs with allowances for contractor overhead and profit, mobilization/demobilization, and construction contingencies.
(2) Probable present worth costs were calculated using 1.5% discount over 20-year planning period.

We estimate the SBRs would be about 6% higher in life-cycle costs than aerated lagoons, whereas we estimate the other alternatives would be about 12% to 13% higher. Our estimates indicate aerated lagoons would have annual O&M costs 22% to 25% less than the other alternatives, which more than offsets the higher probable capital cost. The closeness of the probable present worth costs for the aerated lagoons and SBRs magnifies the importance of nonmonetary considerations.

6.3.2 Evaluation of Nonmonetary Considerations

Evaluations of the alternative secondary treatment processes were conducted based on the nonmonetary criteria presented in Subsection 6.1.2. Key advantages and disadvantages of each alternative with regard to these evaluation criteria are summarized in the following paragraphs.

1. Aerated Lagoons

a. O&M Requirements

Advantages:

- simple process to control;
- no automated control valves and no RAS system;
- process can be designed with only mechanical aerators to eliminate O&M of air blowers and fine-bubble diffusers; and
- less WAS and stabilized biosolids to handle than extended aeration systems results in less wear on equipment for handling biosolids.

Disadvantages:

- aeration components in lagoons can be difficult to reach;
- O&M requirements for clarifier equipment; and
- partial-mixing of lagoons results in some solids accumulation that would need to be dredged after 15-20 years.

b. Land Use Impacts

Advantage:

- earthen basins are shallower and less visible than concrete aeration basins.

Disadvantages:

- more land is needed than other processes (would occupy more existing farmland); and
- more difficult to mitigate wildlife attractions with lagoons due to larger surface area, less mixing and sloped sides.

c. Sustainability

Advantages:

- partial-mix process does not require aeration for mixing;
- less energy consumed for pumping influent to lagoons (through headworks) and pumping biosolids than extended aeration systems; and
- less energy is consumed to stabilize and land apply biosolids than other processes.

Disadvantage:

- need for more land with lagoons may increase energy use to pump effluent to more distant farmland for recycling.

d. Reliability

Advantages:

- aerated lagoon system is a stable process that is not sensitive to typical variations in flows and organic loading;
- limited reliance on automation and less pumping equipment reduces risk of electrical and mechanical failures; and

Disadvantage:

- process may not consistently produce the high quality effluent that extended aeration systems can produce resulting in potential for higher disinfection costs.

e. Flexibility

Advantages:

- the proposed, 3-cell system would allow each treatment cell to be separately taken out of service, leaving 67% of treatment capacity in service; and
- lagoons can be retrofitted with partitions, additional aeration and mixing equipment, and/or fixed-film modules to increase treatment capacity.

Disadvantages:

- limited process control gives operators less flexibility to adjust system for changing conditions; and
- earthen basins cannot be designed for adjacent expansions using common-wall construction.

2. **Oxidation Ditches**

   a. **O&M Requirements**

   Advantages:

   - oxidations ditches rely less on automated process controls and control valves than SBRs;
   - process can be designed with only mechanical aerators to eliminate O&M of air blowers and fine-bubble diffusers; and
   - less automation than SBRs and no automated control valves.

   Disadvantages:

   - requires O&M of clarifier equipment that is not included with SBRs;
   - requires O&M of RAS system that is not included with aerated lagoons and SBRs;
   - process control is less simple than aerated lagoons; and
   - higher production of WAS and stabilized biosolids than aerated lagoons results in more O&M requirements for biosolids handling.

   b. **Land Use Impacts**

   Advantages:

   - less land is needed than aerated lagoons; and
   - less difficult and costly to mitigate wildlife attractions with smaller, concrete basins than with lagoons.

   Disadvantages:

   - concrete basins are deeper and more visible than lagoons; and
   - slightly more land is needed than compact extended aeration and SBR processes;
   - need for clarifiers may produce more of a wildlife attraction than SBR process.

   c. **Sustainability**

   Advantages:

   - need for less land than lagoons protects more nearby farmland for recycling;

   Disadvantage:

   - extended aeration processes are more energy intensive than lagoons due to higher biosolids production and more mixing in aeration basins.

   d. **Reliability**

   Advantages:

   - extended aeration processes may produce a higher quality effluent than aerated lagoons resulting in the potential for lower disinfection costs; and
   - oxidation ditches typically produce thicker WAS than SBRs due to use of separate clarifier, resulting in less volume being handled in aerobic digesters.

   Disadvantages:

   - extended aeration processes with smaller reactor basins can be more sensitive than lagoons to variations in flows and organic loading.

e. **Flexibility**

Advantages:

- greater process control than lagoons gives operators more opportunity to adjust system for changing conditions; and
- oxidation ditches can be designed for expansions using common wall construction.

Disadvantages:

- the proposed, 2-basin system would mean greater reduction in treatment capacity than lagoons, if one basin is removed from service; and
- less room for retrofit modifications in extended aeration basins than in larger lagoons.

3. **Compact Extended Aeration**

a. **O&M Requirements**

Advantages:

- compact extended aeration relies less on automated process controls and control valves than SBRs; and
- less automation than SBRs and no automated control valves.

Disadvantages:

- requires O&M of clarifier equipment that is not included with SBRs;
- requires O&M of RAS system that is not included with aerated lagoons and SBRs;
- process would include air blowers that require regular maintenance;
- process would include fine-bubble air diffusers that require annual cleaning to maintain efficiency;
- process control is less simple than aerated lagoons; and
- higher production of WAS and stabilized biosolids than aerated lagoons results in more O&M requirements for biosolids handling.

b. **Land Use Impacts**

Advantages:

- less land is needed than aerated lagoons and oxidation ditches; and
- less difficult and costly to mitigate wildlife attractions than aerated lagoons due to smaller, concrete basins.

Disadvantages:

- concrete basins are deeper and more visible than lagoons; and
- need for clarifiers may produce more of a wildlife attraction than SBR process.

c. **Sustainability**

Advantages:

- need for less land than lagoons protects more nearby farmland for recycling; and
- diffused air systems with fine-bubble diffusers can be more energy efficient than mechanical aeration, if diffusers are cleaned annually.

Disadvantage:

- extended aeration processes are more energy intensive than lagoons due to higher biosolids production and more mixing in aeration basins.

d. Reliability

Advantages:

- extended aeration processes may produce a higher quality effluent than aerated lagoons resulting in the potential for lower disinfection costs; and
- compact extended aeration will typically produce thicker WAS than SBRs due to use of separate clarifier, resulting in less volume being handled in aerobic digesters.

Disadvantages:

- extended aeration processes with smaller reactor basins can be more sensitive than lagoons to variations in flows and organic loading.

e. Flexibility

Advantages:

- greater process control than lagoons gives operators more opportunity to adjust system for changing conditions.

Disadvantages:

- the proposed, 2-basin system would mean greater reduction in treatment capacity than lagoons, if one basin is removed from service; and
- less room for retrofit modifications in extended aeration basins than in larger lagoons.

4. Sequencing Batch Reactors

a. O&M Requirements

Advantages:

- no clarifier equipment or RAS system; and
- SBR options are available with only mechanical aerators that eliminate O&M of air blowers and fine-bubble diffusers.

Disadvantages:

- process control is less simple than aerated lagoons;
- SBRs rely more on automation and automated control valves than other alternatives;
- higher production of WAS and stabilized biosolids than aerated lagoons results in more O&M requirements for biosolids handling.

b. Land Use Impacts

Advantages:

- less land is needed than other alternatives; and
- less difficult and costly to mitigate wildlife attractions than all other alternatives without clarifiers and with deeper concrete basins.

Disadvantages:

- concrete basins are deeper and more visible than other alternatives.

c. Sustainability

Advantages:

- need for less land than other alternatives protects more nearby farmland for recycling.

Disadvantage:

- extended aeration processes are more energy intensive than lagoons due to higher biosolids production and more mixing in aeration basins.

d. Reliability

Advantages:

- extended aeration processes may produce a higher quality effluent than aerated lagoons resulting in the potential for lower disinfection costs.

Disadvantages:

- SBRs typically produce dilute WAS due to lack of separate clarifier, resulting in more volume being pumped to aerobic digesters.
- SBRs are more sensitive than other processes to variations in flows and organic loads.

e. Flexibility

Advantages:

- greater process control than lagoons gives operators more opportunity to adjust system for changing conditions; and
- SBRs provide greatest flexibility for expansions by adding individual SBR basins.

Disadvantages:

- the proposed, 2-basin system would mean greater reduction in treatment capacity than lagoons, if one basin is removed from service; and
- less room for retrofit modifications in extended aeration basins than in larger lagoons.

Based on the qualitative alternatives evaluation summarized above, each secondary alternative was assigned a ranking for each nonmonetary criterion. A total score and overall rank was then established from the sum of the individual rankings. The matrix presented in Table 6-7 identifies these non-cost rankings for the secondary alternatives.

Table 6-7
Matrix of Secondary Alternatives Ranking

Secondary Alternative	Evaluation Criteria						
	O&M Issues (1)	Land Use (2)	Sustainability (3)	Reliability (4)	Flexibility (5)	Combined Score (6)	Nonmonetary Rank
1. Aerated Lagoons	1	4	1	1	2	9	1
2. Oxidation Ditches	3	3	3	2	3	14	3
3. Compact Extended Aeration	4	2	2	2	4	14	3
4. Sequencing Batch Reactors	2	1	3	3	1	10	2

(1) O&M Issues: relative operation and maintenance requirements and process complexity.
(2) Land Use Impacts: land requirements, future expandability, and impacts on existing land uses.
(3) Sustainability: energy consumption, conservation opportunities, and other environmental issues.
(4) Treatment Reliability: process stability (sensitivity to changed treatment conditions).
(5) Operating Flexibility: relative flexibility in process control and modifications.
(6) Total Score: Sum of rankings for five criteria, higher ranking represented by lower score.

6.3.3 *Summary of Secondary Alternatives Evaluation*

Based on our evaluation, an aerated lagoon system is the most cost-effective secondary treatment alternative to implement at the NWWTP. The main advantages to this process are the lower O&M requirements and lower associated costs relative to the other alternatives. There is also considerable flexibility in how aerated lagoons can be configured and there are likely to be opportunities for reducing probable capital costs relative to our planning-level estimate. Therefore, we recommend the City plan to implement aerated lagoons as the secondary treatment process for a retrofit or replacement of the NWWTP and for any future expansions.

Overall, aerated lagoons and SBRs rank close in both costs and nonmonetary factors. Moreover, these alternatives compare well relative to the other alternatives. If the Federal Aviation Administration (FAA) requires covers over lagoons and basins, then the SBR process could be worthy of further consideration due to its smaller footprint.

Oxidation ditches and compact extended aeration are basically the same process with different configurations. As such, there is little difference in their relative rankings and they generally rate lower than the aerated lagoons and SBRs in both monetary and nonmonetary criteria.

6.4 DEVELOPMENT OF DISINFECTION ALTERNATIVES

6.4.1 *General*

The alternative disinfection systems being evaluated for expansions to the NWWTP (Table 5-9) are described in this section. Preliminary equipment requirements and sizing were developed for these alternatives to provide a basis for estimating probable life-cycle costs and space requirements. The criteria used to size the disinfection equipment and chlorine contact tank for a 0.5-MGD module are provided in Table 6-8.

Table 6-8
Preliminary Sizing Criteria – Alternative Disinfection Processes

	Process Parameter	Criterion	
1.	Secondary Effluent Suspended Solids	30	mg/L
2.	Design Effluent Total Coliform	2.2	Organisms/100 mL
3.	Peak Design Flow	1.33	MGD
4.	Max. Design Chlorine Dose	12	mg/L
5.	Chlorine Contact Time @ ADF	60	minutes

To provide a common basis for comparing alternatives, this evaluation has assumed a separate, CMU building on a concrete slab would house the equipment. The size of this building would vary for the different alternatives. The cost effectiveness of locating this equipment in the secondary process building can be evaluated during project development.

6.4.2 *Sodium Hypochlorite Bulk Storage and Feed*

The main components specific to this alternative include the following:

- a storage tank for bulk deliveries of sodium hypochlorite (NaOCl) solution;
- two metering pumps with accessories for feeding NaOCl into the secondary effluent; and
- a building about 10 feet by 12 feet in size.

The storage tank would be located outside and would be provided with a heat jacket and insulation for freeze protection. Interior space is required only to house the metering pumps, piping and valves, instrumentation and controls, and other accessories.

6.4.3 Onsite Sodium Hypochlorite Generation and Feed

The main components specific to this alternative include the following:

- a storage tank for bulk deliveries of brine solution;
- a package NaOCl generator system supplied with associated instrumentation and controls;
- a day tank to store dilute NaOCl solution as it is generated;
- two metering pumps with accessories for feeding NaOCl into the secondary effluent;
- electrical equipment for the generator system; and
- a CMU building about 12 feet by 22 feet in size.

The brine storage tank and NaOCl solution tank would be located outside and would be provided with a heat jacket and insulation for freeze protection. The building would house all the generator equipment, pumps, day tank, and process controls. A separate room would be provided in the building to house the electrical equipment.

6.4.4 Tablet Chlorination (Calcium Hypochlorite) Equipment

The main components specific to this alternative include the following:

- a package tablet-chlorinator system supplied with associated instrumentation and controls;
- a day tank to store hypochlorite solution;
- two metering pumps with accessories for feeding NaOCl into the secondary effluent; and
- an building about 12 feet by 16 feet in size.

The hypochlorite solution tank would be located outside and would be provided with a heat jacket and insulation for freeze protection. The building would house all the equipment, pumps, day tank, and process controls.

6.4.5 Common Disinfection Facilities for All Alternatives

Additional facilities that are common to all disinfection alternatives are listed below. These facilities have been excluded from the alternatives evaluation because they would not differ significantly for the different alternatives.

- a chlorine residual analyzer;
- a concrete containment area for the storage tank;
- a concrete contact tank to provide proper time for adequate disinfection;
- a mixer to disperse hypochlorite solution at the upstream end of the contact tank;
- water service connection to building and emergency eyewash; and
- access driveway and other site work.

6.5 DISINFECTION ALTERNATIVES COMPARISON AND RANKING

6.5.1 *Estimates of Probable Present-Worth Costs for Disinfection Alternatives*

Table 6-9 summarizes the preliminary estimates of probable costs for each disinfection alternative. These estimates are given as present worth costs using a 20-year planning period. The scope of each estimate is based on the alternative descriptions provided in Section 6.3. Breakdowns of these preliminary estimates are presented in Appendix L.

Table 6-9
Estimates of Probable Costs – Disinfection Alternatives

Disinfection Alternative	Present Worth Costs (in thousands – Dec. 2016) Capital (1)	O&M (2)	Salvage Value (2)	Total Life Cycle	Rank
1. NaOCl Bulk Storage& Feed	$ 141	$ 926	$ 37	$ 1,030	3
2. Onsite NaOCl Generation & Feed	$ 421	$ 601	$ 77	$ 945	2
3. Tablet Chlorination Equipment	$ 224	$ 735	$ 51	$ 908	1

(1) Capital costs are probable construction costs with allowances for contractor overhead and profit, mobilization/demobilization, and construction contingencies.
(2) Probable present worth costs were calculated using 1.5% discount over 20-year planning period.

The tablet chlorination system is estimated to have lower life-cycle costs than the other alternatives. However, the life-cycle costs of the onsite generation and feed system are estimated to be only about 4% higher. The bulk storage and feed option would require the lowest capital investment, but has the highest O&M costs due to the need to purchase liquid NaOCl solution.

6.5.2 *Evaluation of Nonmonetary Considerations*

Evaluations of the alternative disinfection treatment processes were conducted based on the applicable nonmonetary criteria presented in Subsection 6.1.2. Summaries of the key advantages and disadvantages for each alternative are provided below.

The criterion of land use impacts was not considered in the evaluation because the alternatives do not significantly differ with regard to the amount of land required and associated impacts. Process flexibility is also not a variable among the disinfection alternatives. Each alternative can be designed with similar levels of operating flexibility.

1. NaOCl Bulk Storage and Feed

a. O&M Requirements

Advantages: simple process with the least amount of equipment.

Disadvantages: requires storage and feed of more concentrated NaOCl solution than onsite generation with greater risk to personnel of burning or irritation.

b. Land Use Impacts – no significant differences

c. Sustainability

Advantages: no onsite generation of disinfectant solution results in less power being required for onsite process.

Disadvantages: requires trucking of bulk deliveries of NaOCl solution.

d. Reliability

Advantages: less equipment results in lower chances of equipment faults or failures.

Disadvantages: relies on more frequent deliveries.

e. Flexibility – no significant differences

2. Onsite NaOCl Generation and Feed

a. O&M Requirements

Advantages: more dilute NaOCl solution generated than other alternatives posing less of a potential hazard to personnel.

Disadvantages: more complex than other alternatives with more equipment components and associated O&M required.

b. Land Use Impacts – no significant differences

c. Sustainability

Advantages: Onsite generation involves transportation of less bulk material resulting in fewer deliveries (less brine solution than NaOCl solution by weight).

Disadvantages: requires more onsite power than other alternatives for other generation and requires trucking of bulk brine-solution deliveries.

d. Reliability

Advantages: less frequent brine deliveries than bulk NaOCl deliveries.

Disadvantages: more equipment results in higher chances of equipment faults or failures.

e. Flexibility – no significant differences

3. Tablet Chlorination Equipment

a. O&M Requirements

Advantages: requires storage and handling of dry tablets with low hazard potential.

Disadvantages: more equipment than storage and feed of bulk NaOCl.

b. Land Use Impacts – no significant difference

c. Sustainability

Advantages: Use of dry tablets requires no transportation of bulk solution resulting in least amount of material deliveries by weight and frequency.

Disadvantages: dissolving tablets and mixing solution requires more onsite power than bulk storage and feed of NaOCl solution.

d. Reliability

Advantages:

- lower space requirements for tablet storage allows less frequent deliveries; and
- less equipment than onsite NaOCl generation results in lower chances of equipment faults or failures.

Disadvantages: more equipment than bulk NaOCl storage and feed results in higher chances of equipment faults or failures.

e. Flexibility – no significant difference

The matrix presented in Table 6-10 identifies the non-cost rankings for the disinfection alternatives. Each disinfection alternative was assigned a ranking for each applicable criterion based on the qualitative alternatives evaluation summarized above. A total score and overall rank was then established from the sum of the individual rankings.

Table 6-10
Matrix of Disinfection Alternatives Ranking

Disinfection Alternative	Evaluation Criteria				
	O&M Issues (1)	Sustainability (2)	Reliability (3)	Total Score (4)	Overall Rank
1. NaOCl Bulk Storage & Feed	1	3	1	5	1
2. Onsite NaOCl Generation & Feed	3	2	3	8	3
3. Tablet Chlorination Equipment	2	1	2	5	1

(1) O&M Requirements: relative operation and maintenance requirements and process complexity.
(2) Sustainability: energy consumption, conservation opportunities, and other environmental issues.
(3) Treatment Reliability: process stability (sensitivity to changed treatment conditions).
(4) Total Score: Sum of rankings for six criteria, higher ranking represented by lower score.

6.5.3 Summary of Disinfection Alternatives Evaluation

The rankings show the tablet chlorination system scores about the same in nonmonetary considerations as the bulk storage and feed system. Since the tablet chlorination system is estimated to have a lower life-cycle cost, and about 20% lower O&M costs, it appears to be the preferred disinfection alternative.

6.6 EVALUATION OF ALTERNATIVES FOR EXISTING NWWTP

6.6.1 General

The condition assessment described in Chapter 2 reports that the existing NWWTP will require significant investment within 15 years to maintain the 0.5-MGD facility in reliable service. As discussed in Chapter 5, the City could renovate, retrofit, or replace the existing facility to provide the required capacity.

We evaluated alternatives for upgrading the NWWTP in conjunction with an expansion to identify a preferred approach for addressing condition issues while maintaining industrial site readiness. The evaluation compared alternatives for providing an expanded NWWTP capacity of 1.0 MGD and considered site requirements for an additional expansion to 1.5 MGD.

Aerated lagoons were incorporated into the alternatives evaluation as the recommended secondary treatment process, consistent with our analysis of process alternatives. All options for retrofitting or replacing the existing lagoons and constructing future plant expansions included aerated lagoons for secondary treatment. Alternatives that involve renovating the existing lagoons to maintain the partially-aerated, facultative lagoon process in service were also considered.

The main considerations in evaluating these alternative upgrades are summarized below:

- the pace of development in the North Area;
- the need for flexibility to accommodate expansions for maintaining industrial site readiness;
- the impacts on the airport that expansions of open lagoons would have; and
- the availability of farmland near the NWWTP for effluent recycling by irrigation.

6.6.2 Descriptions of Alternatives

This subsection describes the alternative approaches for addressing upgrades and expansions to the existing NWWTP over the planning period. The main elements listed as being specific to each alternative were included in the estimates of probable construction cost. The cost estimates exclude the common elements listed at the end of this subsection.

1. **Option 1 – Full Renovation of Lagoon System and Adjacent Expansion.** A complete renovation of the partially-aerated, facultative lagoons would maintain the current 0.5-MGD capacity in the existing footprint. The renovation would occur in phases to keep the facility in service with the scheduling of the phases based on available funding and priorities for equipment replacement.

   The main elements specific to a full renovation are listed below.

   - Clean, replace the liner, and restore the earthen liner cover in the primary and secondary lagoon cells (Cells A thru D).
   - Replace the aeration systems and influent pipes in the primary cells (Cells A and B).
   - Replace the lagoon transfer structures and access walkways for Cells A thru D.
   - Replace transfer piping between lagoon cells.

   The two primary cells would continue to be aerated lagoons and the secondary cells would remain facultative lagoons. Yard piping at the plant site installed during the 1990s or later would be left in place to the extent feasible. The polishing lagoon is no longer needed with the installation of the DAF clarifier and would be demolished or converted to effluent storage.

   A 0.5-MGD aerated lagoon module and additional effluent storage capacity would be constructed on adjacent land to expand the NWWTP capacity to 1.0 MGD.

   A preliminary layout for this approach is shown in Figure 6-5. This layout assumes the renovated lagoons would be replaced with a second, adjacent treatment module either before or as part of an expansion to 1.5 MGD. This sequence would allow the existing lagoon site to be converted to an effluent storage pond.

   If the pace of development requires an expansion beyond 1.0 MGD while the renovated lagoons still have significant service life remaining, the effluent storage pond for the 1.5-MGD capacity would be constructed on an adjacent site, similar to what is shown for Option 4 in Figure 6-8.

2. **Option 2 – Partial Renovation Combined with Adjacent Expansion.** As an alternative to full renovation, the City could renovate half the lagoon system (one primary and one secondary cell). The renovated lagoons would provide a 0.25-MGD capacity. Therefore, the City would need to construct a separate 0.75-MGD treatment module to expand the plant to a 1.0-MGD capacity. The remainder of the existing lagoon system would be converted to an effluent storage pond. Figure 6-6 illustrates this alternative.

The following main elements are specific to the partial lagoon renovation.

- Replace the liner in one primary and one secondary cell (Cells A and C).
- Replace the aeration systems and influent pipes in Cell A.
- Replace the lagoon transfer structures and access walkways for Cells A and C.
- Replace transfer piping between Cells A and C.
- Modify Cells B and D to convert the area to an effluent storage pond.
- Construct an adjacent treatment module to expand capacity.

This approach would increase land area required for an adjacent lagoon system expansion, but would reduce the required land area outside the existing plant footprint for effluent storage. As with the full renovation, the renovated lagoons could eventually be replaced and converted to effluent storage capacity.

3. **Option 3 – Retrofit to 0.5-MGD Aerated Lagoons with Adjacent Expansion.** The existing lagoon system can be retrofitted to convert one primary cell to a 0.5-MGD aerated lagoon system. This retrofit option would reduce the volume required to provide a 0.5-MGD capacity by increasing lagoon depth and installing a new aeration system, partitions, fixed-film media, and/or other process components.

   The remainder of the existing lagoon footprint would be converted to effluent storage and an adjacent aerated lagoon system would be constructed to expand to NWWTP to 1.0-MGD. Figure 6-7 shows a preliminary layout for this option.

   The following main elements are specific to this lagoon retrofit option.

   - Replace the liner and influent pipes in one primary cell (Cell A).
   - Retrofit one primary cell (Cell A) by installing a higher-capacity aeration system, two or three partitions to subdivide the cell, and plastic media to promote fixed-film growth.
   - Replace the lagoon transfer structure and access walkway for Cell A.
   - Install new piping between Cell A and the DAF clarifier.

4. **Option 4 – Retrofit to Increase Capacity with Aerated Lagoons.** This second retrofit option would convert the entire lagoon system to aerated lagoons in two phases to double the plant capacity within the existing footprint. The retrofit/expansion would include similar components as described in Option 3 above and would require construction of effluent storage capacity entirely on adjacent land (see Figure 6-8).

   The following main elements are specific to this lagoon retrofit option.

   - Replace the liner and influent pipes in both primary cells (Cells A and B).
   - Retrofit both primary cells with a higher-capacity aeration system, two or three partitions to subdivide each cell, and plastic media to promote fixed-film growth.
   - Replace the lagoon transfer structure and access walkway for Cells A and B.
   - Install new piping to allow the two primary cells to be operated in series.
   - Install new piping from each primary cell to the DAF clarifier.

5. **Option 5 – Complete Replacement with New Facility.** The City could construct an entirely new 0.5-MGD WWTP and abandon all existing components instead of implementing a major renovation or retrofit. The replacement facilities would consist of the same preliminary, secondary and disinfection processes that are recommended for expansions.

It would make sense to combine this replacement with an expansion that would convert the existing lagoon footprint to effluent storage. If the replacement were needed before the expansion was warranted, the existing lagoons could be abandoned until an expansion is needed. However, some regrading and maintenance would be required to prevent that area from becoming an attractant for wildlife.

6. **Common Facilities**. Each option described above would include the following common elements.

   - Add new headworks and replace the influent flow meter.
   - Replace the DAF clarifier.
   - Construct a new building to house the DAF unit(s) and accessories for weather protection.
   - Replace the disinfection equipment with a tablet chlorinator.
   - Coat the interior of the existing chlorine contact tank.
   - Abandon and regrade the polishing pond (Cell E).
   - Replace pumps and associated valves (intermediate, effluent, solids and chemical pumps).
   - Renovate the existing main building and demolish the small chlorination building.
   - Keep the existing sludge drying beds and expand them as part of plant expansions.

   These other facilities could potentially be installed or constructed in a separate project phase from the renovation, retrofit, or replacement of the lagoon system depending on the availability of funds, equipment condition, and other factors.

6.6.3 *Estimates of Probable Present-Worth Costs for Alternative NWWTP Upgrades*

Table 6-11 lists the preliminary estimates of probable costs for the alternative approaches to upgrading the NWWTP and expanding it to a 1.0-MGD capacity. The present worth estimates are based on a 20-year planning period and the alternative descriptions provided above. Breakdowns of these preliminary estimates are presented in Appendix L. The probable cost of expanding effluent storage capacity is not included since it would be about equal for each alternative.

Table 6-11
Estimates of Probable Costs
Alternative NWWTP Upgrades and Expansions

Alternative Approach (1)	Present Worth Costs (in millions – Dec. 2016)				
	Capital (2)	O&M (3)	Salvage Value (3)	Total Life Cycle	Rank
1. Full Renovation of Lagoons	$ 15.67	$ 4.77	$ 3.53	$ 16.91	1
2. Partial Renovation of Lagoons	$ 16.70	$ 5.03	$ 3.78	$ 17.95	4
3. Retrofit to Maintain Capacity (4)	$ 16.32	$ 5.30	$ 3.88	$ 17.74	3
4. Retrofit to Expand Capacity (4)	$ 15.26	$ 5.30	$ 3.72	$ 16.84	1
5. Replace w/New Facility	$ 17.63	$ 5.30	$ 4.03	$ 18.90	5

(1) Each alternative includes an expansion w/aerated lagoons to provide a 1.0-MGD NWWTP capacity.
(2) Capital costs are probable construction costs with allowances for contractor overhead and profit, mobilization/demobilization, and construction contingencies.
(3) Probable present worth costs were calculated using 1.5% discount over 20-year planning period.
(4) Retrofit would construct aerated lagoon system in place of the existing partially aerated lagoons.

6.6.4 *Evaluation of Alternative NWWTP Upgrades and Expansions*

The estimated probable present worth costs of Options 1 and 4 are essentially equal. Option 1 would involve a full renovation of the existing plant plus an adjacent 0.5-MGD expansion, whereas Option 4 would entail a complete lagoon retrofit to provide a 1.0 MGD capacity. The probable present worth costs for the other three options are estimated to be about 5% to 12% higher.

Both Options 1 and 4 would require the expansion of effluent storage capacity outside the footprint of the existing facilities for a 1.0 MGD facility. As a result, the implementation of either of these options would depend on the FAA accepting the expansion of open lagoon surfaces outside the existing footprint. However, Option 4 would eliminate facultative lagoons from the secondary process and reduce the overall surface area of treatment lagoons relative to Option 1. This smaller footprint for treatment lagoons combined with increased surface agitation in aerated lagoons can help mitigate wildlife attraction.

There is also greater variety in the equipment and process configurations that could be used with aerated lagoons. As a result, there would be more flexibility in establishing the process sizing and layout relative to the partially-aerated, facultative lagoon system.

Options 2 and 3 would allow the conversion of approximately half the existing site into effluent storage, but would still require additional effluent storage capacity outside the existing plant footprint. Option 5 would allow the expansion of effluent storage capacity for a 1.0-MGD plant entirely within the existing lagoon footprint. However, our estimates indicate this option would have the highest present worth cost.

The future expansion of the NWWTP up to 1.5 MGD would require the construction of an effluent storage pond on adjacent land for all options.

6.6.5 *Recommended Approach to NWWTP Upgrades and Expansions*

We recommend the City plan to implement Option 4 for upgrading and expanding the NWWTP for the following reasons.

- Option 4 is estimated to have probable capital and life-cycle costs that are approximately equal to Option 1 and lower than the other options.
- The full retrofit Option 4 provides would eliminate the larger facultative lagoons (secondary cells) that would remain under both Options 1 and 2. Facultative lagoons not only require more area, they also are more prone to algae growth and more likely to act as wildlife attractants.
- There is considerable flexibility in how the aerated-lagoon retrofits can be configured which allows flexibility in tailoring the design capacity of the retrofits to actual development conditions. Potentially, it could even be feasible to fit aerated lagoons with a total capacity of 1.5 MGD within the footprint of the existing lagoon system.
- Aerated lagoons receive more aeration and mixing than the existing lagoon system. This reduces the probability of algae growth and also provides a less attractive environment for water fowl due to greater surface agitation.

Table 6-12 summarizes the recommended Option 4 improvements. The retrofit to upgrade the plant and maintain the 0.5-MGD capacity will likely be completed in phases due to limitations in funding and differing conditions of existing components. The recommended phasing, our estimates of probable project costs for each phase, and project timing are presented in the capital improvements plan (Chapter 8).

Table 6-12
Summary of Proposed Improvements for NWWTP Scenario

A. Phased NWWTP Retrofit to Maintain 0.5-MGD Capacity (Complete within 15 years).

- Replace DAF clarifier, disinfection system, pumps, and related components.
- Construct headworks with mechanical screen and low-energy, vortex grit chamber.
- Retrofit half of the existing lagoons to convert to an aerated lagoon system as the new secondary treatment process.
- Construct an aerobic digester/holding tank for biosolids.
- Prioritize and complete the improvements in phases as funds are available and according to O&M priorities.
- Maintain existing sludge drying beds in service.
- Maintain existing effluent storage pond and associated piping in service.

B. NWWTP Expansion(s) – Future 0.5-MGD Incremental Expansion(s) When Needed to Serve Industrial-Park Developments. (1) (2)

- Expand influent screening and grit removal processes at headworks.
- Construct aerated lagoon system w/clarifier and aerobic digester.
- Provide tablet chlorinator process for effluent disinfection.
- Expand effluent storage capacity.
- Expand sludge drying beds.

(1) Timing of NWWTP expansions would be driven by Industrial-Park developments and any NWWTP expansion would be contingent on acceptance from the FAA.
(2) Phase 2 SWWTP expansion would allow future NWWTP expansions to be delayed or avoided by freeing up most or all the 0.5-MGD NWWTP capacity to serve the Industrial Park.

6.7 EVALUATION OF BIOSOLIDS ALTERNATIVES FOR EXISTING SWWTP

6.7.1 Existing SWWTP Biosolids Handling

Biosolids consisting mostly of water and microorganisms must be routinely wasted from the SWWTP SBR basins to maintain a stable process. These biosolids are pumped to adjacent aerobic digesters where the material receives further treatment. After a sufficient residence time in the digesters, the treated biosolids are pumped to a 4,300-gallon tank truck and hauled to the sludge drying beds at the NWWTP.

Dried material is removed from the drying beds and spread on farmland as a soil amendment. Although data is not currently available on the solids content of the hauled liquid, it is likely to contain approximately 1.0 – 1.5 percent solids on a dry weight basis (98.5 – 99.0 percent water).

Table 6-13 describes the average hauling efforts required to transport biosolids to the drying beds at current flow rates and biosolids production.

Table 6-13
Current Biosolids Hauling Practices

	Description of Practice	Average Value	
1.	Hauling Frequency	6	days/month
2.	Truck Loads:		
	a) Daily	7	loads/day
	b) Annually	504	loads/year
3.	Roundtrip Distance	10	miles/load
4.	Annual Volume Hauled	1.80	MG/year
5.	Approximate Annual Solids Hauled (1)	146,000	lbs./year
6.	Annual Labor Requirement (2)	576	hours/year
7.	Annual Fuel Requirement (3)	1,800	gallons/year
9.	Estimated Hauling Cost (4)	$ 32,000	/year

(1) Assumes 1.0% dry solids content.
(2) City reports 8 hours labor for one worker required per haul day.
(3) City reports 0.5 tank consumed per haul day and 50-gallon tank capacity.
(4) Includes hauling labor, fuel cost, and annual truck maintenance.

The data in Table 6-13 show that biosolids hauling requires approximately 30% of the hours worked by one worker, after deducting leave time. As SWWTP flows increase, biosolids production in the SBR will increase and the hauling effort will need to ramp up accordingly. We estimate the time commitment would increase to approximately 65% for one worker when flows reach the capacity of the proposed Phase One SWWTP expansion.

6.7.2 Descriptions of SWWTP Biosolids Alternatives

General. The only alternative processes we evaluated for the SWWTP were the addition of either biosolids thickening equipment or biosolids dewatering equipment. Each of these options would reduce the volume of water the City would need to transport from the SWWTP and discharge onto the drying beds. Lower biosolids volume would reduce hauling costs and allow a reduction in the required drying bed capacity.

Alternative One – Continue Hauling Dilute Biosolids. The main considerations in continuing current hauling practices are the increasing labor commitment it will require and the need to expand the drying beds to provide capacity to store the high volume of liquid.

Our calculations estimate an additional 48 drying beds would need to be constructed when average flows reach the design flows for the Phase 1 expansion of the SWWTP. This expansion would provide capacity for drying through drainage and evaporation during most of the year, plus seasonal storage capacity when cold and wet conditions can prevent any net moisture loss.

Alternative Two – Biosolids Thickening. The main components specific to this alternative include the following:

- a polymer storage and feed system;
- a flocculation tank;
- the thickener unit with instrumentation and controls;
- a stainless steel discharge bin sized to hold at least 1.5 truckloads of thickened biosolids;
- a positive displacement pump for biosolids transfer to the truck; and
- continued use of the existing tank truck.

The City has identified an existing storage building at the SWWTP as a suitable location to house the thickener and associated equipment. This building is near the site where the tank truck is currently filled with liquid biosolids. Piping would need to be installed to convey thickener supernatant to the plant drain sump for recycling to the headworks.

Staff would operate the thickener on hauling days to reduce the biosolids volume before transferring it to the truck. Our analysis is based on producing material with an average solids content of 4.0%. This is a conservative estimate, since well-operated thickeners commonly produce material at 5.0% solids. We've assumed the thickened biosolids would need to be pumped from the tank truck onto the drying beds to expedite unloading.

We estimate the combined labor required for thickened-biosolids hauling and thickening system O&M would be approximately half the labor required for hauling dilute biosolids. We also estimate an additional 12 drying beds would need to be constructed for the Phase 1 SWWTP expansion, if a thickening system were installed.

Alternative Three – Biosolids Dewatering. This alternative would add a screw press to dewater the biosolids. The digested biosolids would be pumped into the flocculation tank, then flow to the screw press. A dewatered cake would discharge into a hopper and a conveyor system would load the material into a dump truck.

We have assumed the dewatering process with associated equipment would be housed in the same existing storage building identified for the thickener alternative. Similar to the thickener process, recycle piping would need to be installed to the plant drain sump.

Our analysis is based on the screw press producing material with an average solids content of 15%, since the typical production range for a well-operated process is 15 – 18% solids. Because the screw press output must be handled as a solid material, some additional labor time would be needed to spread the cake onto the drying beds to facilitate the evaporation process. It is unlikely that any drainage would occur from the dewatered material as it does most of the year from liquid biosolids.

We have included the purchase of a used dump truck with a 25 cubic yard capacity for hauling biosolids to the drying beds. Assuming the purchase of a used truck allows for a fair comparison to the other alternatives, since the existing tank truck is used. A truck with a minimum 25 cubic yards load capacity is needed since a smaller, conventional dump truck with a 10-14 cubic yard capacity would not carry enough material in each load to be cost competitive.

Since dewatered solids from a screw press would require very little winter storage capacity, we estimate existing drying bed capacity would be adequate for the biosolids produced at the proposed Phase One design flows.

6.7.3 *Estimates of Probable Present-Worth Costs for SWWTP Biosolids Alternatives*

Table 6-14 summarizes the preliminary estimates of probable costs for each biosolids alternative. These estimates are given as present worth costs using a 20-year planning period. Breakdowns of these preliminary estimates are presented in Appendix L.

Table 6-14
Estimates of Probable Costs – SWWTP Biosolids Handling Alternatives

Biosolids Handling Alternative	Present Worth Costs (in thousands – Dec. 2016)				
	Capital (1)	O&M (2)	Salvage Value (2)	Total Life Cycle	Rank
1. Haul Dilute Liquid Biosolids (3)	$ 1,270	$ 910	$ 350	$ 1,830	3
2. Add Thickening Process (4)	$ 875	$ 605	$ 160	$ 1,320	1
3. Add Dewatering Process	$ 970	$ 695	$ 120	$ 1,545	2

(1) Capital costs are probable construction costs with allowances for contractor overhead and profit, mobilization/demobilization, and construction contingencies.
(2) Probable present worth costs were calculated using 1.5% discount over 20-year planning period.
(3) Capital costs are for the addition of 48 drying beds (Total of 72 beds).
(4) Capital costs include the thickening process and the addition of 12 drying beds (Total of 36 beds).

The addition of a thickening process is estimated to have significantly lower life-cycle costs than the other alternatives. This is estimated to include both lower capital investments and lower O&M costs. We estimate the life-cycle costs of a dewatering process would more than offset the savings from not expanding the drying beds.

The combined labor required for Alternative Three (dewatered-biosolids) is estimated to be slightly less than the combined labor required for Alternative Two (thickened-biosolids). However, Alternative Three is estimated to have approximately 10% higher O&M costs than Alternative Two because of higher polymer use. Other material costs for maintenance and repairs would also be higher with the addition of a dewatering unit.

6.7.4 *Evaluation of Nonmonetary Considerations*

Alternatives Two and Three would increase reliance on mechanical equipment. However, neither of the processes is particularly complex or difficult to maintain. The thickening and dewatering equipment are also proven technologies that are widely used for biosolids.

Key considerations in evaluating the biosolids handling alternatives include the impacts of transporting the material between sites. Alternatives Two and Three would significantly reduce the environmental impacts and safety concerns associated with biosolids hauling. Both these alternatives would also reduce land requirements for drying bed expansions.

The thickening process would require the addition of approximately half the polymer that the dewatering unit would require. This has environmental benefits due to lower energy use for manufacturing and transporting the chemicals. There are also safety and housekeeping benefits from less handling of polymer drums and polymer feed equipment.

Alternative Two also has the potential operating benefit of allowing thickened biosolids to be pumped back to the digesters with the addition of return sludge piping. Circulating a portion of the digester contents through the thickener could effectively increase the volumetric capacity of the digesters by reducing water content. This practice would be more costly than decanting, but far more effective in removing water.

Overall, Alternative Two offers clear nonmonetary benefits that further establish the cost effectiveness of the biosolids thickening alternative.

6.7.5 Recommended SWWTP Biosolids Alternative

Given the clear monetary and nonmonetary benefits to adding a thickening process at the SWWTP, we recommend the City implement Alternative Two. Because the thickener will reduce O&M costs, we propose the City consider this a high-priority improvement.

The thickening process should be designed to accommodate the future addition of a dewatering process in case a more cost effective dewatering option is developed or other conditions change.

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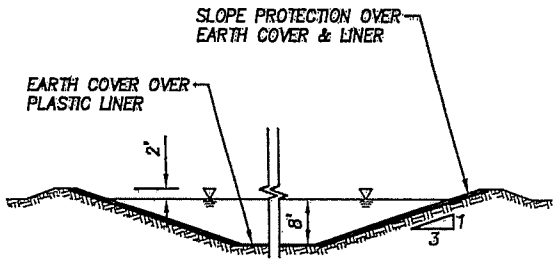
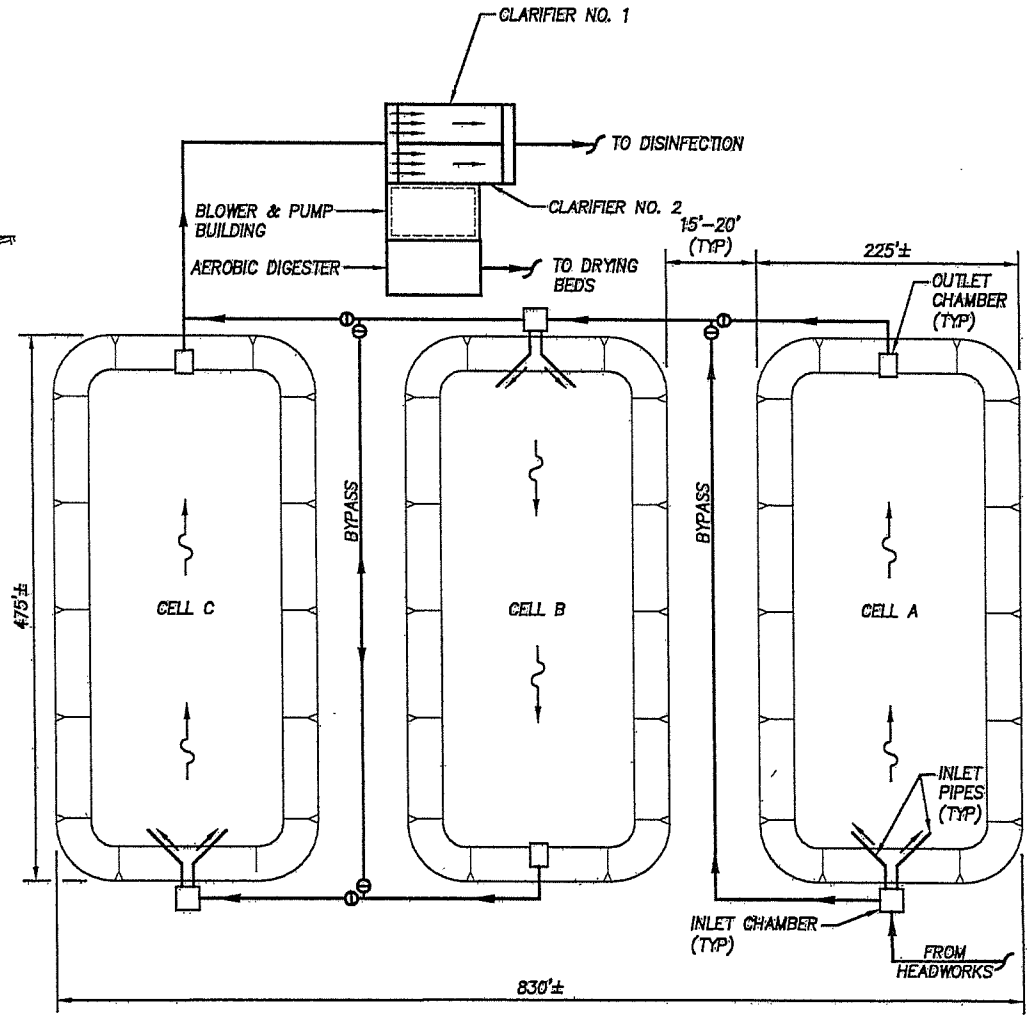


TYPICAL LAGOON SECTION
N.T.S



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AERATED / PARTIALLY-MIXED LAGOON PROCESS LAYOUT

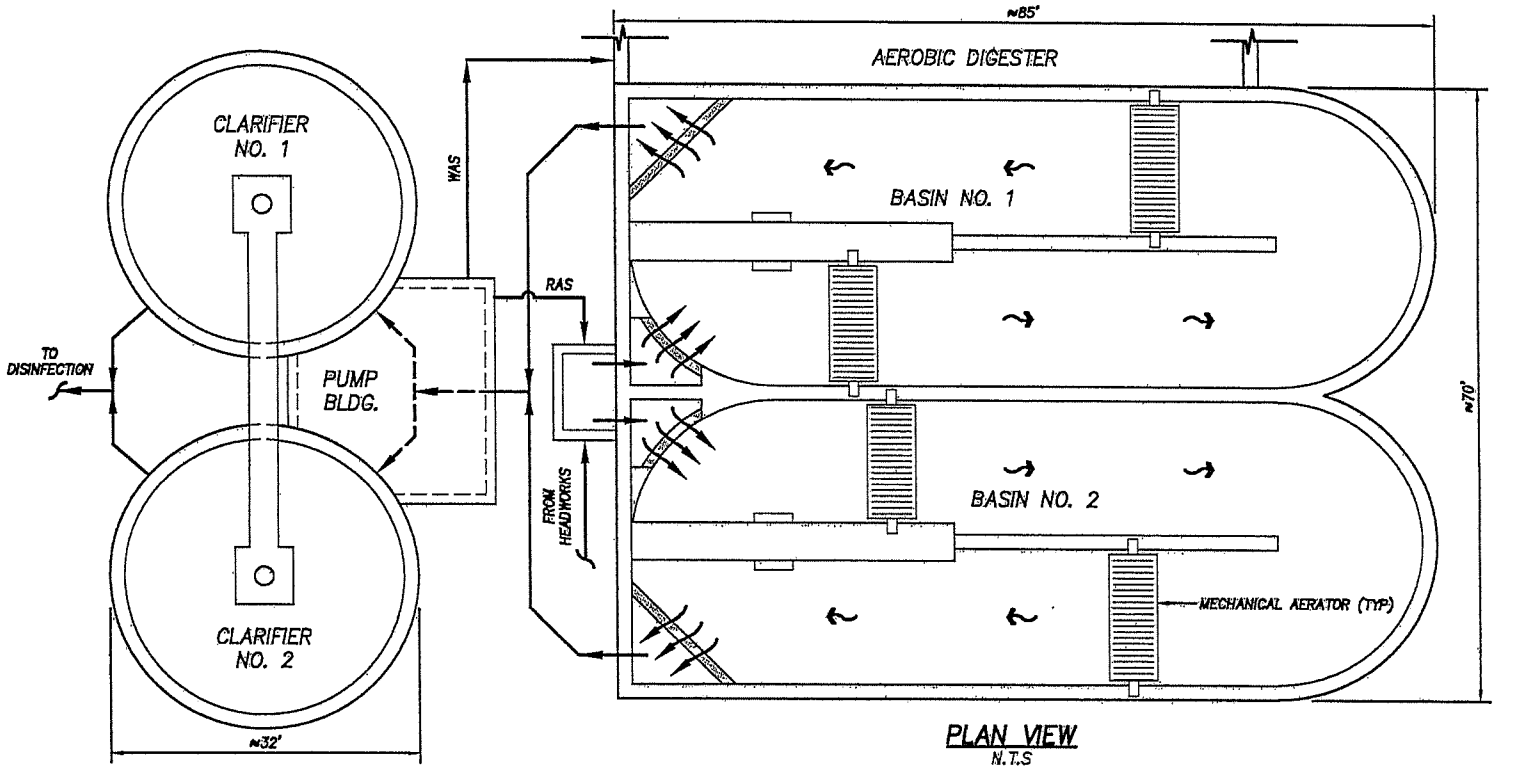
WASTE WATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

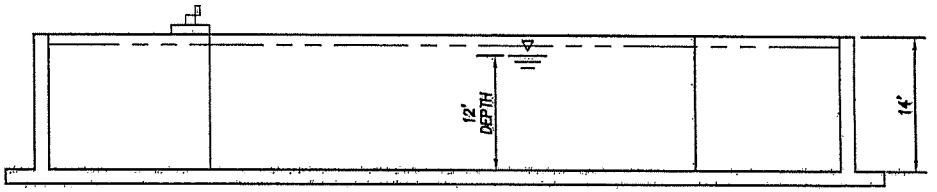
SHEET NO. FIG 6-1

JOB NO. MAD-02

NOV 2017



PLAN VIEW
N.T.S



TYPICAL SECTION
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OXIDATION DITCH PROCESS LAYOUT

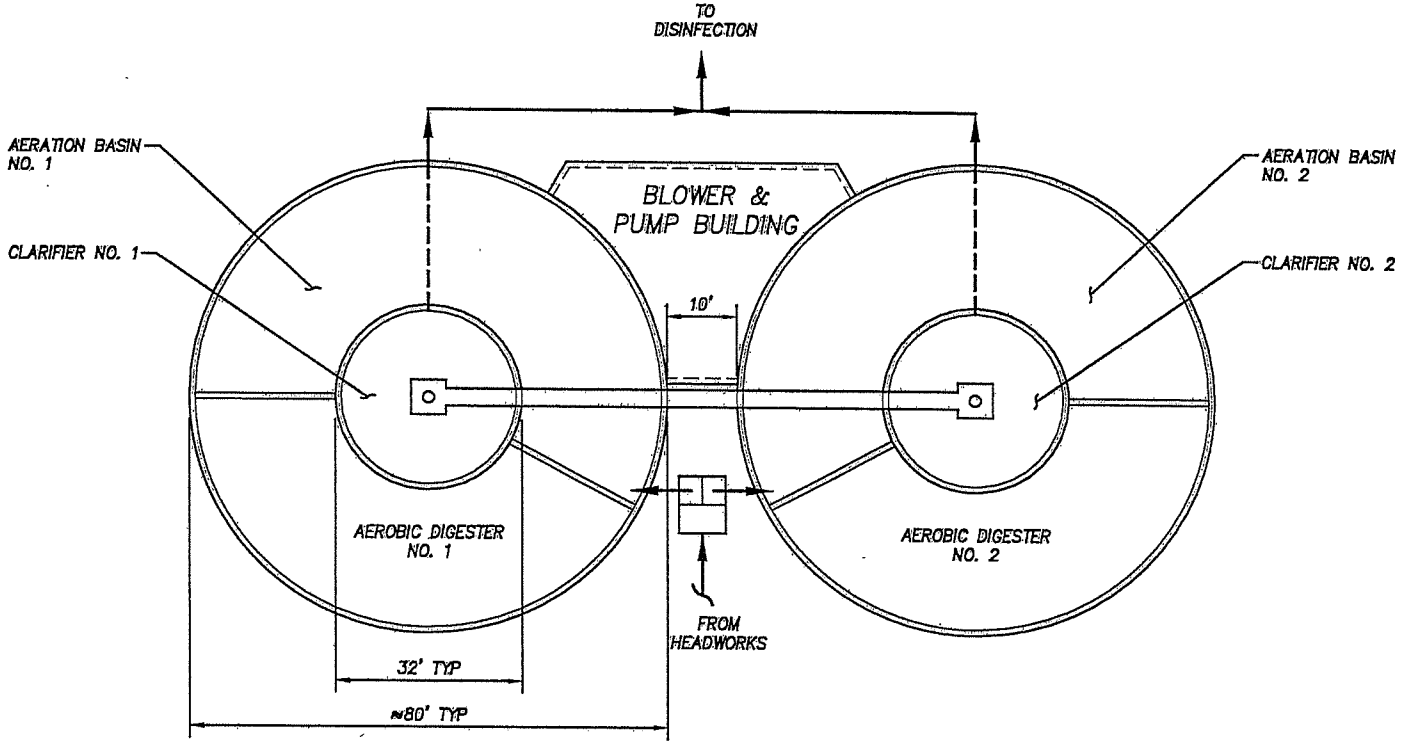
WASTE WATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

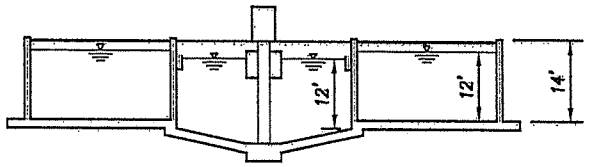
FIG 6-2

JOB NO. MAD-02

NOV 2017



PLAN VIEW
N.T.S



SECTION VIEW
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COMPACT EXTENDED AERATION PROCESS LAYOUT

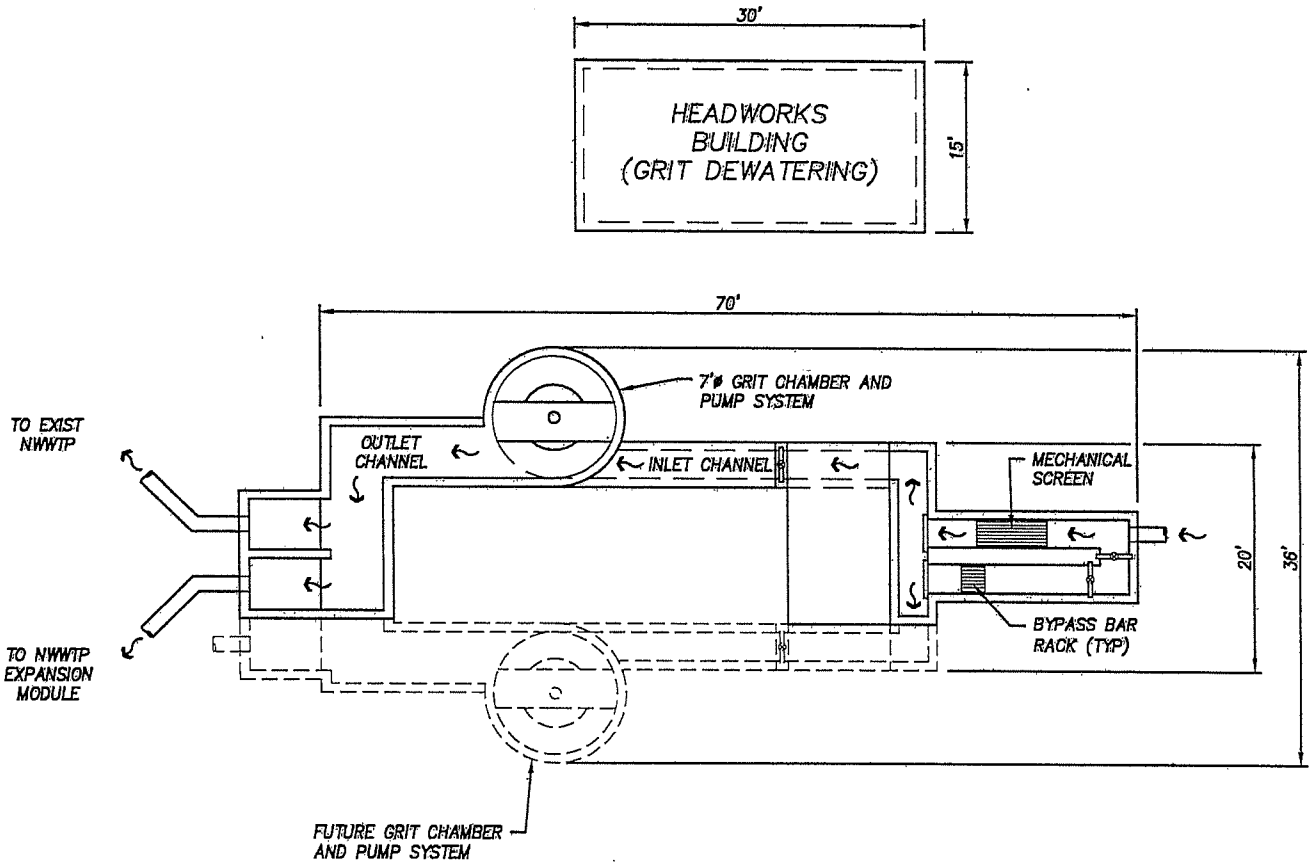
WASTE WATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

SHEET NO. FIG 6-3

JOB NO. MAD-02

NOV 2017



PLAN VIEW
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PROPOSED NWWTP HEADWORKS LAYOUT

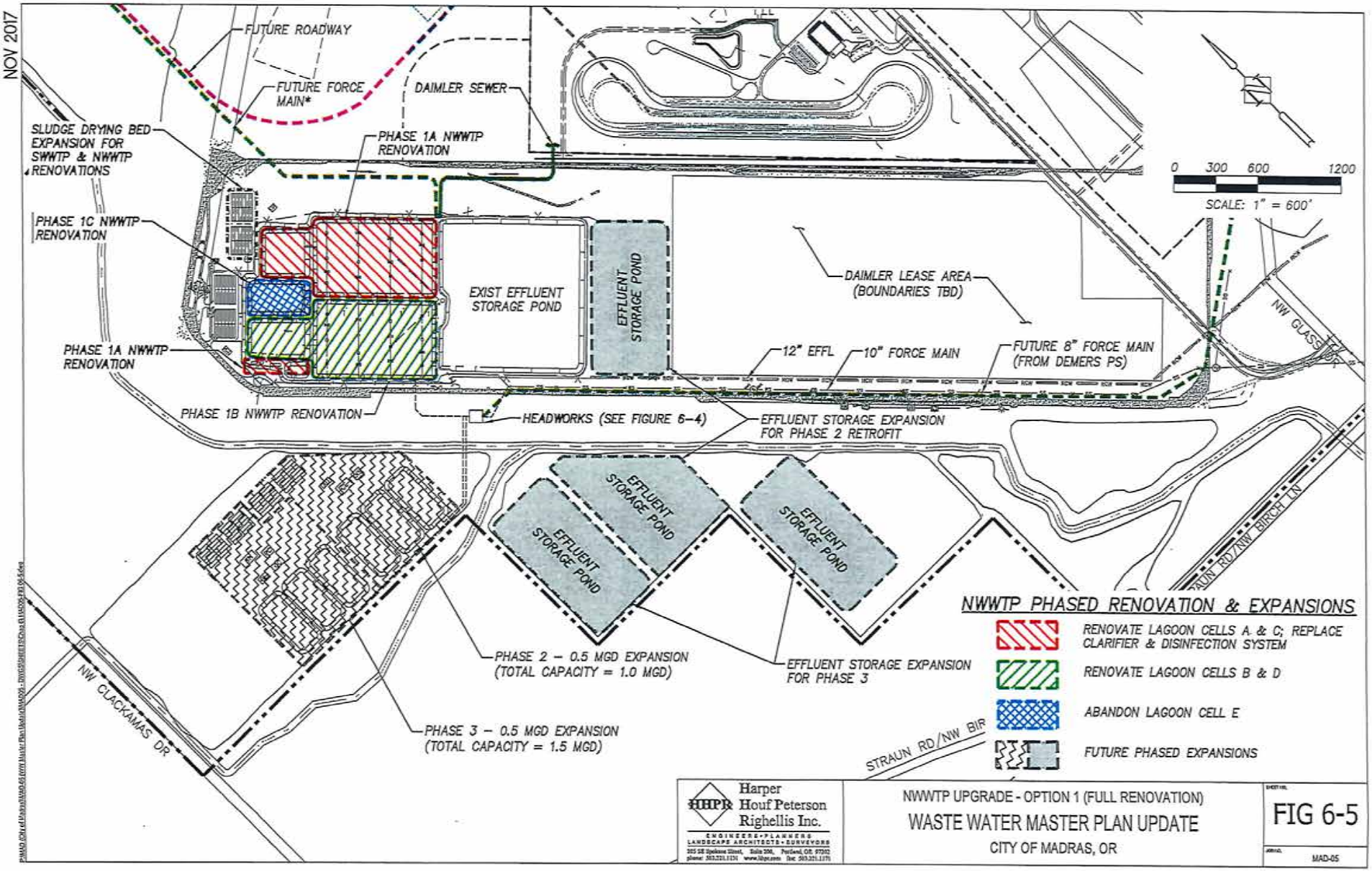
WASTE WATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

SHEET NO.
FIG 6-4

JOB NO.
MAD-02

NOV 2017



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NWWTP UPGRADE - OPTION 1 (FULL RENOVATION)

WASTE WATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

FIG 6-5

MAD-05

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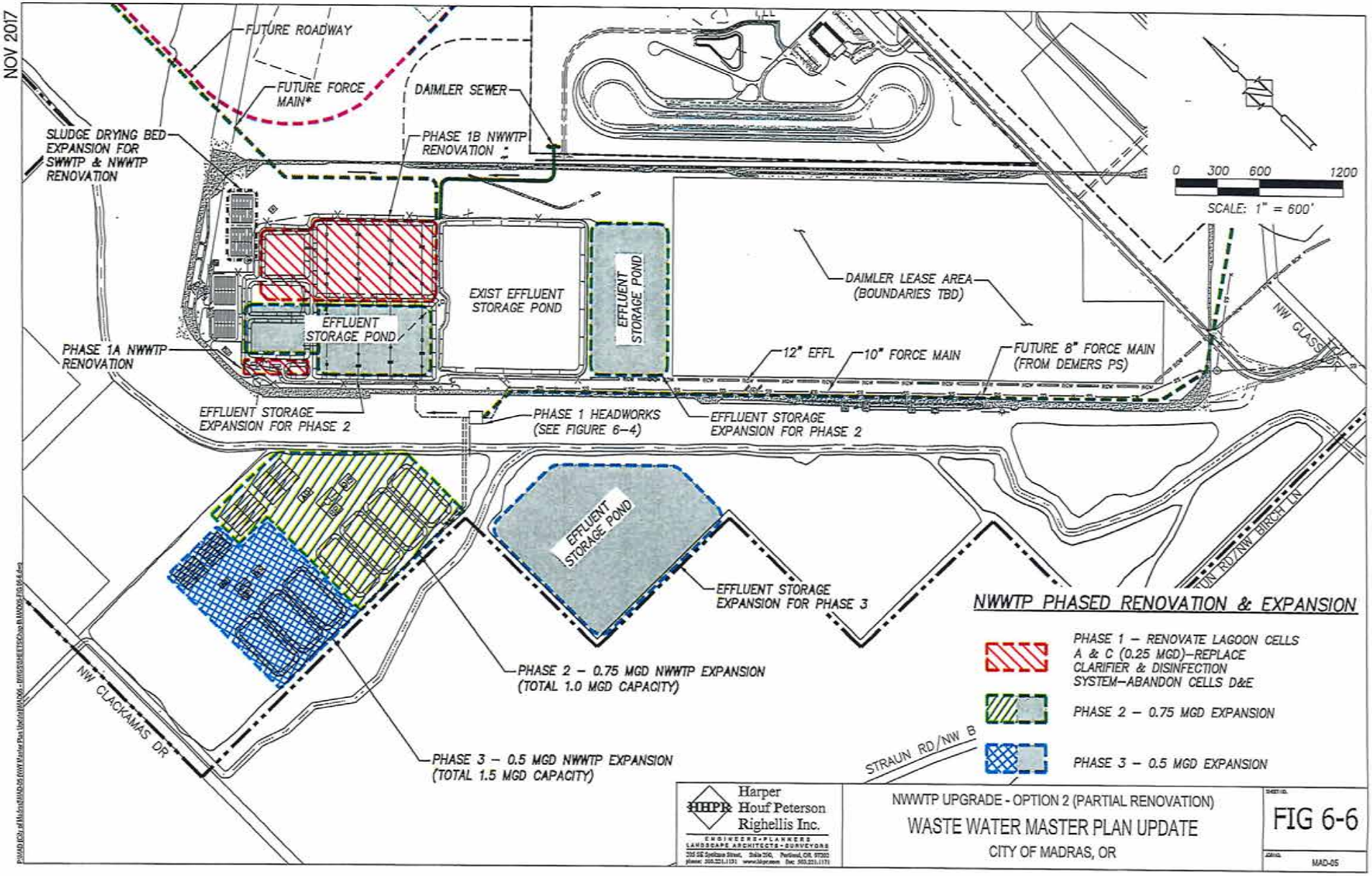

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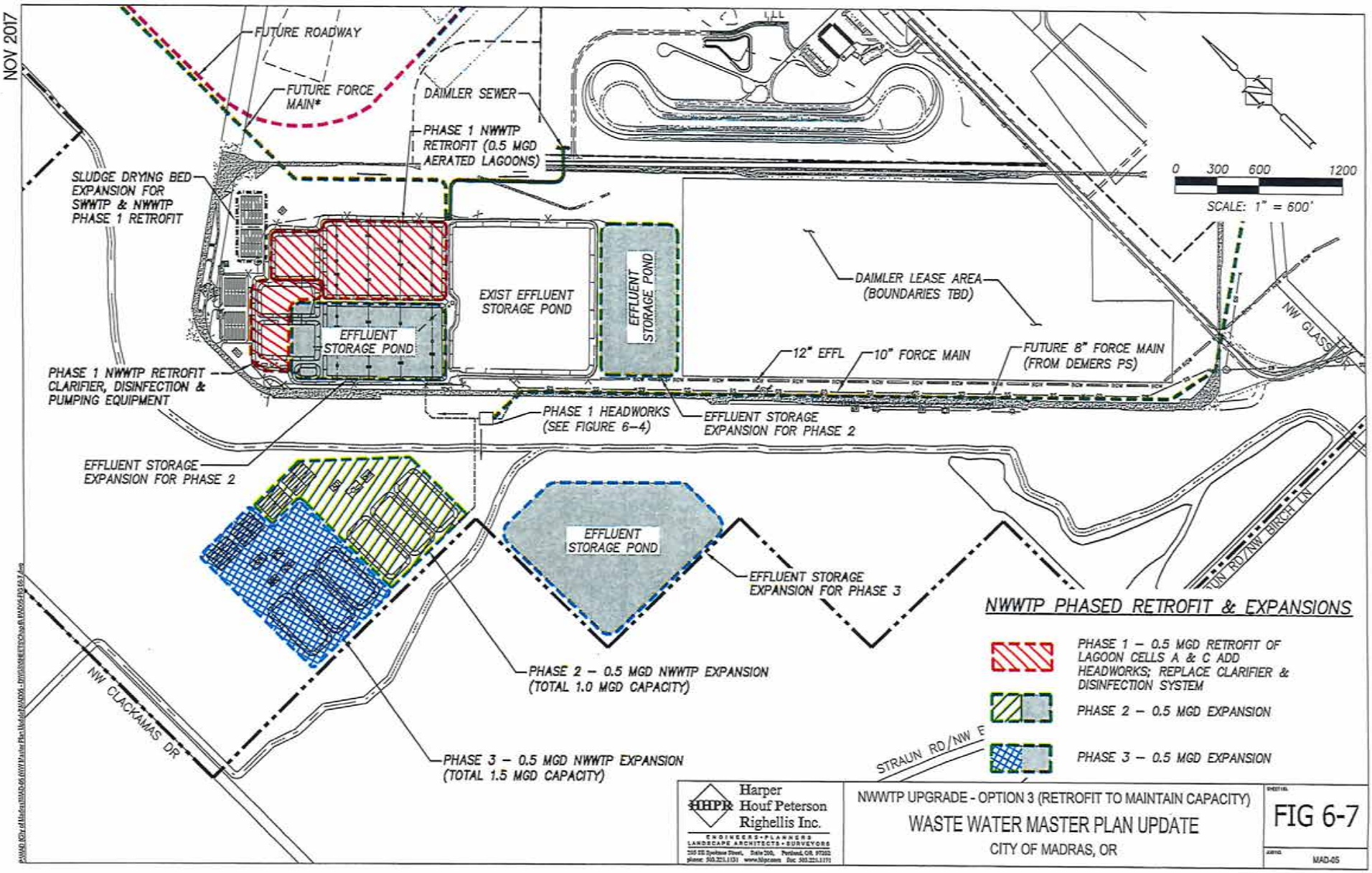
NWWTP UPGRADE - OPTION 2 (PARTIAL RENOVATION)

WASTE WATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

FIG 6-6

MAD-05



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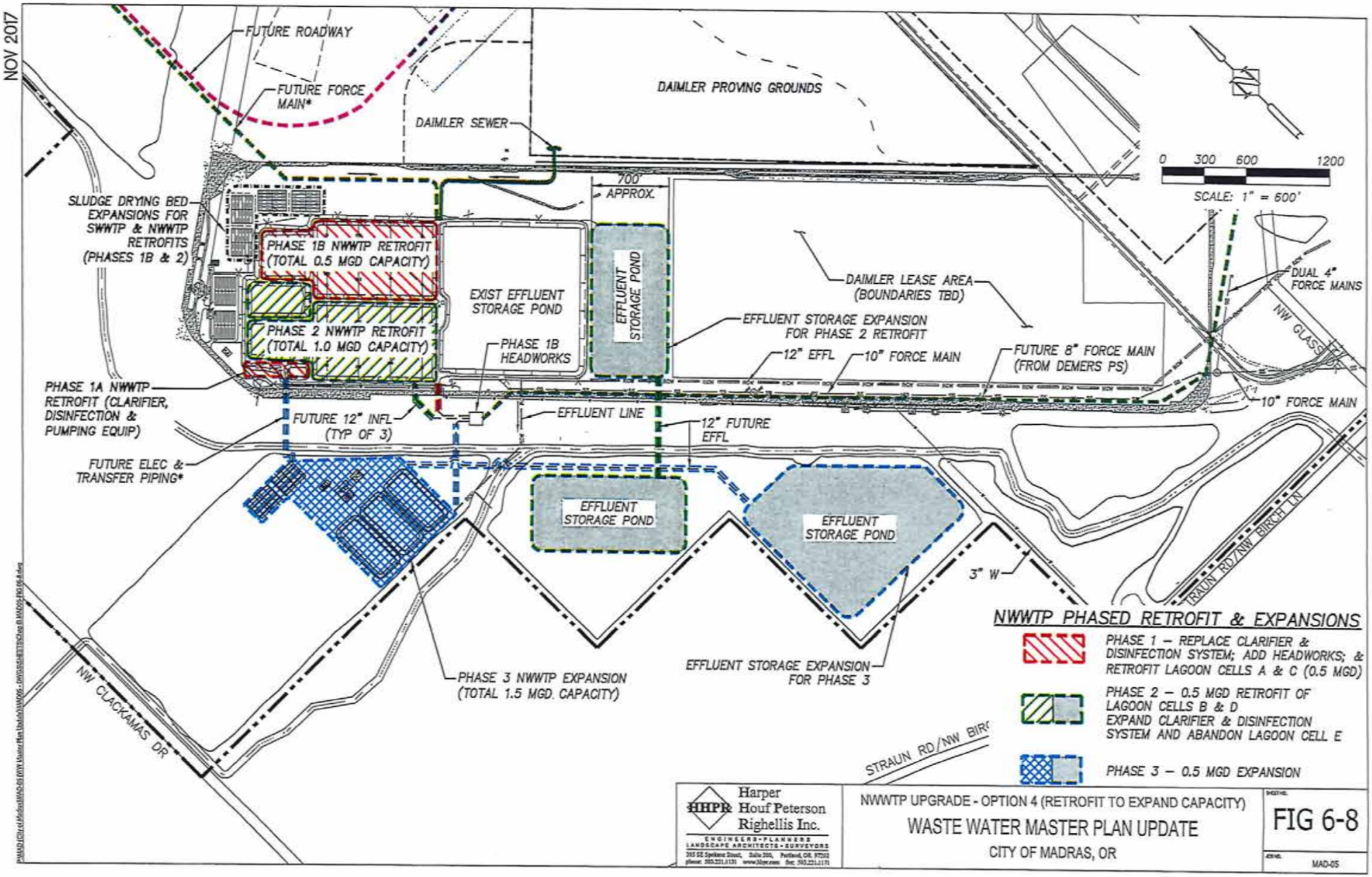
NWWTP UPGRADE - OPTION 3 (RETROFIT TO MAINTAIN CAPACITY)

WASTE WATER MASTER PLAN UPDATE

CITY OF MADRAS, OR

FIG 6-7

MAD-05


NOV 2017
FUTURE ROADWAY
FUTURE FORCE MAIN*
DAIMLER SEWER
DAIMLER PROVING GROUNDS
0 300 600 1200
SCALE: 1" = 600'
700' APPROX.
SLUDGE DRYING BED EXPANSIONS FOR SWWTP & NWWTP RETROFITS (PHASES 1B & 2)
PHASE 1B NWWTP RETROFIT (TOTAL 0.5 MGD CAPACITY)
PHASE 2 NWWTP RETROFIT (TOTAL 1.0 MGD CAPACITY)
EXIST EFFLUENT STORAGE POND
EFFLUENT STORAGE POND
PHASE 1B HEADWORKS
DAIMLER LEASE AREA (BOUNDARIES TBD)
EFFLUENT STORAGE EXPANSION FOR PHASE 2 RETROFIT
12" EFFL
10" FORCE MAIN
FUTURE 8" FORCE MAIN (FROM DEMERS PS)
DUAL 4" FORCE MAINS
NW GLASS
10" FORCE MAIN
PHASE 1A NWWTP RETROFIT (CLARIFIER, DISINFECTION & PUMPING EQUIP)
FUTURE 12" INFL (TYP OF 3)
EFFLUENT LINE
12" FUTURE EFFL
FUTURE ELEC & TRANSFER PIPING*
EFFLUENT STORAGE POND
EFFLUENT STORAGE POND
3" W
TRAUN RD/NW BIRCH LN
PHASE 3 NWWTP EXPANSION (TOTAL 1.5 MGD. CAPACITY)
EFFLUENT STORAGE EXPANSION FOR PHASE 3
NW CLACKAMAS DR
STRAUN RD/NW BIR
NWWTP PHASED RETROFIT & EXPANSIONS
PHASE 1 – REPLACE CLARIFIER & DISINFECTION SYSTEM; ADD HEADWORKS; & RETROFIT LAGOON CELLS A & C (0.5 MGD)
PHASE 2 – 0.5 MGD RETROFIT OF LAGOON CELLS B & D EXPAND CLARIFIER & DISINFECTION SYSTEM AND ABANDON LAGOON CELL E
PHASE 3 – 0.5 MGD EXPANSION
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NWWTP UPGRADE - OPTION 4 (RETROFIT TO EXPAND CAPACITY)
WASTE WATER MASTER PLAN UPDATE
CITY OF MADRAS, OR
FIG 6-8
MAD-05

CHAPTER 7
EFFLUENT STORAGE AND RECYCLING

7.1 GENERAL

The City uses lined ponds for seasonal storage of effluent from each wastewater treatment plant (WWTP) and recycles the effluent through irrigation during the growing season. Effluent storage consists of a 79-million gallon (MG) pond at the North WWTP (NWWTP) site and two ponds near the South WWTP (SWWTP), an 88-MG pond about 1.8 miles east of the plant and a 25-MG pond at the plant site. Figures 7-1 and 7-2 show the locations of the existing storage ponds.

The City owns property near each WWTP that it leases as farmland and uses for effluent recycling. The municipal golf course also uses NWWTP effluent for irrigation. Effluent recycling generally supplements the use of irrigation water obtained from the North Unit Irrigation District (NUID) through existing water rights. Because this water recycling helps to conserve NUID irrigation water, the State considers recycling a beneficial use of the treated effluent produced at each WWTP.

We have developed estimates for future effluent storage and farmland requirements based on the assumption that the City will continue to recycle all effluent flows with no surface water discharge.

7.2 EFFLUENT STORAGE VOLUME REQUIREMENTS

Table 7-1 lists the effluent storage volumes needed for each incremental expansion described in Chapter 6 for the two WWTPs. The requirements are based on our estimate that a 79-MG volume is needed for each 0.5-MGD in average design capacity at either WWTP. Appendix M includes a water balance table and explanatory notes describing the basis for our estimate.

Table 7-1
Projected Storage Capacity Requirements for Both WWTPs

Phase Description (Capacity)	Required Storage Volume (MG) (1)	Projected Surplus or Deficit (MG) (2)
A. NWWTP		
Phase 1 Retrofit/Current Capacity (0.50 MGD)	79	0
Phase 2 – Expansion 1 (1.00 MGD)	158	-79
Phase 3 – Expansion 2 (1.50 MGD)	237	-158
B. SWWTP		
Current Capacity (0.54 MGD)	85	28
Phase 1 Expansion (0.65 MGD)	103	10
Phase 2 Expansion (1.15 MGD)	182	-69

NOTES:

(1) Estimates of required storage volume are based on the following conditions:
- Both the maximum annual precipitation (1983 Western Regional Climate Center, Madras Data) and minimum annual evaporation (1993 NUID Data) occur.
- Average annual flows equal to 90% of WWTP design capacity (maximum monthly flow).
- All effluent produced from October 10 through April 15 must be stored.

(2) Surplus/deficit based on existing storage capacities of 79 MG at NWWTP and 113 MG at SWWTP.

7.3 FARMLAND REQUIREMENTS FOR EFFLUENT RECYCLING

7.3.1 Existing Recycling Sites

Table 7-2 summarizes the acreages of the irrigation sites the City can potentially use for recycling effluent from the NWWTP and Figure 7-1 shows the locations of these sites. The table also shows projections for the future available farmland when the NWWTP reaches the average design capacity of each proposed phase of improvements described in Chapter 6. These projections deduct lands where commercial/industrial developments would occur under current land-use plans or where NWWTP expansions are proposed.

Table 7-2
NWWTP Effluent Recycling Sites
Current and Projected Availability

Site Designation	Current Gross Site Area (AC)	Projected Net Usable Area (AC) [1]		
		Phase 1 Retrofit [2]	Phase 2 Expansion [3]	Phase 3 Expansion [4]
Farm Field 6	41	37	37	37
Farm Field 7	12	11	11	11
Farm Field 8	34	31	31	20
Farm Field 9	38	34	20	--
Farm Field 11 [5]	68	61	61	43
Farm Field 14	53	---	---	---
Farm Fields 21 & 22 [6]	---	---	---	---
Municipal Golf Course [7]	75	71	114	114
Total Area	**321**	**245**	**274**	**225**
Farmland Area	**246**	**174**	**160**	**111**

NOTES:

(1) Net usable area assumes 90% of farmland and 95% of golf course are available for effluent recycling each season. This assumes the remaining land would be used as buffer, left fallow, or used for crops not suitable for effluent.

(2) Phase 1 Projection (0.5-MGD Retrofit): deduct Field 14 due to airport development.

(3) Phase 2 Projection (1.0-MGD): deduct 16 gross acres for expansion of effluent storage capacity (part of Field 9). Net usable farmland deducted = 62 acres.

(4) Phase 3 Projection (1.5-MGD): deduct 55 gross acres for NWWTP expansion (remainder of Field 9 and parts of Fields 8 & 11). Net usable farmland deducted = 49 acres.

(5) Field 11 is currently leased for farming, but is not irrigated with effluent.

(6) Fields 21 and 22 are no longer available for effluent recycling due to developments that have cut off routes for effluent transmission piping.

(7) Planned golf course expansion would result in a 43-acre increase in net usable land at golf course. We assume the expansion would occur before NWWTP flows reach the Phase 2 capacity.

Tables 7-3 summarizes the acreages of the irrigation sites the City can potentially use for recycling effluent from the SWWTP and Figure 7-2 shows the locations of these sites. Development plans for the "Upper Parcel" call for the construction of a golf course that would be irrigated with recycled water in the future. If the golf course is not developed before the City needs more land for effluent recycling, this site could be used in the interim as farmland for irrigation opportunities.

Table 7-3
SWWTP Effluent Recycling Sites
Current and Future Farmland Availability

	Areas of Dedicated Sites (AC)	
Site Designation	**Total Site Area**	**Net Usable Area (1)**
Existing Woodworth Farmland	76	68
Existing Deschutes Basin Farms	35	32
Current Available Farmland	**111**	**100**
Addition of Upper Parcel (2)	193	174
Total Future Farmland Area	**304**	**274**

NOTES:

(1) Net usable area assumes 90% of total farmland is available for effluent recycling each season. This assumes the remaining land would be used as buffer, left fallow, or used for crop not suitable for effluent.

(2) Upper parcel, east of SWWTP, originally obtained for future golf course construction. Our analysis assumes the City would use the site as farmland for effluent recycling until golf course development occurs.

7.3.2 *Projected Recycling Land Requirements*

To address future recycling needs, we estimated the amount of farmland required for future effluent volumes when the WWTP expansions described in Chapter 6 are implemented. The estimates are based on information presented in the previously-prepared effluent reuse plans (CH2M Hill, 1993, and ACE Consultants, 2007). We also updated the information in these reuse plans based on input from the City regarding effluent uses. Our calculations for the NWWTP deduct effluent volume used to satisfy about 25% of the irrigation demand for the municipal golf course.

Tables 7-4 and 7-5 (end of chapter) summarize farmland requirements for recycling effluent from each WWTP when peak-monthly flows reach the capacity of each proposed WWTP improvement. The tables also show estimates of farmland required at current flow rates and Table 7-5 includes an estimate for conditions when the Deer Ridge facility would contribute its full flow allowance.

Key assumptions used in developing our estimates are described in the notes following the tables. The irrigation usage was estimated using water demand for alfalfa because the intermediate irrigation requirements for this crop are representative of average conditions. Grass crops generally have higher water demands and grains generally require lesser amounts.

A higher irrigation efficiency has been assumed for farmland around the airport because the shallow depth to rock may reduce the water losses through infiltration below the top soil with crop roots. The higher efficiency means less water can be applied to meet the crop demands.

Future farmland requirements for NWWTP effluent would be reduced relative to Table 7-4, if more than 25% of the water demand for the golf course can be met using recycled water. Also, there would be a smaller farmland shortfall for SWWTP effluent in the future relative to Table 7-5, if a golf course is developed as planned on the available parcel. This is because water demands for turf grass would be higher than those for the reference crop of alfalfa. Appendix M includes additional tables and explanations that further describe the basis for the acreage estimates.

7.4 SUMMARY

NWWTP Effluent Storage. The City will need to expand effluent storage volume in conjunction with a NWWTP expansion above current capacity. We estimate a 79-MG expansion of effluent storage capacity would be required with each proposed 0.5-MGD expansion of average capacity. Figure 6-8 identifies potential sites for the additional storage ponds near the NWWTP site.

NWWTP Farmland. As shown in Table 7-4, we project the NWWTP would have a farmland deficit of approximately 37 acres when peak monthly flows reach 0.50 MGD. This estimate accounts for the loss of fields in the airport area due to potential development. Existing irrigable lands might meet the City's needs at this flow rate, if more of the golf-course water demand were met using recycled water. However, the City should plan to identify and purchase at least 40 more acres of farmland to use for irrigation within the planning period.

Our projections also show the NWWTP site would face a farmland deficit of approximately 300 acres and 610 acres for design flows of 1.0 MGD and 1.5 MGD, respectively. These deficits would also be less, if more of the golf-course water demand can be met with recycled effluent.

SWWTP Effluent Storage. Our estimate shows there is enough effluent storage volume for a design capacity up to about 0.70 MGD at the SWWTP. Therefore, no expansion of storage capacity would be required for the Phase One expansion. However, an additional 70-MG storage pond would be required in conjunction with an expansion to 1.15 MGD. The existing site of the upper storage pond for the SWWTP has room for the future addition of another pond.

SWWTP Farmland. We estimate the existing 111 acres of total available farmland for effluent recycling can accommodate average annual flows up to about 0.24 MGD at the SWWTP. As a result, the City should plan to make the future golf course parcel available for irrigation in 5 years or sooner, if flow contributions from Deer Ridge increase significantly. Since the timing of the future golf course development is uncertain, we have included a project in the capital improvements plan (Chapter 8) to provide an irrigation system for that site to allow it to be used as farmland.

As shown in Table 7-5, we estimate the City would need to add about 125 acres of the upper parcel as farmland to handle an average annual flow equal to the current SWWTP capacity of 0.54 MGD. If the full 193-acre site is made available as farmland, there would be a surplus of 28 acres when flows reach the 0.65-MGD design capacity of the proposed Phase 1 expansion.

According to our projections, there would be a farmland deficit of almost 180 acres when flows reach the Phase 2 capacity of 1.15 MGD. This deficit could be reduced, if the future golf course is developed as planned and effluent is used to meet most or all of the irrigation demand.

Probable Costs. Chapter 8 provides estimates of probable costs for expanding effluent storage capacity as part of WWTP expansions. Chapter 8 also includes probable costs for purchasing additional farmland near the NWWTP and conveying recycled effluent to this property.

Table 7-4
NWWTP Effluent Recycling – Summary of Projected Farmland Requirements

Phase Description	Avg. Design Flow (MGD) (Note 1)	Projected Avg. Annual Flow (MGD) (Note 2)	Net Recycled Water Volume (MG) (Note 3)	Total Farmland Requirements (Acres)		
				Farmland Required (Note 4)	Net Available Farmland (Note 5)	Projected Land Surplus or Deficit
Current Conditions	--	0.31	81	130	222	92
Phase 1 - Retrofit	0.50	0.45	132	211	174	-37
Phase 2 - Expansion 1	1.00	0.90	285	457	160	-297
Phase 3 - Expansion 2	1.50	1.35	449	721	111	-610

NOTES:

(1) Average Design Flow = Projected Peak Monthly Flow.

(2) Average Annual Flow = 90% of Peak Monthly Flow.

(3) Recycled Water Volume = Net Available Water (Treated Effluent + Stored Precipitation - Pond Evaporation - Golf Course Irrigation).
   a. Assume maximum year precipitation (1983 Western Regional Climate Center, Madras Data).
   b. Assume minimum year evaporation (1993 NUID Data).
   c. Effluent use at Municipal Golf Course assumes 25% of gross demand for turf grass. NUID water would be used for the remaining water demand.
   d. Assume future Municipal Golf Course expansion increases acreage by 60% and occurs before NWWTP flows reach 1.0 MGD (Phase 2 capacity).

(4) Required farmland based on average, net irrigation demand for alfalfa.
   a. Assume irrigation efficiency = 85% .
   b. Net irrigation demand estimated to cover 80% of gross water demand for alfalfa satisfied by recycled effluent (remainder from NUID).

(5) Net available farmland is equal to projected available acreages shown in Table 7-2.
   a. Assume 90% of total acreage available for effluent application (remainder left fallow or used to grow food crop).
   b. Current available farmland assumed to be 80% of remaining fields in airport area (Fields 6, 7, 8, 9, 11, & 14). Fields 21 & 22 no longer available.
   c. Phase 1: Subtract Field 14.
   d. Phase 2: Subtract an additional 16 acres of land for one Phase 2 effluent storage pond (part of Field 9, in addition to Phase 1 subtraction).
   e. Phase 3: Subtract another 55 acres of land for Ph. 3 WWTP module & effluent ponds (parts of Fields 8 & 11 & remainder of Field 9). Also subtract an additional 120 acres of land for development of airport land (Field 11 & remainder of Fields 21 & 22).

Table 7-5
SWWTP Effluent Recycling – Summary of Projected Farmland Requirements

Phase Description	Avg. Design Flow [1] (MGD)	Projected Avg. Annual Flow [2] (MGD)	Net Recycled Water Volume [3] (MG)	Total Farmland Requirements (Acres)		
				Farmland Required [4]	Net Available Farmland [5]	Projected Land Surplus or Deficit
Approximate Current Flow	--	0.22	66	88	100	12
Full Prison & Current Flows	--	0.40	131	177	100	-77
Current SWWTP Capacity	0.54	0.45	150	201	274	73
Phase 1 Expansion	0.65	0.54	183	246	274	28
Phase 2 Expansion	1.15	0.86	335	450	274	-176

NOTES:

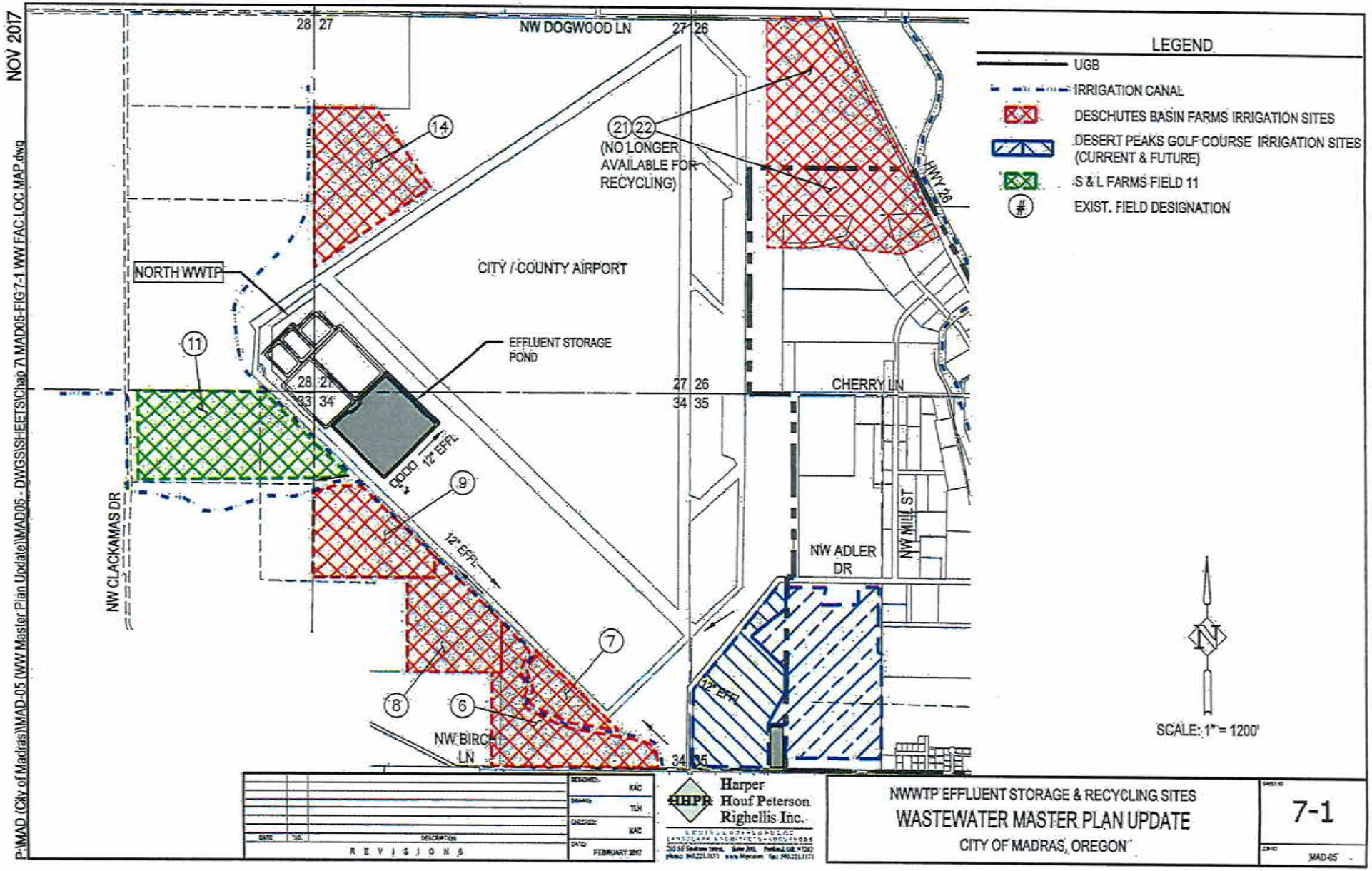
(1) Average Design Flow = Projected Peak Monthly Flow.

(2) Average Annual Flow = 90% of Peak Monthly Flow.

(3) Recycled Water Volume = Net Available Water (Treated Effluent + Stored Precipitation - Pond Evaporation - Golf Course Irrigation).
   a. Assume maximum year precipitation (1983 Western Regional Climate Center, Madras Data).
   b. Assume minimum year evaporation (1993 NUID Data).

(4) Required farmland based on average, net irrigation demand for alfalfa.
   a. Assume irrigation efficiency = 80% .
   b. Net irrigation demand assumes 90% of alfalfa gross water demand satisfied by recycled effluent (remainder from NUID).

(5) Net available farmland is equal to projected available acreages shown in Table 7-3.
   a. Assume 90% of total acreage available for effluent application (remainder left fallow or used to grow food crop).
   b. Conditions listed for current flow and full-prison flow include area of Woodworth and McTaggart lots.
   c. Listings for flows at current, Phase 1, and Phase 2 capacities include Woodworth, McTaggart and future Golf Course lands.



NOV 2017
P:\MAD (City of Madras)\MAD-05 (WW Master Plan Update)\MAD05 - DWGS\SHEETS\Chap 7\MAD05-FIG 7-1 WW FAC LOC MAP.dwg
LEGEND
UGB
IRRIGATION CANAL
DESCHUTES BASIN FARMS IRRIGATION SITES
DESERT PEAKS GOLF COURSE IRRIGATION SITES (CURRENT & FUTURE)
S & L FARMS FIELD 11
EXIST. FIELD DESIGNATION
NW DOGWOOD LN
CITY / COUNTY AIRPORT
NORTH WWTP
EFFLUENT STORAGE POND
(NO LONGER AVAILABLE FOR RECYCLING)
HWY 26
CHERRY LN
NW ADLER DR
NW MILL ST
NW CLACKAMAS DR
NW BIRCH LN
12" EFFL
SCALE: 1" = 1200'
REVISIONS
DESIGNED: KAC
DRAWN: TLH
CHECKED: KAC
DATE: FEBRUARY 2017
Harper Houf Peterson Righellis Inc.
NWWTP EFFLUENT STORAGE & RECYCLING SITES
WASTEWATER MASTER PLAN UPDATE
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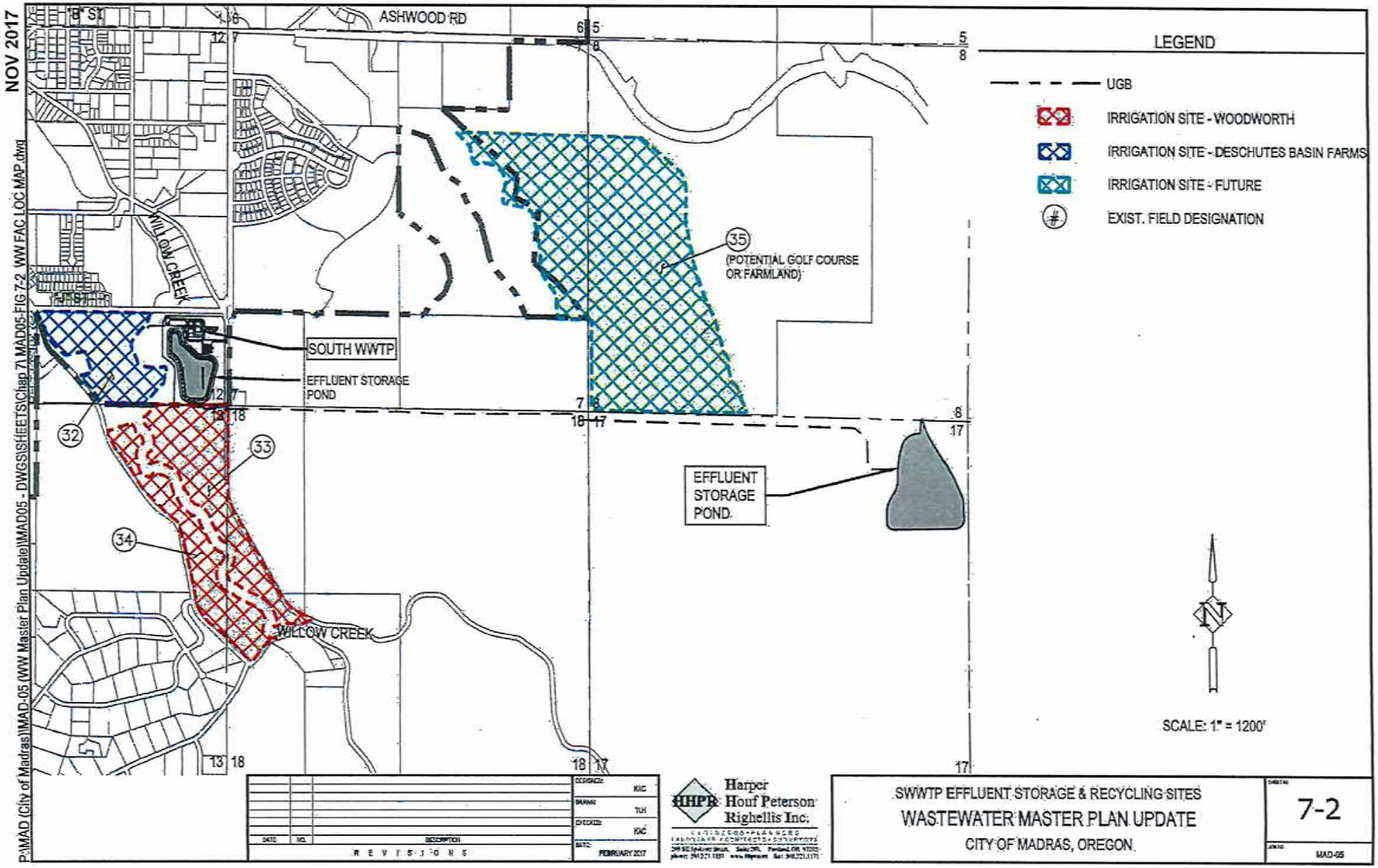
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B ST
ASHWOOD RD
WILLOW CREEK
SOUTH WWTP
EFFLUENT STORAGE POND
35
(POTENTIAL GOLF COURSE OR FARMLAND)
32
33
34
EFFLUENT STORAGE POND
WILLOW CREEK
LEGEND
UGB
IRRIGATION SITE - WOODWORTH
IRRIGATION SITE - DESCHUTES BASIN FARMS
IRRIGATION SITE - FUTURE
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SWWTP EFFLUENT STORAGE & RECYCLING SITES
WASTEWATER MASTER PLAN UPDATE
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MAD-05

CHAPTER 8
RECOMMENDED IMPROVEMENTS AND PLANNING CONSIDERATIONS

8.1 PUBLIC INVOLVEMENT

Public meetings were held on January 26, 2017 and November 29, 2017 at Madras City Hall to present the findings and initial recommendations of the 2016 Wastewater Master Plan (WWMP) Update and to solicit public comments. The main elements of the meeting presentations are briefly summarized below. Appendix N includes the meeting minutes for these meetings.

1. Reasons for preparing the WWMP Update.
2. Briefly describe the existing wastewater (WW) facilities serving the City.
3. Provide an overview of the WW facilities condition assessments.
4. Describe the population forecasts and WW flow projections used as the basis of planning.
5. Briefly summarize the collection system analysis and identify the recommended collection system improvements.
6. Briefly summarize the WW treatment alternatives evaluation and identify the recommended wastewater treatment plant (WWTP) improvements.

Questions and comments were received on the proposed improvements and related issues from individuals at the meeting. In response to questions and discussions during the meeting, additional information on the following subjects has been incorporated into this WWMP Update.

1. Regulations governing surface-water discharges of WWTP effluent (Chapter 1).
2. Key issues that affect the potential for implementing constructed wetlands and a surface-water discharge at the City's South WWTP (Chapter 5).
3. Projected farmland requirements for effluent recycling (Chapter 7).

8.2 CAPITAL IMPROVEMENTS PLAN

8.2.1 General

This section presents the capital improvements plan (CIP) for the recommended WW improvements identified in Chapters 4, 6 and 7. To facilitate planning, we list the proposed projects according to the anticipated time periods when the improvements will most likely be needed. The actual implementation schedule will depend on various factors, including those listed below:

- the availability of funds for capital improvements;
- the actual rates of population growth and commercial/industrial development;
- ongoing changes in the conditions & adequacy of major components; and
- future changes in regulations affecting the WW facilities.

Potential improvements identified for industrial site readiness (ISR) planning must be reevaluated based on actual development proposal(s). Project timing and scope will be development dependent.

8.2.2 Basis of Estimates of Probable Costs

We have developed the preliminary estimates of probable costs presented in this WWMP from information available at the time this study was prepared. The cost information used to generate the estimates was current to December 2016. The estimates were subsequently updated to December 2017 using the Engineering News-Record Construction Cost Index of 10,873.

The probable construction costs developed for this study are planning-level estimates and their level of detail falls within Estimate Class 4 as defined by the Association for the Advancement of Cost Engineering International (Recommended Practice #18R-97, Rev. March 2016). Consistent with this estimate class, the accuracy is anticipated to be within +35% to –20% of the actual cost.

Allowances for contractor overhead and profit, mobilization/demobilization, and construction contingencies are included to provide conservative estimates. A nonconstruction cost factor was also applied to each project to include an allowance for planning, engineering, and administrative costs. Because the estimates are preliminary, we used a 25% factor for construction contingences and a 35% factor for nonconstruction costs.

Actual project costs will depend on the scope identified during project development. Actual construction costs will also be affected by labor and material costs and competitive market conditions at the time bids are solicited, as well as by specific site conditions and other factors. Consequently, the final construction costs will vary from our estimates.

8.2.3 Collection System Improvements – Gravity Sewers

The recommended sewer improvements are listed below according to the general timing we anticipate for their implementation. Table 8-1 (following page) summarizes the estimates of probable project costs for the gravity sewers CIP.

A. Short-Term Projects (within 5 years)

1. **Mountain View/Sky Ridge Sewers** – install approximately 4,500 LF of new 8-inch sewers in a currently unserved area.
2. **Jefferson Street/North Unit Sewers** – install approximately 2,900 LF of new 8-inch sewers in a currently unserved area.
3. **Bel Air/Herzberg Heights Sewers** – install approximately 5,100 LF of new 8-inch sewers in pockets of unserved areas.

B. Mid-Term Projects (6 – 10 years)

1. **Hess Street Sewer (Industrial Park)** – install approximately 1,670 LF of new 8-inch sewer in Industrial Park.
2. **Mill Street Sewer (Industrial Park)** – install approximately 1,430 LF of new 8-inch sewer in Industrial Park.

C. Mid- to Long-Term Project (11 – 15 years)

1. **North Y Sewer** – replace approximately 2,060 linear feet (LF) of existing 8-inch sewer with 12-inch sewer by pipe bursting to increase capacity.
2. **Culver Hwy. Parallel Sewer** – install approximately 3,100 LF of new 10-inch parallel sewer to increase capacity.

D. Long-Term Projects (16 – 20 years)

1. **Juniper Heights Sewers** – install approximately 5,350 LF of new 8-inch sewers in currently unserved areas.
2. **Willow Creek North Sewer** – install approximately 2,500 LF of new 8-inch sewer to serve new developments.

E. Potential Project for Major Industrial Park Developments (Industrial Site Readiness)

Our analysis identified alternative sewer improvements that would potentially be needed to serve major Industrial Park developments (Chapter 4). To support ISR planning, Table 8-1 lists the potential North Area-Airport Way parallel sewer project as the least-cost alternative for providing sewer service to a major user. Actual sewer project(s) required for major industrial users will need to be evaluated based on development proposal(s).

Table 8-1
Sewer Improvements – Estimated Timing and Probable Costs (December 2017 Dollars)

Project Description	Probable Construction Cost	Probable Project Cost
A. Short-Term Projects (within 5 years)		
1. Mountain View/Sky Ridge Sewer Extensions	$871,000	$1,175,000
2. Jefferson Street/North Unit	$412,000	$555,000
3. Bel Air/Herzberg Heights	$856,000	$1,155,000
Subtotal for Short-Term Projects	**$2,139,000**	**$2,885,000**
B. Mid-Term Projects (6 – 10 years)		
1. Hess Street Sewer	$258,000	$350,000
2. Mill Street Sewer	$222,000	$300,000
Subtotal for Mid-Term Projects	**$480,000**	**$650,000**
C. Mid- to Long-Term Project (11 – 15 years)		
1. North Y Sewer Replacement (By Pipe Bursting)	$652,000	$880,000
2. Culver Hwy. Parallel Sewer	$561,000	$760,000
Subtotal for Mid- to Long-Term Project	**$1,213,000**	**$1,640,000**
D. Long-Term Projects (16 – 20 years)		
1. Juniper Heights Sewer Extension	$1,036,000	$1,400,000
2. Willow Creek North Sewer Extension	$419,000	$565,000
Subtotal for Long-Term Projects	**$1,455,000**	**$1,965,000**
F. Potential ISR Project (Scope and Timing Are Development Dependent)		
North Area-Airport Way Parallel Sewer	$695,000	$940,000
Subtotal – Potential ISR Project	**$695,000**	**$940,000**
Total – Proposed & Potential Sewer Projects	**$5,982,000**	**$8,080,000**

8.2.4 Collection System Improvements – Pump Stations and Force Mains

The recommended improvements to the collection-system pump stations and force mains are listed below according to the general timing we anticipate for their implementation. Table 8-2 (following page) summarizes the estimates of probable project costs for the PS and force mains CIP.

A. Short-Term Project (within 5 years)

"B" Street North PS Screen – add an influent mechanical screen to prevent pump clogging and increase pump service life, with no expansion of PS capacity.

B. Mid-Term Project (6 – 10 years)

Golf Course PS – replace existing PS and expand peak design capacity to 0.21 MGD.

C. **Mid- to Long-Term Projects (11 – 15 years)**

1. **Renovation of "B" Street North PS** with no expansion of existing capacity.
2. **Generator Set Replacement for "B" Street North and South Pump Stations** including minor building renovations.
3. **South U.S. 97 PS Renovation** with no expansion of existing capacity.

D. **Long-Term Project (16 – 20 years)**

1. **Demers Pump Station (PS)** – replace existing PS with a duplex, submersible PS. Design for future expansion of peak design capacity to 1.33 million gallons per day (MGD).
2. **Expansion and renovation of "B" Street South PS** – expand existing PS to peak design capacity of 2.66 MGD.

E. **Potential Projects for Future Industrial Park Developments (ISR)**

1. **Demers PS Force Main Replacement** – install 11,000 LF of 8-inch force main to replace existing force mains with any future expansion of Demers PS above a 0.70 MGD capacity.
2. **Airport Area PS and Force Main** – construct new PS with 1.33-MGD capacity to serve airport area and install new force main extending from PS to North WWTP.

Table 8-2
Pump Station Improvements – Estimated Timing and Probable Costs (December 2017 Dollars)

Project Description	Probable Construction Cost	Probable Project Cost
A. Short-Term Project (within 5 years)		
Influent Screen at "B" Street North PS – No expansion	$345,000	$465,000
Subtotal for Mid-Term Project	**$345,000**	**$465,000**
B. Mid-Term Project (6 – 10 years)		
Golf Course PS Replacement – Expanded Capacity	$361,000	$490,000
Subtotal for Mid-Term Project	**$361,000**	**$490,000**
C. Mid- to Long-Term Projects (11 – 15 years)		
1. "B" Street North PS Renovation – No expansion	$452,000	$610,000
2. "B" Street North & South Generator Replacement	$181,000	$245,000
3. South U.S. 97 PS Renovation – No expansion	$45,000	$60,000
Subtotal – Mid- to Long-Term Projects	**$678,000**	**$915,000**
D. Long-Term Project (16 – 20 years)		
1. "B" Street South PS Expansion & Renovation	$542,000	$730,000
2. Demers PS Replacement – Expanded Capacity	$1,327,000	$1,790,000
Subtotal – Long-Term Projects	**$1,869,000**	**$2,520,000**
E. Potential ISR Project (Scope and Timing Development Dependent)		
1. Demers Force Main Replacement – 8" Pipe	$1,174,000	$1,585,000
2. Airport Area PS and Force Main	$1,735,000	$2,340,000
Subtotal – Potential ISR Project	**$2,909,000**	**$3,925,000**
Total – Proposed & Potential PS Projects	**$6,162,000**	**$8,315,000**

8.2.5 Wastewater Treatment Plants, Effluent Storage and Effluent Recycling

The recommended improvements to the City's WWTPs and effluent handling systems are listed below according to the general timing we anticipate for project implementation. Table 8-3 (following page) summarizes the estimates of probable project costs for the WWTPs CIP.

The WWTP CIP includes expansions of effluent storage, transmission, and irrigation facilities since these projects would be required in conjunction with treatment expansions. Estimated farmland acreages for irrigation expansions include a 10% allowance for buffers and access.

A. Short-Term Project (within 5 years)

1. **North WWTP (NWWTP) Phase 1A Improvements:** Replace the existing clarifier and disinfection equipment, the in-plant pumps, and the associated valves and piping. Construct a new building to house the clarifier to allow reliable year-round operation.

   ** ***Alternate NWWTP Phase 1A Improvements*:** Complete limited upgrade within 3 years to allow reliable year-round operation in the near term (construct a new building to house the existing clarifier, protect exposed in-plant pumps, rebuild in-plant pumps, replace associated valves, refurbish clarifier equipment, and modify piping).

2. **South WWTP (SWWTP) Thickening System:** Install a biosolids thickening system and associated improvements.

B. Mid-Term Project (6 – 10 years)

1. **SWWTP Phase 1 Expansion and Partial Renovation:** Modify the existing plant to expand average design flow capacity to 0.65 MGD.

2. **Irrigation System Expansion for SWWTP Effluent Recycling:** Install an irrigation system at the 193-acre Upper Parcel to prepare the site for effluent recycling on crops.

C. Mid- to Long-Term Projects (11 – 15 years)

1. **NWWTP Phase 1B Improvements:** Retrofit the existing lagoons by constructing an aerated lagoon system and related facilities. Maintain the current average design capacity of 0.50-MGD.

2. **Irrigation System Expansion for NWWTP Effluent Recycling:** Purchase 42 acres of farmland, install an effluent transmission pipeline to the additional land, and install an irrigation system at the new site.

D. Long-Term Project (16 – 20 years)

1. **SWWTP Phase 2 Expansion/Renovation:** Construct a 0.5-MGD treatment module and renovate existing facilities to expand average design flow capacity to 1.15 MGD.

2. **SWWTP Phase 2 Effluent Storage and Irrigation System Expansions:** Construct an effluent storage pond with 70-million gallon (MG) capacity. Purchase 195 acres of farmland, install an effluent transmission pipeline to this land, and install an irrigation system at the new site.

E. Potential Projects for Future Industrial Park Developments (ISR Planning)

1. **NWWTP Phase 2 Improvements:** Construct a 0.5-MGD treatment facility with an aerated lagoon system to expand average flow capacity to 1.0 MGD. Construct a second 79-MG effluent storage pond, buy 290 acres of farmland, install an effluent transmission piping to this land, and install an irrigation system at the new site.

2. **NWWTP Phase 3 Improvements:** Construct another 0.5-MGD expansion similar to Phase 2, except that we estimate an additional 345 acres of farmland would be needed.

Table 8-3
WWTP Improvements – Estimated Timing and Probable Costs (December 2017 Dollars)

Project Description	Probable Construction Cost	Probable Project Cost
A. Short-Term Projects (within 5 years)		
1. NWWTP Phase 1A Improvements	$1,766,000	$2,385,000
Alternate NWWTP Phase 1A Improvements	*$1,002,000*	*$1,355,000*
2. SWWTP Biosolids Thickening System	$929,000	$1,255,000
Subtotal – Short-Term Project (1)	**$1,931,000**	**$2,610,000**
B. Mid-Term Projects (6 – 10 years)		
1. SWWTP Phase 1 Expansion/Renovation	$921,000	$1,245,000
2. SWWTP Irrigation System Expansion	$382,000	$515,000
Subtotal – Mid-Term Projects	**$1,303,000**	**$1,760,000**
C. Mid- to Long-Term Project (11 – 15 years)		
1. NWWTP Phase 1B Improvements (2)	$6,082,000	$8,210,000
2. NWWTP Land Acquisition & Irrigation System (3)	$1,185,000	$1,600,000
Subtotal – Mid- to Long-Term Projects	**$7,267,000**	**$9,810,000**
D. Long-Term Projects (16 – 20 years)		
SWWTP Phase 2 Expansion		
a. Treatment Module w/SBR process	$7,426,000	$10,025,000
b. Effluent Storage Pond	$6,815,000	$9,200,000
c. Farmland Acquisition & Irrigation System (3)	$2,530,000	$3,415,000
Subtotal – Long-Term Projects	**$16,771,000**	**$22,640,000**
E. Potential ISR Projects		
1. NWWTP Phase 2 Expansion		
a. Treatment Module w/aerated lagoons	$7,915,000	$10,685,000
b. Effluent Storage Pond	$9,286,000	$12,535,000
c. Farmland Acquisition & Irrigation System (3)	$3,478,000	$4,695,000
2. NWWTP Phase 3 Expansion		
a. Treatment Module w/aerated lagoons	$9,253,000	$12,490,000
b. Effluent Storage Pond	$9,286,000	$12,535,000
c. Farmland Acquisition & Irrigation System (3)	$3,981,000	$5,375,000
Subtotal - Potential NWWTP ISR Projects	**$43,199,000**	**$58,315,000**
Total – Proposed & Potential WWTP Projects	**$70,471,000**	**$95,135,000**

(1) Subtotal includes the alternate NWWTP Phase 1A Improvements project as the lower cost option.

(2) Overall scope and probable project cost of NWWTP Phase 1B project may change if City implements the Alternate NWWTP Phase 1A Improvements project.

(3) Probable costs include additional farmland and 1.0-mile effluent transmission line to this new land. Further investigation into effluent transmission requirements will be needed once potential properties are identified for purchase.

Potential expansions to the NWWTP would be dependent on future commercial/industrial developments. Project requirements must be evaluated based on actual development proposals. The financial analysis addresses development charges and other funding options for these projects.

The NWWTP projects are also contingent on Federal Aviation Administration (FAA) reviews and acceptance. Additional mitigation measures beyond those incorporated into these probable project costs may be required based on FAA input.

8.3 ADDITIONAL PLANNING CONSIDERATIONS

8.3.1 Planning Effort for Surface-Water Discharge

Before the City proceeds with the Phase 1 SWWTP expansion and renovation, it may be worthwhile to further investigate the feasibility of an indirect discharge to Willow Creek. The first step would be to communicate with DEQ regarding the potential for obtaining a discharge permit.

Depending on the response DEQ provides, the City may want to proceed with a study to evaluate the feasibility and potential cost effectiveness of a surface-water discharge. Such a feasibility study is beyond the scope of this WWMP Update. However, Chapter 5 of this WWMP (Section 5.2.2) provides some general background information on the issues affecting a surface-water discharge and outlines some key issues that a Feasibility Study should address.

8.3.2 Capacity, Management, Operations and Maintenance (CMOM) Program Planning

Introduction. The City is vested with the responsibilities of providing adequate sewer system capacities and properly managing, operating and maintaining the systems. A formal Capacity, Management, Operations and Maintenance (CMOM) program can support these efforts by providing a framework to help owners adopt and follow accepted wastewater-industry practices.

The general goals of a formal CMOM program are described below.

- Assure that adequate sewer capacity remains available under projected conditions.
- Develop a proactive (predictive) approach to system management, operations and maintenance and reduce reliance on being reactive to unplanned or emergency events.
- Provide quality customer service that helps generate support for dedicating the revenues needed to sustain reliable, sewer service.

The following paragraphs provide an overview of CMOM programs. This information is intended as a starting point for efforts by the City to plan and adopt a formal CMOM program. A detailed analysis of the City's current practices and specific recommendations for improvements to these practices are beyond the scope of this study.

CMOM Program Planning. Since the City has been providing sewer service for over 40 years, it has been following many recognized CMOM practices for an extended period. Some examples of these practices are summarized below.

- The City has adopted a sewer use ordinance, user rates and other charges, and system design and construction standards to establish a legal framework for the systems management.
- The City prepares and submits reports to the DEQ and operates and maintains the WWTPs in compliance with the City's permit requirements.

A key part of CMOM planning is the periodic collection of information on current facilities and CMOM practices. Key information in this WWMP Update that can be particularly useful to a CMOM program review and upgrade are listed below:

- Chapter 2 and the associated appendices, conditions assessments of WW facilities and initial maintenance plan;
- Chapter 4, the collection system analysis; and
- Chapter 9, the financial analysis.

It is important for the City to make use of this WWMP Update as a tool in CMOM program planning and regularly update the WWMP to keep CMOM activities current to actual conditions.

General Requirements of a CMOM Program. It is important that a CMOM program is a formal set of practices that are tailored specifically to the City's circumstances and are understood by the responsible staff members. Staff must also view the program as a dynamic tool that designated personnel should update regularly to keep it current to actual conditions and priorities.

Seven key elements that a CMOM program should incorporate are:

- a clear purpose;
- a well-defined overall goal;
- a written program document;
- implementation by trained, or contracted, personnel;
- clear performance measures to track program effectiveness; and
- plans for periodic reviews and updates.

The CMOM program should be developed and implemented to provide owners and operators with the following capabilities:

- The understanding of how the system components and the overall systems are performing.
- The ability to identify specific performance objectives based on current conditions and needs.
- The organizational structure, staffing, training, and other resources needed to allow personnel to meet performance objectives.
- A recognition of the need to review and adjust activities such as sewer cleaning, inspections, and other maintenance responsibilities to respond to changing conditions.
- An understanding of the need to conduct system capacity evaluations, including flow monitoring when necessary, and implement a capacity assurance program.
- The responsibility to conduct periodic reviews that evaluate CMOM program implementation, identify deficiencies, and take corrective steps.
- The training, equipment, and other preparations needed to respond to emergency events.
- An ability to communicate what efforts are required for CMOM program performance.

CMOM Program Review. The City can improve current practices by conducting a thorough review of their CMOM practices, developing a written CMOM program, and establishing specific objectives for CMOM performance.

The United States Environmental Protection Agency (USEPA) has published a "*Guide for Evaluating CMOM Programs at Sanitary Sewer Collection Systems*" (2005) to support such efforts. This document describes the main elements of CMOM, the procedures for conducting reviews, and the process of implementing a successful program. The City should find this guidance helpful in program planning.

The USEPA guidance focuses on collection system CMOM as part of a regulatory effort to prevent sanitary sewer overflows. However, many CMOM practices in Madras can be effectively applied to all wastewater services the City provides.

We recommend the City conduct an assessment of current CMOM practices, either internally or with the help of a consultant, to identify areas of improvement. Appendix O includes a CMOM Program Self-Assessment Checklist published by the USEPA that provides guidance in performing this program review.

Each CMOM program is specific to the utility that provides the sewer service. Therefore, only applicable aspects of the checklist should be used in the program review and other considerations not reflected in the checklist may need to be addressed.

Performance Objectives for CMOM Program. USEPA guidance emphasizes the importance of measurable performance objectives as part of a successful CMOM program. The City should establish performance objectives in coordination with current priorities for addressing areas of concern.

The following is a brief list of potential areas the City may want to emphasize in defining CMOM performance objectives.

- Maintenance Plan – formally establish and implement a plan that prioritizes maintenance needs, supports budgeting, and tracks progress.
- Sewer Cleaning Program – develop a plan that prioritizes system needs and adopts a schedule.
- Recordkeeping – establish goals for updating and maintaining records such as safety procedures, emergency response plans, O&M manuals, and/or record drawings.
- Training Program – develop goals for periodic safety and/or emergency response training.

The City may prefer to emphasize other aspects of system management, operations and maintenance in the performance objectives. Regardless, the key is to clearly define the objectives, develop a process for tracking progress, and determine whether staff are can meet these objectives.

8.3.3 Solar Power Array Funding and Partnering Opportunities

Background. Solar photovoltaic (PV) panels have become increasingly cost competitive as a way to generate electricity onsite and reduce the amount of electricity purchased from a utility. Additionally, the State of Oregon has established policies and implemented incentives programs to encourage the development of renewable energy sources (renewables) such as solar power. The State offers these incentives through the Oregon Energy Trust and the Oregon Department of Energy. Currently these State programs are augmented by Federal tax incentives offered in the form of credits and accelerated depreciation for renewables investments.

Due to the availability of State and Federal incentives, it may be cost effective for the City to install an array of PV panels at either or both WWTP sites as a means for lowering power costs. The following paragraphs describe key issues affecting the installation of solar arrays at each site.

Type of Solar Array Installations. Solar arrays can potentially be installed on ground-based supports, on roof-mounted supports, or on anchored floats in a pond. Given the power consumption and building sizes at the City's WWTPs, roof-mounted arrays would not provide enough PV capacity to reduce electricity costs significantly. Therefore, we recommend the City focus any investigation into solar arrays on ground-based and floating solar arrays.

An array mounted on the ground would generally be preferred due to the cost and access issues associated with a floating array. However, installing a floating array on an effluent storage pond at the NWWTP could potentially provide the benefit of mitigating wildlife attraction by covering part or most of the pond surface. A floating array would also leave surrounding land available for industrial development, farming or other uses. In addition, the pond water can help to cool PV panels and improve power-generating efficiency

Solar Power Purchase Agreements. Federal tax credits and depreciation incentives would not be directly available to a government entity. Therefore, to take advantage of these benefits, a City could enter into a power purchase agreement (PPA) with a private, solar service provider.

Under a PPA, the service provider would furnish, install, own and maintain the power-generating system. The provider would also be responsible for project financing and would receive the incentives and tax benefits for which the project qualifies. In exchange, the City would agree to purchase the electricity produced by the system for the term of the PPA, usually 20 years in Oregon.

The rate established by the PPA for the solar-generated power would typically be less than the current electricity rate to give the City an incentive to enter the PPA. At the end of the PPA term, the City would have the option to renew the PPA, purchase the system, or remove the system.

Appendix P contains a fact sheet on PPAs published by the National Renewable Energy Laboratory. The main advantages to a PPA for the City include:

- low initial cost for a solar array;
- the ability to benefit from Federal tax benefits;
- a predictable cost of electricity for the term of the PPA;
- no need to deal with the solar system permitting, design, and construction; and
- no operations and maintenance responsibilities for the array.

State Incentives. The following is a brief summary of the incentives available through the State.

- *Energy Trust Incentives*. Pacific Power customers can receive cash incentives from the Energy Trust that lower capital costs based on the power-generating capacity. This incentive program is primarily funded by the utility in response to State legislation requiring utilities to meet goals for renewables development.

  Current Energy Trust incentives for Pacific Power customers start at $0.80/watt for a generating capacity of 10 kW or less and decrease to $0.45/watt for a capacity of 200 kW or more.

  The Energy Trust does not have an agreement with the Central Electric Cooperative for cash incentives. Therefore, this incentive is only available at the SWWTP site.

- *Renewable Energy Development (RED) Grants.* The Oregon Department of Energy (ODOE) currently offers RED grants annually through a competitive application process. ODOE has been advertising the availability of RED grants near the end of a calendar and then accepting applications through the early part of the following year. In the past, grants have been limited to 35% of project cost and $250,000. The State authorizes and funds the RED grant program through legislation and the resulting statute.

Federal Tax Incentives. The following is a brief summary of the incentives for renewables investment currently offered by the Federal government.

- *Tax Credit.* The Business Energy Investment Tax Credit can currently cover 30% of the capital cost of a solar system. However, this percentage is scheduled to begin dropping in 2020.
- *Accelerated Depreciation.* Federal tax law allows businesses to depreciate the cost of a solar system following the Modified Accelerated Cost Recovery System. This approach can provide a tax deduction that offsets up to 25% of the project cost.

Solar Arrays at Airports. The FAA recognizes the benefits of installing solar power projects at airports and generally supports their implementation. To promote aviation safety, the FAA has studied the visual impacts of solar panels and ways to prevent hazards from panel installations.

These studies have resulted in FAA guidance that addresses technical considerations for solar projects (*Technical Guidance for Evaluating Selected Solar Technologies on Airports*, 2010). The FAA also published an interim policy in the Federal Register (Volume 78 – No. 205) that addresses standards for glint, a brief flash of light, and glare, a sustained source of brightness, from solar panels (*FAA Review of Solar Energy System Projects on Federally Obligated Airports*, 2013).

Because the NWWTP is located adjacent to the airport, a solar array installed at the plant site would need to be designed according to FAA standards and technical guidance. Therefore, an evaluation of solar arrays at the NWWTP site should consider the impacts of FAA policy and guidance.

8.3.4 Master Plan Updates

We recommend the City update this WWMP and the CIP on a regular basis, particularly when changes occur that are likely to have significant impacts on previous recommendations. In general, the City should plan to have a WWMP update prepared every 5 years. The City should tailor the scope of each update to address any changes in the basis of planning (population growth and wastewater production), conditions of existing components, regulatory requirements, effluent handling practices, biosolids management, and other issues described in this report.

CHAPTER 9
WASTEWATER SYSTEM DEVELOPMENT CHARGE UPDATE

9.1 INTRODUCTION

As part of this master planning effort, FCS GROUP performed an analysis to update the City's system development charges (SDCs) for wastewater services. This chapter includes a summary of the SDC report FCS GROUP prepared to describe their analysis and present their conclusions. The complete report is contained in Appendix Q. The City plans to have a full financial analysis of the wastewater facilities and a sewer rate study completed separately at a later date.

9.2 GENERAL DESCRIPTION OF SYSTEM DEVELOPMENT CHARGES

The City levies SDCs as one-time fees on new developments to recover a fair share of the cost of facilities that provide capacity to serve future growth. The authority to levy local SDCs was established by the Oregon Legislature and incorporated into the Oregon Revised Statutes. The law allows SDCs only for the recovery of eligible capital costs and not the recovery of costs to operate and maintain facilities.

The City's SDCs consist of the following three main components:

1. A **reimbursement fee component** is included to recover a share of the costs associated with existing wastewater facilities or capital projects under construction.
2. An **improvement fee component** is included to recover the estimated costs of planned capital improvements that will expand capacity for future users.
3. An **administrative cost component** is included to recover the portion of SDCs spent on compliance with applicable rules, including costs to determine SDCs and costs to account for SDC expenditures.

The SDC calculation requires a determination of the eligible costs for capital improvements and an estimate of the growth in customer base that the improvements can accommodate. In general terms, the SDC is established by dividing the eligible capital costs by the estimated number of new customers that can be served.

9.3 CUSTOMER BASE

Since there are different types of customers with differing service needs, the existing and expanded customer base are each estimated on an equivalent basis using water meter size. A standard residential meter size of 5/8-inch has a meter capacity equivalent (MCE) of 1.0 and larger meters have higher MCEs based on their relative capacity. Using the current breakdown of water meter sizes for customers in Madras, FCS GROUP identified an existing MCE of 3,074 for the City's wastewater facilities.

FCS GROUP used the following flow data to establish a future customer base:

- the planned total future capacity (1.65 MGD total – 1.04 MGD existing and 0.61 MGD expansion);
- the existing average wastewater flows (0.493 MGD);
- capacity reserved for the Deer Ridge facility (0.230 MGD); and
- net available capacity (0.927 MGD).

The existing MCE of 3,074 and existing average flow of 0.493 MGD produce a unit wastewater flow of 160 gallons per MCE. Based on this unit flow, the net available capacity of 0.927 MGD translates to 5,779 MCEs in future growth that could be served. FCS GROUP used this available growth in customer base as the denominator for calculating the reimbursement and improvement components of the SDCs.

9.4 REIMBURSEMENT FEE

The reimbursement fee is based on the City's eligible costs for constructing the unused part of the existing facilities capacity. Existing average flows and the dedicated capacity for the Deer Ridge facility constitute 70% of the existing facilities capacity. Therefore, 30% of the existing capacity is unused and available for future growth.

FCS GROUP compiled and analyzed data from the City on previous capital expenditures for wastewater facilities to estimate the total original cost of providing the existing capacity. A 30% share of this total amount was used to identify the eligible cost basis. Further deductions were then made to account for the current balance in the reimbursement SDC fund and to avoid duplicate charges in the reimbursement fee.

The analysis determined that the City's net eligible cost for unused existing capacity is approximately $3.4 million. Dividing this cost by the future MCE of 5,779 results in an updated reimbursement fee of $586.

9.5 IMPROVEMENT FEE

The improvement fee cost basis is the portion of the Capital Improvements Plan presented in Chapter 8 that constitutes net eligible costs. Capital costs that are not eligible for SDCs include the following planned expenditures:

- costs for projects not expected to be funded by the City; and/or
- costs for projects, or portions of projects, that do not expand capacity.

Once these ineligible costs were deducted, FCS GROUP incorporated approximately $25 million into the improvement fee calculation. After deducting the current balance in the City's Improvement SDC Fund, the net eligible future costs were divided by the future MCE of 5,779. The result is an updated improvement fee of $4,281.

9.6 ADMINISTRATIVE COST ADJUSTMENT FOR COMPLIANCE

The cost adjustment for compliance with existing statutes includes an estimate of annual administrative costs related to the SDCs and the amortized costs for the SDC study prepared by FCS GROUP (Appendix Q). The combined total for these annual compliance costs is $279 per new connection.

9.7 SUMMARY OF RECOMMENDED SYSTEM DEVELOPMENT CHARGES

Table 9-1 on the following page summarizes the recommended wastewater SDC components and fee schedule. FCS GROUP recommends the City periodically adjust these proposed SDCs to account for inflation by using the Engineering News Record 20-City Average Construction Cost Index.

Table 9-1
Summary of Recommended Wastewater System Development Charges

A. Updated Wastewater SDC per MCE

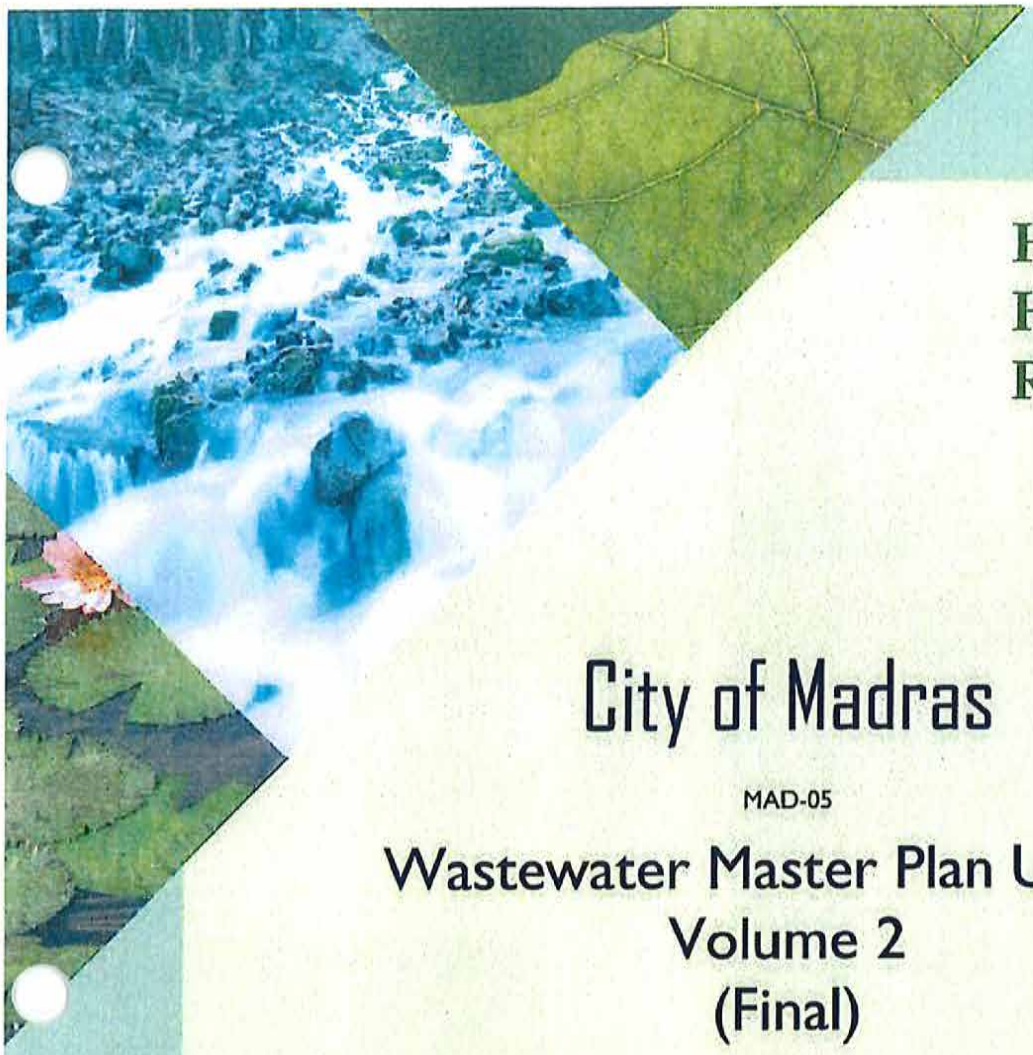
Reimbursement Fee	$586
Improvement Fee	$4,281
Administrative Cost Recovery	$279
Total Updated SDC	**$5,146**
Net Decrease from Existing SDC	**($143)**

B. Wastewater SDC Fee Schedule Based on Meter Size

Meter Size	MCEs	Updated SDC
5/8 inch	1.0	$5,146
1 inch	2.5	$12,864
1.5 inches	5.0	$25,729
2 inches	8.0	$41,166
3 inches	17.5	$90,051
4 inches	30.0	$154,373
5 inches	62.5	$321,611
6 inches	90.0	$463,120

C. Wastewater SDC Fee Schedule – Multi-Unit Developments

Customer Type	Assumed MCE/Unit	Updated SDC/Unit
Multi-Unit Residential	0.71	$3,654
Lodging Facility	0.74	$3,808



Harper
Houf Peterson
Righellis Inc.

City of Madras

MAD-05

Wastewater Master Plan Update
Volume 2
(Final)

May 2018

Prepared For:

City of Madras
125 SW "E" Street
Madras, OR 97741
P: 541-475-2344

Enter client number (if applicable)

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HHPR

ENGINEERS ◆ PLANNERS
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CITY OF MADRAS

WASTEWATER MASTER PLAN UPDATE

VOLUME TWO
APPENDICES A & B
(FINAL)

EXPIRES 12-31-2019

May 2018

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CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX A

CURRENT WATER POLLUTION CONTROL FACILITY PERMIT

DEQ Emergency Spill # 800-452-0311
7-27-08 McDonald's Hwy 26 Spill ORS# 20081806

Expiration Date: October 31, 2016
Permit Number: 101739
File Number: 52520

WATER POLLUTION CONTROL FACILITIES PERMIT

Department of Environmental Quality
2146 NE Fourth, Suite 104, Bend, OR 97701
Telephone: (541) 388-6146

Issued pursuant to ORS 468B.050

COPY

ISSUED TO:

City of Madras
800 SE Grizzly Road
Madras, OR 97741

SOURCES COVERED BY THIS PERMIT:

Type of Waste	Method of Disposal
Domestic Wastewater	Evaporation and Land Irrigation

PLANT TYPE AND LOCATION:

Stabilization Lagoons
and Land Irrigation (Outfall 001)
West of Madras Airport
Madras, Oregon

Sequencing Batch Reactor (SBR)
and Land Irrigation (Outfall 002)
South Madras
Madras, Oregon

RECEIVING SYSTEM INFORMATION:

Basin: Deschutes
Sub-Basin: Lower Deschutes
LLID: 1208087445078-5.7-N
County: Jefferson
Nearest surface stream which would receive waste if facility was to discharge: Willow Creek

Treatment System Class: III
Collection System Class: II

Issued in response to Application No. 982853 received September 17, 2004.

This permit is issued based on the land use findings in the permit record.

Eric Nigg, Manager
Bend Water Quality Section
Eastern Region

November 16, 2006
Date

PERMITTED ACTIVITIES

Until this permit expires or is modified or revoked, the permittee is authorized to construct, install, modify, or operate a wastewater collection, treatment, control and disposal system in conformance with all the requirements, limitations, and conditions set forth in the attached schedules as follows:

	Page
Schedule A - Waste Discharge Limitations not to be Exceeded	2-3
Schedule B - Minimum Monitoring and Reporting Requirements	4-6
Schedule C - Compliance Conditions and Schedules	--
Schedule D - Special Conditions	7-8
Schedule E - Not Applicable	--
Schedule F - General Conditions	9-12

All direct discharges to public waters are prohibited.

SCHEDULE A

Waste Discharge Limitations:

Waste Stabilization Lagoons and Irrigation Facility- Outfall 001:

1. No discharge to state waters is permitted. All reclaimed water shall be distributed on land, for dissipation by evapotranspiration and controlled seepage by following sound irrigation practices so as to prevent:

   a. Prolonged ponding of treated reclaimed water on the ground surface;

   b. Surface runoff or subsurface drainage through drainage tile;

   c. The creation of odors, fly and mosquito breeding or other nuisance conditions;

   d. The overloading of land with nutrients, organics, or other pollutant parameters;

   e. Impairment of existing or potential beneficial uses of groundwater.

2. Until otherwise approved in writing by the Department, the monthly average, dry weather influent flow shall not exceed 0.5 MGD. The Department may allow exceedances of the flow limitation if needed to accommodate necessary operation and maintenance.

3. The period for land application will be generally between April 1 and November 1 of each year. Unless otherwise approved by the Department, wastewater shall not be applied to land that is frozen, snow covered or saturated, or during precipitation periods.

4. The storage ponds must be lowered sufficiently by the end of the irrigation season to ensure maximum practicable storage capacity during non-irrigation months.

5. Prior to land application of the reclaimed water, for reuse for beneficial purposes requiring Level II treatment as defined in OAR 340-55, the quality of reclaimed water shall not exceed the following effluent limitations:

   a. Total Coliform shall not exceed 240 organisms/100 ml in two consecutive samples, and a 7-day median of 23 organisms/100 ml.

6. No Level II reclaimed water shall be applied to food crops destined for human consumption or shall otherwise be made available for a use that is inconsistent with the uses provided for in OAR 340-55.

7. For reuse for beneficial purposes requiring Level IV treatment as defined in OAR 340-55, prior to land application, the wastewater shall be treated as required for Level IV effluent pursuant to OAR 340-55 and the quality of reclaimed water shall not exceed the following effluent limitations:

   a. Total Coliform shall not exceed a 7-day median of 2.2 organisms/100 ml, and no single sample to exceed 23 organisms/100 ml.

   b. Turbidity shall not exceed a 24-hour mean of 2 NTU, and shall not exceed 5 NTU for more than 5% of the time during a 24-hour period.

Sequencing Batch Reactor-Outfall (002)

1. No discharge to state waters is permitted. All reclaimed water shall be distributed on land, for dissipation by evapotranspiration and controlled seepage by following sound irrigation practices so as to prevent:

   a. Prolonged ponding of treated reclaimed water on the ground surface;

   b. Surface runoff or subsurface drainage through drainage tile;

   c. The creation of odors, fly and mosquito breeding or other nuisance conditions;

   d. The overloading of land with nutrients, organics, or other pollutant parameters;

   e. Impairment of existing or potential beneficial uses of groundwater.

2. Until otherwise approved in writing by the Department, the monthly average, dry weather influent flow to the sequencing batch reactor shall not exceed 0.5 MGD. Upon completion of a DEQ-approved expanded sequencing batch reactor, the monthly average, dry weather influent to the treatment plant shall not exceed 1.5 MGD. The Department may allow exceedances of the flow limitation if needed to accommodate necessary operation and maintenance.

3. The period for land application will be generally between April 1 and November 1 of each year. Unless otherwise approved in writing by the Department, wastewater shall not be applied to land that is frozen, snow covered or saturated, or during precipitation periods.

4. Prior to land application of the reclaimed water, for reuse for beneficial purposes requiring Level II treatment as defined in OAR 340-55, the quality of reclaimed water shall not exceed the following effluent limitations:

   a. Total Coliform shall not exceed 240 organisms/100 ml in two consecutive samples, and a 7-day median of 23 organisms/100 ml.

5. No Level II reclaimed water shall be applied to food crops destined for human consumption or shall otherwise be made available for a use that is inconsistent with the uses provided for in OAR 340-55.

6. Prior to land application of the reclaimed water for reuse for beneficial purposes, requiring Level IV treatment as defined in OAR 340-55, and shall not exceed the following limitations:

   a. Total Coliform shall not exceed a 7-day median of 2.2 organisms/100 ml, and no sample shall exceed 23 organisms/100 ml.

   b. Turbidity shall not exceed a 24-hour mean of 2 NTU, and shall not exceed 5 NTU for more than 5% of the time during a 24-hour period.

7. The storage ponds must be lowered sufficiently by the end of the irrigation season to ensure maximum practicable storage capacity during non-irrigation months.

SCHEDULE B

1. Minimum Monitoring and Reporting Requirements

The permittee shall monitor the operation and efficiency of all treatment and disposal facilities. Unless otherwise agreed to in writing by the Department of Environmental Quality, data collected, and submitted shall include but not necessarily be limited to the following parameters and minimum frequencies:

a. Influent-Lagoons & SBR

Item or Parameter	Minimum Frequency-Lagoons	Minimum Frequency-SBR*	Type of Sample
Flow	Daily	Daily	Reading
Flow Meter Calibration	Annual	Annual	Verification
pH	3/week	3/week	Grab
BOD_5	Once Every 2weeks	Once Every 2 weeks	24-hour composite
TSS	Once Every 2 weeks	Once Every 2 weeks	24-hour composite
Sewer Connections	Yearly	Yearly	Type and Number

*Based on a design capacity of 0.50 MGD

b. Outfall 001& 002-Land Irrigation-Lagoons & SBR- Level II

Item or Parameter	Minimum Frequency	Type of Sample
Water Level each Cell	Weekly	Staff Gauge
Flow	Daily	Totalizer
Sprinkler Set Used	Daily	Record/Map
Total Coliform	1/week	Grab
Chlorine Residual	Daily	Grab
TKN	Monthly	Grab
NO_2+NO_3-N	Monthly	Grab
pH	3/week	Grab
Quantity Irrigated (inches/acre)	Monthly	Calculation
Nitrogen Application Rate (#/acre)	Annually	Calculation
Quantity Chlorine Used	3/week when irrigating	Measurement

c. Outfall 001 & 002-Land Irrigation-Lagoons & SBR- Level IV

Item or Parameter	Minimum Frequency	Type of Sample
Flow	Daily	Totalizer
Sprinkler Set Used	Daily	Record/Map
Total Coliform	Daily	Grab
Chlorine Residual	Daily	Grab
TKN	Monthly	Grab
NO_2+NO_3-N	Monthly	Grab
pH	3/week	Grab
Turbidity (NTU) **	Hourly	Meter
Quantity Irrigated (inches/acre)	Monthly	Calculation
Nitrogen Application Rate (#/acre)	Annually	Calculation
Quantity Chlorine Used	3/week when irrigating	Measurement

**Level IV monitoring required only when lagoons and/or SBR system is operating at a Level IV treatment.

2. Biosolids Minimum Monitoring and Reporting Requirements for Lagoons/DAF & SBR

Item or Parameter	Minimum Frequency	Type of Sample
Sludge analysis including: Total Solids (% dry wt.) Volatile solids (% dry wt.) Biosolids nitrogen for: NH_3-N; NO_3-N; & TKN (% dry wt.) Phosphorus (% dry wt.) Potassium (% dry wt.) pH (standard units) Sludge metals content for: As, Cd, Cu, Hg, Mo, Ni, Pb, Se & Zn, measured as total in mg/kg	Annually	Composite sample to be representative of the product to be land applied (See Note 1/)
Record of % volatile solids reduction accomplished through stabilization	Annually	Calculation (See Note 2/)
Record of locations where biosolids are applied on each DEQ approved site. (Site location maps to be maintained at treatment facility for review upon request by DEQ)	Each Occurrence	Date, volume & locations where sludges were applied recorded on site location map.

Notes:

1. Composite samples from the drying bed shall be taken from reference areas in the drying bed pursuant to Test Methods for Evaluating Solid Waste, Volume 2: Field Manual, Physical/Chemical Methods, November 1986, Third Edition, Chapter 9.

   Inorganic pollutant monitoring must be conducted according to Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Second Edition (1982) with Updates I and II and third Edition (1986) with Revision I.

2. Calculation of the % volatile solids reduction is to be based on comparison of a representative grab sample of total and volatile solids entering each digester (a weighted blend of the primary and secondary clarifier solids) and a representative composite sample of solids exiting each digester withdrawal line. Testing for % volatile solids is only required when trying to meet a 38% reduction for compliance with this VAR option.

3. Reporting Procedures

   a. Monitoring results shall be reported on Department approved forms. The reporting period is the calendar month. Reports must be submitted to the Department by the 15th day of the following month.

   b. State monitoring reports shall identify the name, certificate classification and grade level of each principal operator designated by the permittee as responsible for supervising the wastewater collection and treatment systems during the reporting period. Monitoring reports shall also identify each system classification as found on page one of this permit.

   c. Monitoring reports shall also include a record of the quantity and method of use of all sludge removed from the treatment facility and a record of all applicable equipment breakdowns and bypassing.

4. Report Submittal

   a. By no later than February 1st of each year the permittee shall submit to the Department an annual report describing the effectiveness of the reclaimed water system to comply with the approved reclaimed water use plan, the rules of Division 55, and the limitations and conditions of this permit applicable to reuse of reclaimed water.

   b. For any year in which biosolids are land applied, a report shall be submitted to the Department by February 19th of the following year that describes solids handling activities for the previous year and includes, but is not limited to, the required information outlined in OAR 340-50-035(6)(a)-(e).

SCHEDULE D

Special Conditions

1. An adequate contingency plan for prevention and handling of spills and unplanned discharges shall be in force at all times. A continuing program of employee orientation and education shall be maintained to ensure awareness of the necessity of good in-plant control and quick and proper action in the event of a spill or accident.

2. The permittee shall meet the applicable requirements for use of reclaimed water under Division 55, including the following:

   a. All reclaimed water shall be managed in accordance with the approved Reclaimed Water Use Plan. No substantial changes shall be made in the plan without written approval of the Department.

   b. No reclaimed water shall be released by the permittee to another person, as defined in Oregon Revised Statute (ORS) 468.005, for use unless there is a valid contract between the permittee and that person that meets the requirements of Oregon Administrative Rule (OAR) 340-55-015(9).

   c. The permittee shall notify the Department within 24 hours if it is determined that the treated effluent is being used in a manner not in compliance with OAR 340-55. When the Department offices are not open, the permittee shall report the incident of non-compliance to the Oregon Emergency Response System (Telephone Number 1-800-452-0311).

   d. No reclaimed water shall be made available to a person proposing to recycle unless the person certifies in writing that they have read and understand the provisions in these rules. This written certification shall be kept on file by the sewage treatment system owner and be made available to the Department for inspection.

3. All biosolids shall be managed in accordance with the current biosolids management plan approved by the Department and the site authorization letters issued by the Department. The biosolids management plan shall be kept current and remain on file with the permit or license. No substantial changes shall be made in solids management activities which significantly differ from operations specified under the approved plan without the prior written approval of the Department. All new biosolids application sites shall meet the site selection criteria set forth in Oregon Administrative Rule 340-50-070 and must be located within Jefferson County. These are the counties in which all currently approved sites are located. No new public notice is required for the continued use of the currently approved sites. Property owners adjacent to any newly approved application sites shall be notified in writing of the proposed activity prior to the start of application. For proposed new application sites that are deemed by the Department to be sensitive with respect to residential housing, runoff potential or threat to groundwater, an opportunity for public comment shall be provided in accordance with OAR 340-50-030.

   This permit may be modified to incorporate any applicable standard for sewage biosolids use or disposal promulgated under section 405(d) of the Clean Water Act, if the standard for sewage sludge use or disposal is more stringent than any requirements for sludge use or disposal in the permit, or controls a pollutant or practice not limited in this permit.

4. The permittee shall comply with Oregon Administrative Rules (OAR), Chapter 340, Division 49, "Regulations Pertaining To Certification of Wastewater System Operator Personnel" and accordingly:

   a. The permittee shall have its wastewater system supervised by one or more operators who are certified in a classification and grade level (equal to or greater) that corresponds with the classification (collection and /or treatment) of the system to be supervised as specified on page one of this permit. The permittee may contract for part-time supervision in accordance with OAR 340-49-015(3) and 340-49-070.

Note: A "supervisor" is defined as the person exercising authority for establishing and executing the specific practice and procedures of operating the system in accordance with the policies of the permittee and requirements of the waste discharge permit. "Supervise" means responsible for the technical operation of a system, which may affect its performance or the quality of the effluent produced. Supervisors are not required to be on-site at all times.

   b. The permittee's wastewater system may not be without supervision (as required by Special Condition 4 a. above) for more than thirty (30) days. During this period, and at any time that the supervisor is not available to respond on-site (i.e. vacation, sick leave or off-call), the permittee must make available another person who is certified in the proper classification and at grade level I or higher.

   c. The permittee is responsible for ensuring the wastewater system has a properly certified supervisor available at all times to respond on-site at the request of the permittee and to any other operator.

   d. The permittee shall notify the Department of Environmental Quality in writing within thirty (30) days of replacement or redesignation of certified operators responsible for supervising wastewater system operation. The notice shall be filed with the Water Quality Division, Operator Certification Program (811 SW Sixth, Portland, OR 97204). This requirement is in addition to the reporting requirements contained under Schedule B of this permit

WPCF GENERAL CONDITIONS
(SCHEDULE F)

SECTION A. STANDARD CONDITIONS

1. Property Rights

Issuance of this permit does not convey any property rights in either real or personal property or any exclusive privileges, nor does it authorize any injury to private property, any invasion of personal rights, or any infringement of federal, state, or local laws or regulations.

2. Liability

The Department of Environmental Quality or its officers, agents, or employees may not sustain any liability on account of the issuance of this permit or on account of the construction or maintenance of facilities or systems because of this permit.

3. Permit Actions

After notice by the Department, this permit may be modified, suspended, or revoked in whole or in part during its term for cause including but not limited to the following:

a. Violation of any term or condition of this permit, any applicable rule or statute, or any order of the Commission;

b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts.

4. Transfer of Permit

This permit may not be transferred to a third party without prior written approval from the Department. The Department may approve transfers where the transferee acquires a property interest in the permitted activity and agrees in writing to fully comply with all the terms and conditions of this permit and the rules of the Commission. A transfer application and filing fee must be submitted to the Department.

5. Permit Fees

The permittee must pay the fees required with this permit application and annually for permit compliance determination by Oregon Administrative Rules.

SECTION B. OPERATION AND MAINTENANCE OF POLLUTION CONTROLS

1. Proper Operation and Maintenance

At all times the permittee must maintain in good working order and properly operate as efficiently as possible all treatment or control facilities or systems installed or used by the permittee to comply with the terms and conditions of this permit.

2. Standard Operation and Maintenance

All waste collection, control, treatment, and disposal facilities or systems must be operated in a manner consistent with the following:

a. At all times, all facilities or systems must be operated as efficiently as possible in a manner that will prevent discharges, health hazards, and nuisance conditions.

b. All screenings, grit, and sludge must be disposed of in a manner approved by the Department to prevent any pollutant from the materials from reaching waters of the state, creating a public health hazard, or causing a nuisance condition.

c. Bypassing untreated waste is generally prohibited. Bypassing may not occur without prior written permission from the Department except where unavoidable to prevent loss of life, personal injury, or severe property damage.

3. Noncompliance and Notification Procedures

If the permittee is unable to comply with conditions of this permit because of surfacing sewage; a breakdown of equipment, facilities or systems; an accident caused by human error or negligence; or any other cause such as an act of nature, the permittee must:

a. Immediately take action to stop, contain, and clean up the unauthorized discharges and correct the problem.

b. Immediately notify the Department's Regional office so that an investigation can be made to evaluate the impact and the corrective actions taken, and to determine any additional action that must be taken.

c. Within 5 days of the time the permittee becomes aware of the circumstances, the permittee must submit to the Department a detailed written report describing the breakdown, the actual quantity and quality of waste discharged, corrective action taken, steps taken to prevent a recurrence, and any other pertinent information.

Compliance with these requirements does not relieve the permittee from responsibility to maintain continuous compliance with the conditions of this permit or liability for failure to comply.

4. Wastewater System Personnel

The permittee must provide an adequate operating staff that is duly qualified to carry out the operation, maintenance, and monitoring requirements to assure continuous compliance with the conditions of this permit.

SECTION C. MONITORING AND RECORDS

1. Inspection and Entry

The permittee must at all reasonable times allow authorized representatives of the Department of Environmental Quality to:

a. Enter upon the permittee's premises where a waste source or disposal system is located or where any records are required to be kept under the terms and conditions of this permit;

b. Have access to and copy any records required by this permit;

c. Inspect any treatment or disposal system, practices, operations, monitoring equipment, or monitoring method regulated or required by this permit; or

d. Sample or monitor any substances or permit parameters at any location at reasonable times for the purpose of assuring permit compliance or as otherwise authorized by state law.

2. Averaging of Measurements

Calculations of averages of measurements required for all parameters except bacteria must use an arithmetic mean; bacteria must be averaged as specified in the permit.

3. Monitoring Procedures

Monitoring must be conducted according to test procedures specified in the most recent edition of **Standard Methods for the Examination of Water and Wastewater,** unless other test procedures have been approved in writing by the Department and specified in this permit.

4. Retention of Records

The permittee must retain records of all monitoring and maintenance information, including all calibrations, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least 3 years from the date of the sample, measurement, report or application. The Department may extend this period at any time.

SECTION D. REPORTING REQUIREMENTS

1. Plan Submittal

Pursuant to Oregon Revised Statute 468B.055, unless specifically exempted by rule, construction, installation, or modification of disposal systems, treatment works, or sewerage systems may not commence until plans and specifications are submitted to and approved in writing by the Department. All construction, installation, or modification shall be in strict conformance with the Department's written approval of the plans.

2. Change in Discharge

Whenever a facility expansion, production increase, or process modification is expected to result in a change in the character of pollutants to be discharged or in a new or increased discharge that will exceed the conditions of this permit, a new application must be submitted together with the necessary reports, plans, and specifications for the proposed changes. A change may not be made until plans have been approved and a new permit or permit modification has been issued.

3. Signatory Requirements

All applications, reports, or information submitted to the Department must be signed and certified by the official applicant of record (owner) or authorized designee.

SECTION E: DEFINITIONS

1. *BOD_5* means five-day biochemical oxygen demand.
2. *TSS* means total suspended solids.
3. *FC* means fecal coliform bacteria.
4. *NH_3-N* means Ammonia Nitrogen.
5. *NO_3-N* means Nitrate Nitrogen.
6. *NO_2-N* means Nitrite Nitrogen.
7. *TKN* means Total Kjeldahl Nitrogen.
8. *Cl* means Chloride.
9. *TN* means Total Nitrogen.
10. "*Bacteria*" includes but is not limited to fecal coliform bacteria, total coliform bacteria, and E. coli bacteria.
11. *Total residual chlorine* means combined chlorine forms plus free residual chlorine.
12. *mg/l* means milligrams per liter.
13. *ug/l* means micrograms per liter.
14. *kg* means kilograms.
15. *GPD* means gallons per day.
16. *MGD* means million gallons per day.
17. *Grab sample* means an individual discrete sample collected over a period of time not to exceed 15 minutes.
18. *Composite sample* means a combination of samples collected, generally at equal intervals over a 24-hour period, and apportioned according to the volume of flow at the time of sampling.
19. *Week* means a calendar week of Sunday through Saturday.
20. *Month* means a calendar month.
21. *Quarter* means January through March, April through June, July through September, or October through December.

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX B

EFFLUENT REUSE AND BIOSOLIDS MANAGEMENT PLANS

- **B-1 EFFLUENT REUSE PLAN – NORTH WWTP (CH2MHILL, 1993)**
- **B-2 EFFLUENT REUSE PLAN – SOUTH WWTP (ACE CONSULTANTS, 2004)**
- **B-3 1996 BIOSOLIDS MANAGEMENT PLAN W/2005 SUPPLEMENT (CITY)**

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX B-1

EFFLUENT REUSE PLAN – NORTH WWTP
(PREPARED BY CH2MHILL, 1993)

Effluent Reuse Plan

CH2M HILL

February 1993

Effluent Reuse Plan

CH2M HILL
February 1993

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Appendix A. Reclaimed Water Agreement
Appendix B. *Soils Evaluation of the Proposed Effluent Reuse Land Application Site, City of Madras, Oregon*
Appendix C. Estimated Soils Properties and Results of Soil Conservation Service Soils Tests
Appendix D. Fertilizer Guides
Appendix E. Analysis Results for Unfiltered Effluent

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Section 1
TREATMENT PROCESS

Section 1
Treatment Process

The existing Madras wastewater treatment facilities consist of a lagoon system with effluent chlorination and spray irrigation. Proposed new facilities will include a 25-acre lined effluent storage pond, a flotation/filtration clarifier, a chemical handling building, a new chlorine contact basin, irrigation pump station, sludge storage pond, site drain pump station, and other miscellaneous improvements. It is intended that the new facilities will provide treatment sufficient to meet the requirements of Oregon Administrative Rule (OAR) Level IV for reuse. Startup of the new facility is anticipated in June 1993.

The existing lagoon system consists of two 10.5-acre primary ponds, two 2.5-acre secondary ponds, and one 2.0-acre polishing pond. The total pond capacity is 58 million gallons, with an effective storage capacity of 28 million gallons. The system is designed for a 0.45-mgd average daily flow and a 1.35-mgd peak flow rate.

The proposed 25-acre storage pond will provide an additional 41 million gallons of wintertime storage of the lagoon effluent. The effluent storage pond will be lined with a 20-mil PVC liner, which will be covered with 1 foot of earth fill. Figure 1-1 shows the wintertime flow schematic.

During the irrigation season, effluent from the storage pond will be drained by gravity to the wet well of the intermediate lift station (existing irrigation pump). Prior to entering the wet well, the effluent will pass through the existing chlorine contact chamber. The chlorine contact chamber will be used to disinfect the effluent at times when it is desirable to prechlorinate prior to the flotation/filtration clarifier. The intermediate lift pump will pump the lagoon effluent to the flotation/filtration clarifier where alum will be mixed with the effluent. The effluent will then pass through the gravity filter and new chlorine contact basin. The new irrigation pump will discharge the effluent for land application. Figure 1-2 shows the irrigation season flow schematic.

The chlorine contact basin is sized to provide a 1-hour detention time at the design flow of 1 mgd. The chlorine feed system and residual analyzer are sized and set to maintain the effluent chlorine residual between 2 and 5 mg/l.

The facility does not include an emergency power source, since a power outage will result in automatic shutdown of the irrigation system. Wastewater will be stored in the lagoons until the power is restored.

Likewise, no redundancy will be provided for the flotation/filtration clarifier facility, since wastewater can be stored in the lagoons while the system is out of service. Refer to Section 6 for other contingency options available to the City while the treatment system is out of service.

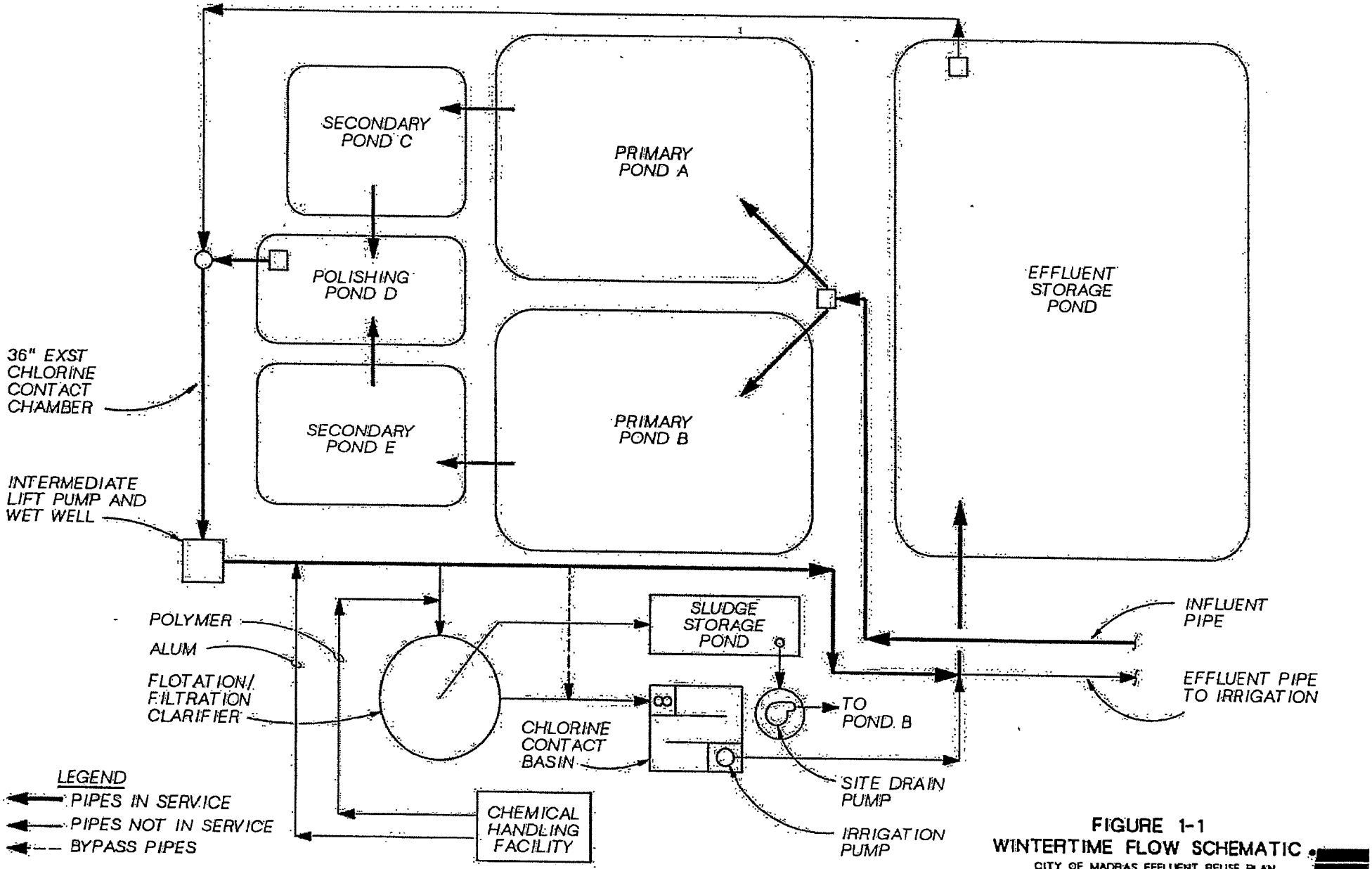

FIGURE 1-1
WINTERTIME FLOW SCHEMATIC
CITY OF MADRAS EFFLUENT REUSE PLAN
MADRAS, OREGON

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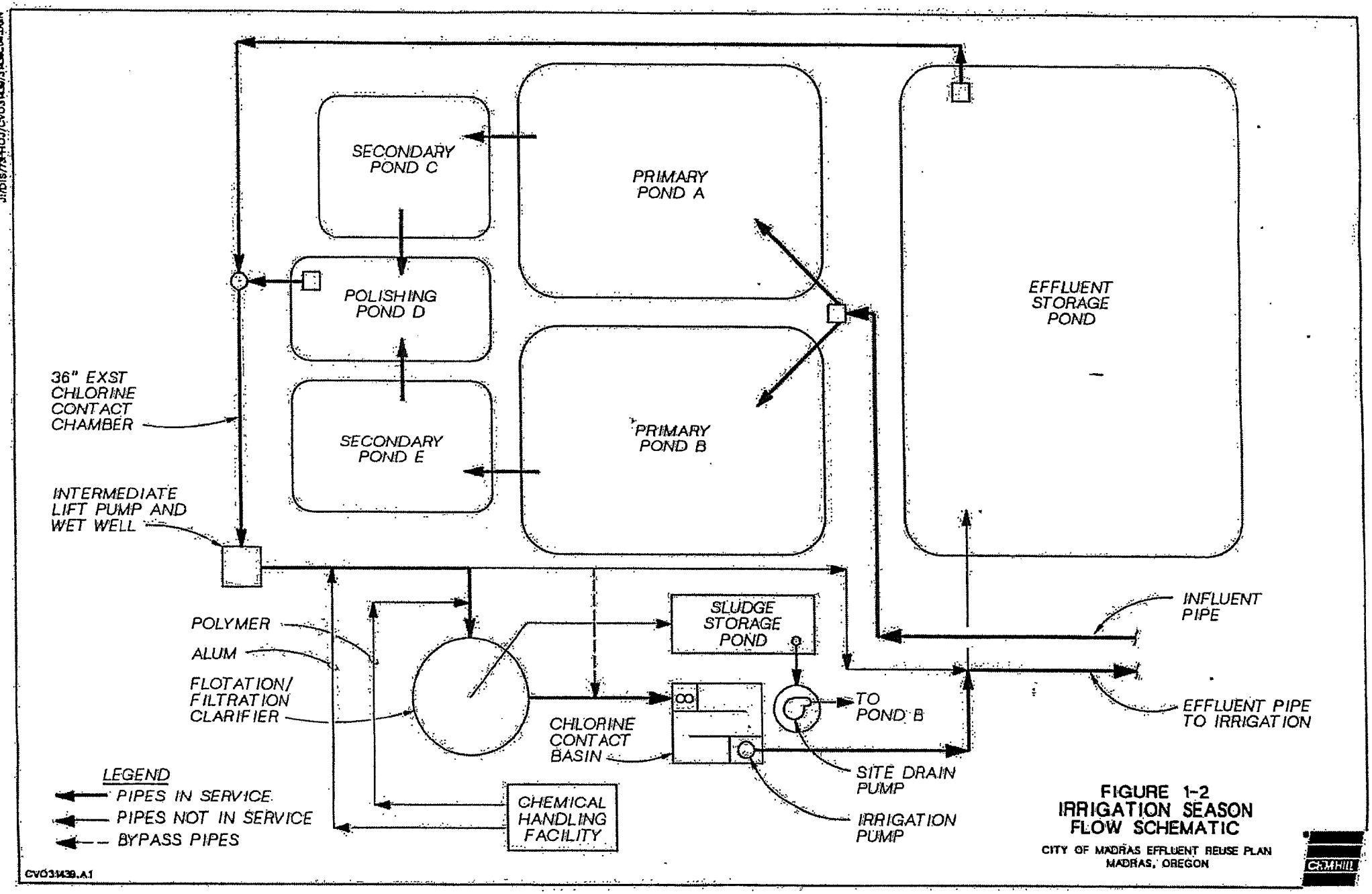

FIGURE 1-2
IRRIGATION SEASON FLOW SCHEMATIC

CITY OF MADRAS EFFLUENT REUSE PLAN
MADRAS, OREGON

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Section 2
LAND APPLICATION IMPLEMENTS

Section 2

Land Application Implements

Effluent from the treatment facility will be pumped through a pipeline dedicated to effluent destined for the land application sites. The pressurized effluent pipeline will provide effluent to the Nine Peaks Golf Course and other irrigation sites. The effluent may also be discharged to a small existing storage pond for redistribution. Several irrigation methods are available to the City, depending on which site is being irrigated. The golf course will be irrigated with a fixed-in-place, pop-up type irrigation system.

The golf course irrigation system was installed prior to the site being selected for irrigation using reclaimed water; therefore, the irrigation system was not installed in accordance with all the *Guidelines for Distribution of Nonpotable Water* published by the California-Nevada section of the AWWA. Because of the costliness of replacing the existing system, the City has requested that an exemption to the guidelines be provided for the buried portions of the distribution system. Above ground elements such as hydrants, valves, and valve boxes will be identified with warning labels in accordance with the guidelines and as required by the Agreement between the City of Madras and Nine Peaks Golf Course.

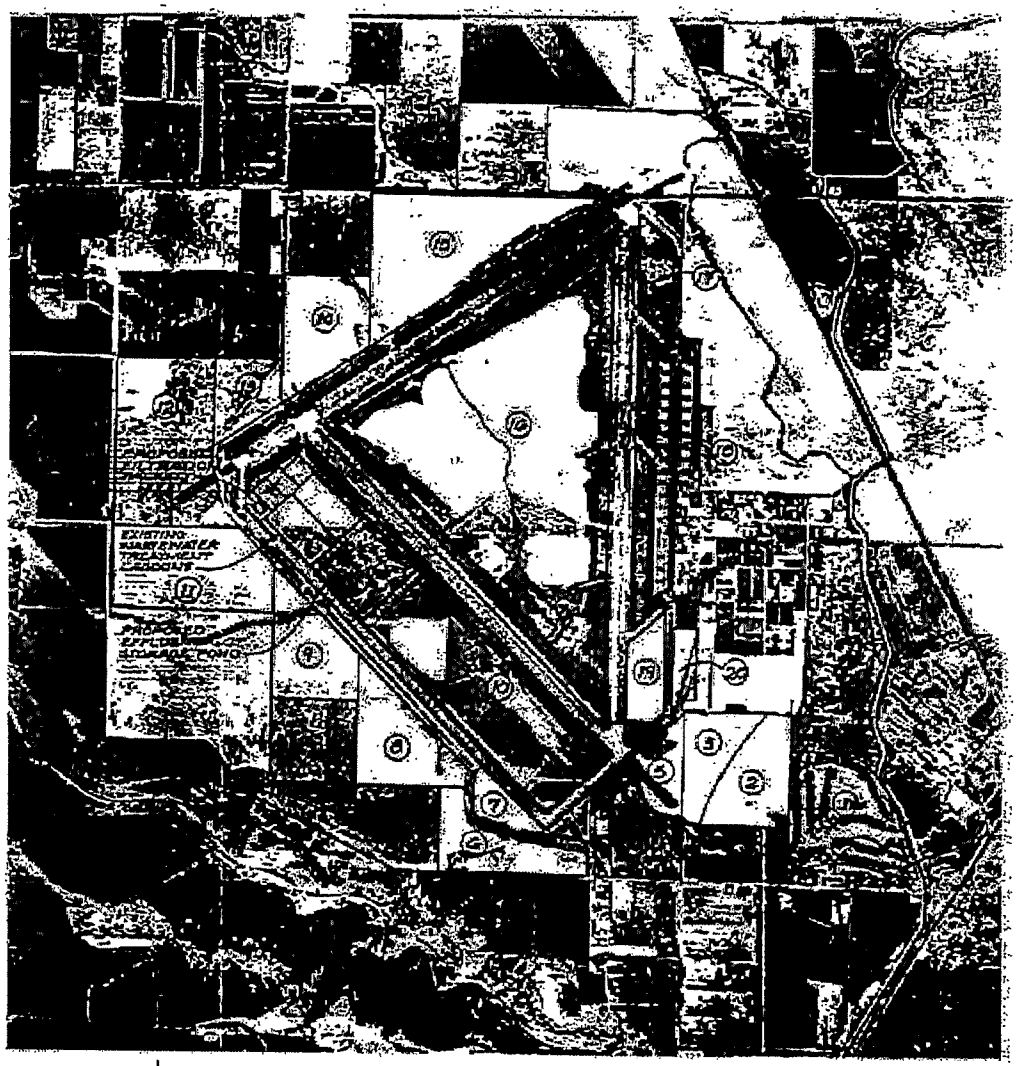
A final copy of the Agreement between the City and the golf course is included in Appendix A. A similar agreement will be implemented for any other reuse sites not under direct control of the City.

All new distribution components will be constructed in such a manner as to prevent cross-connection with potable water, aquifers, or other water sources. In addition, the existing golf course distribution system does not include cross-connections between the potable and nonpotable systems.

The City owns a pivot irrigation system and two big-gun sprinklers for irrigation of adjacent agricultural land. The existing 24-acre flood irrigation field will be irrigated with an overhead system such as hand-move laterals, side-roll wheel laterals, or big-gun sprinklers. Figure 2-1 is a map showing the irrigation sites.

The proposed improvements to the wastewater facility will include a chlorine residual analyzer and a turbidimeter. In the event that the chlorine residual falls below the minimum level or the turbidity exceeds the maximum level, the flow from the irrigation pump will be automatically bypassed to the effluent storage pond until the effluent quality is restored.

The chlorine residual and turbidity will be monitored on a continuous basis. The chlorine residual analyzer will be an amperometric type with pH buffering and reagent supply equipment for sample conditioning. The turbidimeter will be a flow-through type with 90-degree side-scatter using photocell-sensed, nephelometric measurement. The process control logic associated with the effluent residual and turbidity monitoring is described in Section 6, Contingency Options.



APPROX. LOCATION	ACRES*	REMARKS
1	34.1	EXISTING 9 HOLE GOLF COURSE.
2	33.4	EXISTING 9 HOLE GOLF COURSE
3	24.5	LOCATION OF EXISTING PIVOT IRRIGATION SYSTEM
4	24.0	LOCATION OF EXISTING FLOOD FIELD
5	39.1	
6	38.7	
7	17.7	
8	57.0	
9	58.6	
10	143.6	
11	68.3	
12	69.2	
13	81.1	
14	87.3	
15	122.1	
16	59.3	
17	18.6	
18	30.8	
19	20.9	
20	7.8	
	1,257.5	

NOTE:
* INCLUDES ONLY THOSE ACRES TO BE IRRIGATED.

FIGURE 2-1
MAP OF AVAILABLE IRRIGATION SITES
CITY OF MADRAS EFFLUENT REUSE PLAN
MADRAS, OREGON
CH2MHILL

Section 3
IRRIGATION SITE MANAGEMENT INFORMATION

Section 3

Irrigation Site Management Information

The City of Madras intends to provide Level IV effluent for irrigation of an 18-hole golf course. Additional City-owned land is available in the vicinity of the wastewater treatment facility and airport. Refer to Figure 2-1 for the location of the available City-owned land proposed for irrigation.

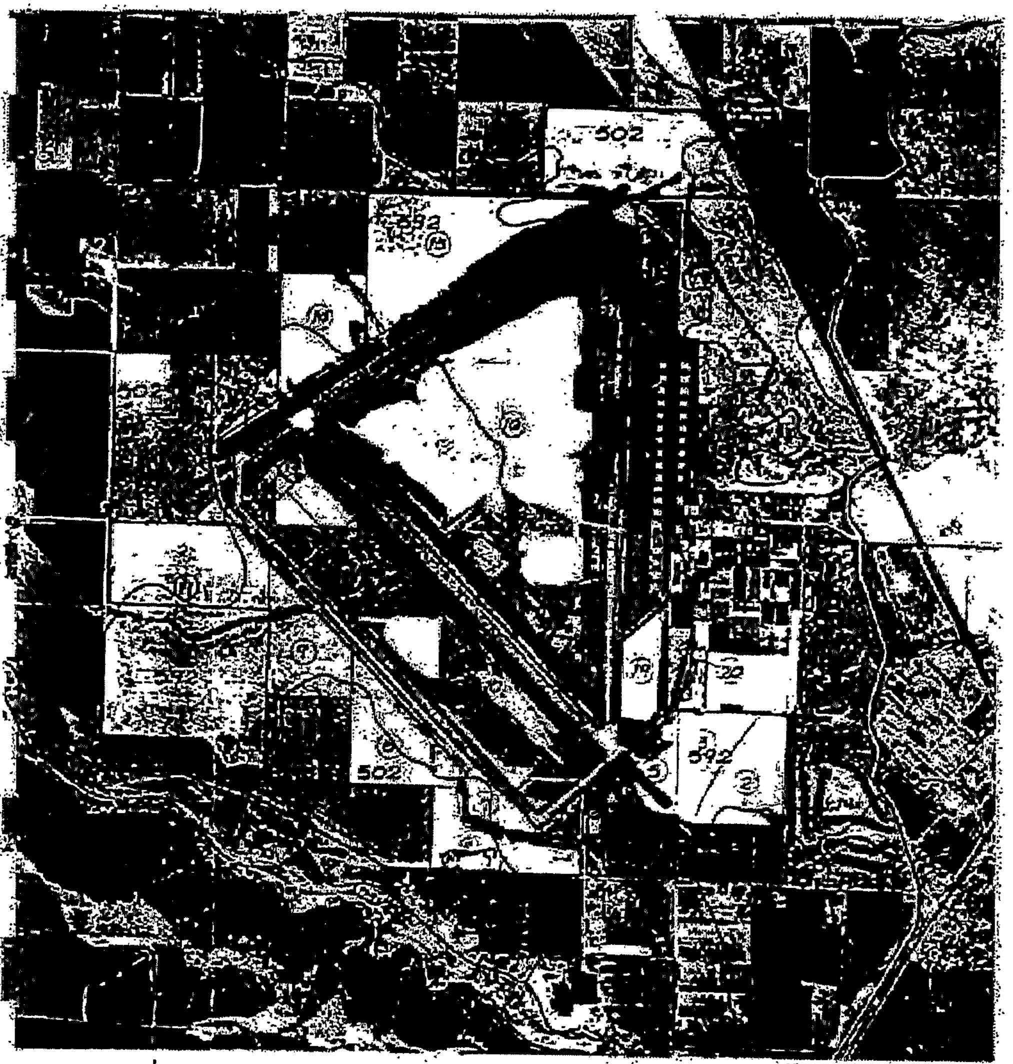
The soils in the areas to be irrigated are classified as Madras loam and Madras silt loam. Figure 3-1 is a soil classifications map of the areas to be irrigated. For additional information on these soils, see the report *Soils Evaluation of the Proposed Effluent Reuse Land Application Site, City of Madras, Oregon,* which is included in Appendix B.

Estimated soils properties from the Soil Conservation Service soils report are included in Appendix C. The most important properties include depth, permeability, available water-holding capacity, pH, and depth to hard pan. These soils are well-suited for irrigated agriculture and are widely developed with major irrigation projects in the Madras area. The soils generally are about 20 inches deep over a hard pan layer. This depth restricts rooting of some crops and farmers commonly rip the hard pan to raise deep-rooted crops such as alfalfa. Turf grass does not require ripping. The soil has a moderate permeability, which is not restrictive with a well-designed irrigation system. The available water-holding capacity in the top 20 inches of soil is about 2.5 to 3 inches. To maintain optimum yields and minimize leaching, some high-water-use crops such as turf grass will require light, frequent irrigations (up to several times per week in July and August). The soil pH is ideal for production of most irrigated crops that are raised in the Madras area, and is well-suited for effluent irrigation.

Results of soils tests are also included in Appendix C. The test results generally show good pH, organic matter content, soluble salt levels, and electrical conductivity, as well as nutrient levels consistent with good agronomic practice.

Fertilizer guides for crops normally grown east of the Cascades, developed by the Oregon State University Extension Service, are included in Appendix D. This information should be very helpful to growers in determining the additional nitrogen required to supplement that provided by the effluent. Growers will be required to keep the total available nitrogen applied equal to that required by the crops.

Signs will be posted around the storage pond and golf course stating in English and Spanish that reclaimed water is used for irrigation and is not suitable for drinking. Irrigation will be controlled to prevent direct public access or contact during irrigation cycles. In addition, the entire treatment facility, including the storage pond, will be fenced to prevent direct public access. Food preparation areas and water fountains will not be irrigated with effluent. All irrigation will be at agronomic rates; prolonged ponding and runoff will be avoided.



SCS CLASSIFICATION NUMBER	[illegible]
502	MADRAS LOAM, 0 TO 3 PERCENT SLOPES
592	MADRAS SILT LOAM, 0 TO 3 PERCENT SLOPES

FIGURE 3-1
SOIL CLASSIFICATION MAP

CH2M HILL

Section 4
WASTEWATER ANALYSIS

Section 4
Wastewater Analysis

Samples of the unfiltered effluent were analyzed for nutrients and heavy metals. The results of the analyses are included in Appendix E.

Table 4-1 lists the amounts of nutrients in the effluent. This table will be used by farmers to determine the amount of supplemental fertilizer required for their crops. The effluent will be analyzed on an annual basis and Table 4-1 will be modified to account for changes in the nutrient concentrations.

Upon completion of the wastewater treatment facilities modifications, a sample of the filtered effluent will be analyzed for nutrients. A new table similar to Table 4-1 will be generated for the filtered effluent.

Table 4-1
Wastewater Nutrient Levels

Crop Nutrients	Effluent Concentration (mg/l)	Pounds of Nutrients Applied in Irrigation per Acre-Inch of Effluent
TKN	23.7	--
Ammonia Nitrogen	21.5	--
Organic Nitrogen	2.2	--
Nitrate Nitrogen	0.05	--
Available Nitrogen[1]	12.78	2.89
Phosphorus	8.3	1.88
Sulphate	27.0	6.11
Boron	1.4	0.32
Zinc	0.034	0.01
Manganese	0.246	0.06
Copper[2]	0.012	0.00
Iron	0.096	0.02
Sodium	75.3	17.05
Calcium	28.7	6.50

[1]Available nitrogen is calculated assuming 50% of the ammonia nitrogen is lost to volatilization from sprinkler application, 10% of the organic nitrogen is lost to denitrification/volatilization losses, and there are no nitrate nitrogen application losses.
[2]Copper level was not detected. Detection limit of 0.012 mg/l was used in calculation.

Section 5
WASTEWATER APPLICATION RATES

Section 5
Wastewater Application Rates

The hydraulic and nutrient loading rates were examined to determine which factor controlled the wastewater application rates. Based on quality data on the City's wastewater effluent, the application rates for Madras' wastewater reuse system are controlled by the hydraulic loading rate. This is because the nitrogen and other nutrient levels in the wastewater are low (see Tables 4-1 and 5-4).

Table 5-1 lists the consumptive use, net irrigation required, and recommended gross irrigation required based on a 5 out of 10-year probability. This probability level for consumptive use and net irrigation requirement represents the recommended rates based on an average year for precipitation and temperature. The gross irrigation required for the various crops was used in determining the required acreage. The maximum hydraulic loading or application rate was based on the dry year period, which is represented by the 19 out of 20-year probability level (Table 5-2). An irrigation efficiency of 80 percent for field crops and 85 percent for turf grass at the golf course was used to determine the gross application (irrigation required) rate for both the 5 out of 10- and 19 out of 20-year net irrigation requirements. The consumptive use and net irrigation requirements for the various crops were based on the Oregon State University publication "Consumptive Use and Net Irrigation Requirement for the State of Oregon" dated July 1992 (draft).

The gross irrigation required, based on the average consumptive use and net irrigation requirement, was used to determine the acreage required to handle the 1992 and projected 2010 treated wastewater flow. The acreage requirements for various crops are summarized in Table 5-3. Table 5-4 shows the available nitrogen required for the various crops. Recommendations on the amount of nitrogen required (lbs/acre) for the various crops were obtained from fertilizer guides published by the Oregon State University Extension Service (see Appendix D). As seen in Table 5-4, most of the crops listed will not receive all of the nutrient requirements from the applied effluent even at the maximum loading rates that will occur in dry years. Therefore, additional commercial fertilizers would need to be applied to maintain a healthy vegetation. The additional commercial fertilizer identified in Table 5-4 provides only a target amount that might be applied to the reuse sites. Actual applications of additional nutrients will be determined from soils analysis of the available nutrients.

The golf course's average (5 out of 10-year) annual gross irrigation requirements would be slightly less than the amount of effluent available during 1992 (for example, 79.2 mg per year). During the lowest annual precipitation (dry year), the annual gross irrigation requirement exceeds the amount of effluent available during 1992 (for example, 96.0 mg per year). Because supplemental land to the existing golf course acres will be required, the City intends to apply the effluent to agricultural land that supports various crops in the vicinity of the wastewater treatment facilities. During the year 2010, the City must reuse

Table 5-1

Consumptive Use, Net Irrigation Requirements, and Gross Application Rate

for Various Crops in the Madras Area (Inches)(a)

5 out of 10 years (Average)--Used in Determining Maximum Land Area Required

Month	Mean Precip (in.)	Min Precip (in.)	Turf Grass (b)	Pasture Grass		Alfalfa		Grass Seed (fall)		Spring Grains		Winter Grains		Mint		Silage Corn	
			Normal Irrigation Practice (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)
Jan.	0.63	0.29	--	--	--	--	--	0.16	--	--	--	--	--	--	--	--	--
Feb.	1.1	0.5	--	--	--	--	--	0.55	0.04	--	--	--	--	--	--	--	--
March	1.04	0.48	--	--	--	--	--	1.57	0.91	--	--	0.67	0.35	--	--	--	--
April	0.25	0.11	2.26	2.13	1.81	1.00	0.69	3.43	2.91	2.17	1.65	2.80	2.28	1.65	1.18	--	--
May	0.57	0.26	4.83	4.72	3.86	3.35	2.56	5.47	4.53	5.12	4.21	5.43	4.53	4.57	3.70	2.24	1.97
June	0.45	0.21	5.90	5.67	4.72	7.80	7.48	6.50	5.47	6.50	5.39	6.50	5.39	6.69	5.59	4.80	4.65
July	0.77	0.35	8.31	7.01	6.65	6.34	6.14	8.03	7.64	7.17	6.81	7.24	6.89	7.36	6.97	7.91	8.03
Aug.	1.41	0.65	6.60	5.55	5.28	4.37	3.82	5.69	5.43	1.26	1.18	0.71	0.71	1.18	1.14	6.34	6.54
Sept.	1.42	0.65	4.48	4.06	3.58	1.06	0.79	2.09	2.09	--	--	--	--	--	--	4.45	4.41
Oct.	1.29	0.59	1.93	2.05	1.54	--	--	1.85	1.85	--	--	--	--	--	--	--	--
Nov.	0.83	0.38	--	--	--	--	--	0.59	0.59	--	--	--	--	--	--	--	--
Dec.	0.74	0.34	--	--	--	--	--	--	0.08	--	--	--	--	--	--	--	--
Total	10.5	4.81	34.30	31.19	27.44	23.92	21.42	35.87	31.54	22.22	19.24	23.35	20.15	21.45	18.58	25.74	25.60
Gross Application Rate (c)			40.35		34.30		26.78		39.43		24.05		25.19		23.23		32.00

(a) Consumptive Use and Net Irrigation Requirements based on meeting 5 out of 10 years for selected crop in Madras-Redmond Region
Source: *Consumptive Use and Net Irrigation Requirement for Oregon, July, 1991*

(b) Historical Usage; Frequent harvesting and intense cultivation allow higher water and nutrient utilization; high value on appearance stresses the need for proper watering (approximately 25 percent increase over pasture grass requirement)

(c) Gross Application Rate (i.e. Gross Irrigation Required)= Net Irrigation Required (NIRR)/Irrigation Efficiency
Assumed Irrigation Efficiency = 80% Assumed Irrigation Efficiency (turf grass--golf course irrigation)= 85%

Table 5-2
Consumptive Use, Net Irrigation Requirements, and Gross Application Rate for Various Crops in Madras Area (inches)(a)
19 out of 20 years-- Maximum Hydraulic Loading Rate, Based on Lowest Annual Precipitation

	Turf Grass (b)	Pasture Grass		Alfalfa		Grass Seed (fall)		Spring Grains		Winter Grains		Mint		Silage Corn	
Month	Normal Irrigation Practice (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)	CU (in.)	NIRR (in.)
Jan.	--	--	--	--	--	0.43	--	--	--	--	--	--	--	--	--
Feb.	--	--	--	--	--	0.87	0.59	--	--	--	--	--	--	--	--
March	--	--	--	--	--	2.01	1.54	--	--	0.79	0.63	--	--	--	--
April	3.00	2.52	2.40	2.56	2.44	4.09	3.78	2.52	2.32	3.27	3.03	1.85	1.73	--	--
May	6.00	5.43	4.80	5.12	4.49	6.22	5.51	5.79	5.16	6.18	5.43	5.08	4.57	2.44	2.17
June	7.48	6.22	5.98	5.83	5.63	7.13	6.85	7.09	6.85	7.09	6.85	7.32	7.09	5.31	5.16
July	9.20	7.36	7.36	6.89	6.89	8.43	8.43	7.52	7.52	7.60	7.60	7.72	7.72	8.31	8.31
Aug.	7.68	6.26	6.14	5.87	5.75	6.42	6.30	1.38	1.38	0.79	0.79	1.30	1.30	7.24	7.05
Sept.	5.46	4.53	4.37	4.25	4.09	2.32	2.24	--	--	--	--	--	--	4.96	4.80
Oct.	2.80	2.32	2.24	--	--	2.13	1.97	--	--	--	--	--	--	--	--
Nov.	--	--	--	--	--	0.79	0.47	--	--	--	--	--	--	--	--
Dec.	--	--	--	--	--	0.35	--	--	--	--	--	--	--	--	--
Total	41.61	34.64	33.29	30.52	29.29	41.19	37.68	24.30	23.23	25.72	24.33	23.27	22.41	28.26	27.49
Gross Application Rate (c)	48.96		41.61		36.61		47.10		29.04		30.41		28.01		34.36

(a) Consumptive Use and Net Irrigation Requirements based on meeting 19 out of 20 years for selected crop in Madras-Redmond Region
Source: *Consumptive Use and Net Irrigation Requirement for Oregon, July, 1991*

(b) Historical Usage; Frequent harvesting and intense cultivation allow higher water and nutrient utilization; high value on appearance stresses the need for proper watering (approximately 25 percent increase over pasture grass requirement)

(c) Gross Application Rate (i.e. Gross Irrigation Required)= Net Irrigation Required (NIRR)/Irrigation Efficiency
Assumed Irrigation Efficiency = 80% Assumed Irrigation Efficiency (Turf grass-- GC Irrigation' 85%

Table 5-3
Maximum Acreage Requirements for Various Crops
Based on Gross Irrigation Requirement (5 out of 10 years)

Crops	Gross Irrigation Requirement (inches) (a)	Available Treated Wastewater (MG)		Acres Required		Additional Acres Req'd w/ 67.5 Acres of Irrigated Turf Grass (Golf Course)	
		1992 Flow	2010 Flow	1992 Flow	2010 Flow	1992 Flow	2010 Flow
Turf Grass	40.4	88	169	80	154	13	87
Pasture Grass	34.3	88	169	95	182	27	114
Alfalfa	26.8	88	169	121	233	54	165
Grass Seed	39.4	88	169	82	158	15	90
Spring Grains	24.1	88	169	135	259	67	191
Winter Grains	25.2	88	169	129	247	61	180
Potatoes	26.8	88	169	121	233	54	165
Mint	23.2	88	169	140	268	72	201
Silage Corn	32.0	88	169	101	195	34	127

(a) Gross Irrigation Requirement = Net Irrigation Requirement (5 out of 10)/Irrigation Efficiency;
Assumed Irrigation Efficiency= 80% field crops
Assumed Irrigation Efficiency= 85% turf grass-- golf course irrigation

Table 5-4
Available Nitrogen Requirements for Various Crops
Based on 19 out of 20 years (Dry Year) Irrigation Requirements

Crops	Total Available Nitrogen Req'd (Lbs/Ac)	Available Nitrogen (a) In Wastewater (Lbs/Ac)	Additional Commercial Nitrogen to Apply (Lbs/Ac) (c)
Turf Grass	300	165	135
Pasture Grass	200	120	80
Alfalfa (b)	-	106	0
Grass Seed	140	136	4
Spring Grains	130	84	46
Winter Grains	110	88	22
Mint	160	81	79
Silage Corn	250	99	151

(a) 2.89 lbs of Available Nitrogen per Acre-inch; Based on 10 % organic nitrogen lost, 50 % ammonia nitrogen lost, and 0 % nitrate-nitrite nitrogen lost; Applied to field crops (i.e. pasture, alfalfa, etc.)
3.38 lbs of Available Nitrogen per Acre-inch; Based on 10 % organic nitrogen lost, 40% ammonia nitrogen lost, and 0 % nitrate-nitrite nitrogen lost; Applied to turf grass due to night irrigation @ golf course
(b) Legumes do not require applied nitrogen
(c) Actual applications of additional commercial fertilizers will be determined from soils analysis of the available nutrients

approximately 169 million gallons per year, which will require additional land ranging from 87 to 200 acres depending on the type of vegetation. In addition to the golf course, the City controls approximately 1,200 acres that could be irrigated with effluent. The projected effluent available from 1992 to 2010 is shown in Figure 5-1. Also represented in the figure is the average and maximum gross irrigation required for the 68-acre golf course. Soil moisture monitoring techniques will be used to help determine the appropriate amount of water required to meet the irrigation needs of the turf crop.

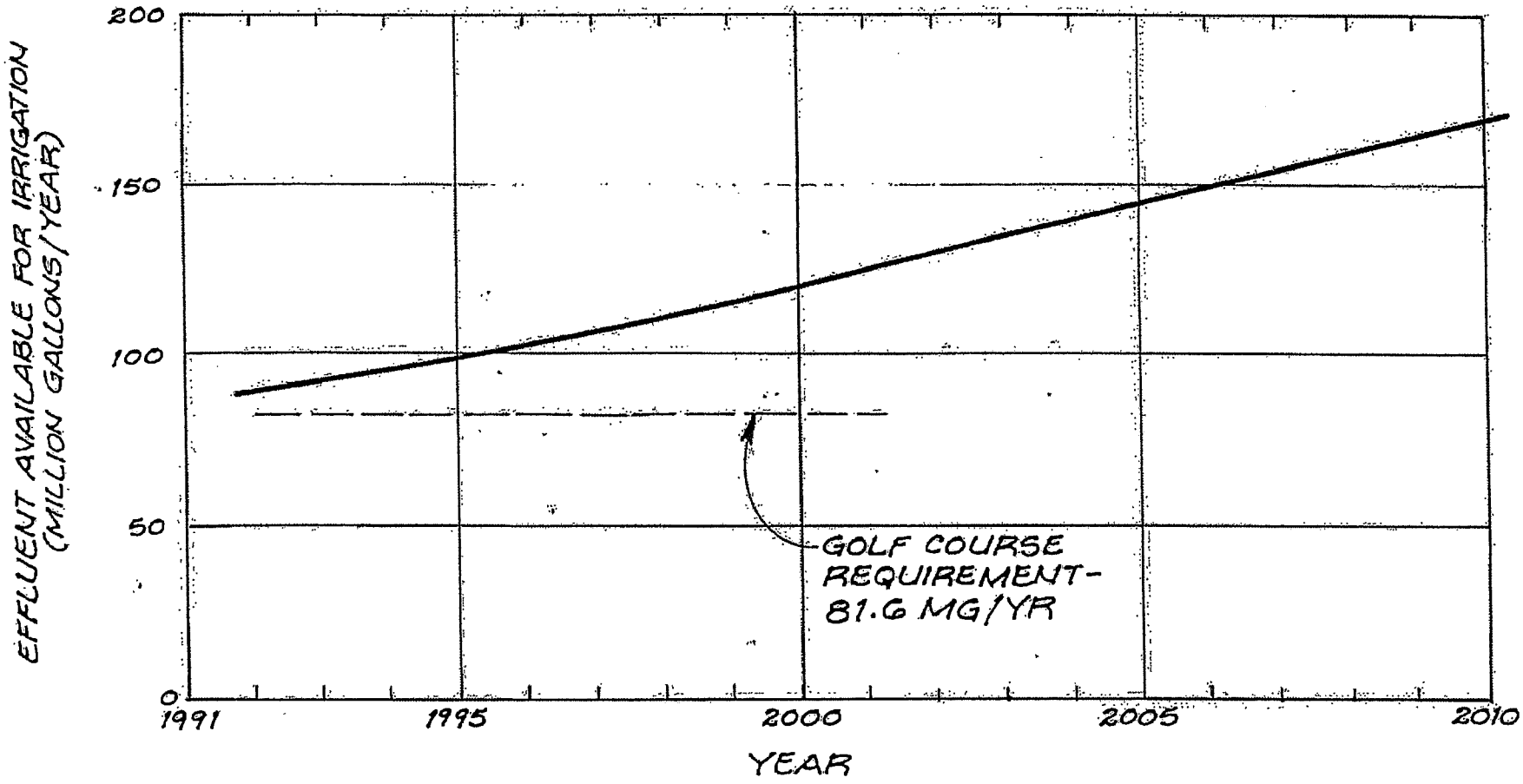


FIGURE 5-1
EFFLUENT AVAILABLE FOR IRRIGATION
CITY OF MADRAS EFFLUENT REUSE PLAN
MADRAS, OREGON

Section 6
CONTINGENCY OPTIONS

Section 6
Contingency Options

In the event of an irrigation system breakdown or treatment facility upset, several contingency options can be implemented. The system will be automatically monitored on a continuous basis for effluent chlorine residual and turbidity. Conditions of low chlorine residual or high turbidity will result in the bypass of effluent to the storage pond and shutdown of the irrigation system. Once the effluent quality is restored, the system will automatically allow effluent to enter the irrigation system. The operation of the irrigation pump will also be controlled by wet well level and discharge line pressure. Either low level or high pressure will shut down the pump. High level will cause the pump to start. If the irrigation pump stops for any reason, the entire treatment system, including the intermediate lift pump, the flotation/filtration clarifier, the chemical feed systems, and the chlorination systems, will be shut down. In this case, effluent will be stored in the treatment ponds until operation can be restored.

If a shutdown is caused by failure of the chlorination system, the effluent may be stored in the treatment ponds. If the ponds are full, the effluent can be pumped to the storage pond using the intermediate lift pump until the chlorination system is back online.

If a shutdown is caused by failure of the flotation/filtration clarifier system, the effluent may be stored in the treatment or storage ponds as described above, or the irrigation system may be changed to irrigate a crop that does not require filtered effluent. In this event, the flotation/filtration clarifier can be bypassed.

If all of the irrigation systems are shut down, the effluent must be stored in the treatment ponds or effluent storage pond as described above.

All instrumentation capable of shutting down the system will be provided with alarms that will be transmitted to the County Sheriff's Department. The Sheriff's Department will be given information on who to contact in the event of an alarm.

Section 7
RECORDKEEPING

Section 7
Recordkeeping

In accordance with DEQ requirements, the City will provide wastewater quality analyses on a monthly basis, maintain a log of wastewater applications, monitor total coliform on a daily basis, and monitor turbidity on an hourly basis. The City will also submit an annual report describing the system's effectiveness in complying with the reuse plan, DEQ rules, and permit limits and conditions.

Wastewater Application Record

The wastewater application record will be a permanent running record of wastewater volume, application rate, dates of application, and the accumulated application for each irrigation area. Figure 7-1 shows a Wastewater Application Record form.

The record will be kept current in order to have an accurate record of application rates and to determine when the total limit on accumulated wastewater application is reached for each irrigation area. A totalizing flowmeter will be installed on the irrigation pump discharge to accurately measure deliveries of effluent for irrigation.

Wastewater Monitoring Record

A wastewater monitoring record will be maintained for the irrigation system. Figure 7-2 shows a sample Wastewater Monitoring Record form. The total coliform count will be recorded on a daily basis. The turbidity will be monitored on a continuous basis with a turbidimeter, and data will be recorded on a plant recorder. The 24-hour mean turbidity will be recorded on the wastewater monitoring record on a daily basis.

Figure 7-1

CITY OF MADRAS
WASTEWATER APPLICATION RECORD

Location of Irrigation: _____

Crop Type: _____ Irrigation Required: _____

Date	Volume (gallons)	Area Covered (acres)	Irrigation Amount (inches)	Cumulative Irrigation Amount (inches)

Figure 7-2

CITY OF MADRAS
WASTEWATER MONITORING RECORD

Date	Total Coliform (organisms per 100 ml)	Turbidity 24-Hour Mean (NTU)

Appendix A
RECLAIMED WATER AGREEMENT

A G R E E M E N T

BETWEEN THE CITY OF MADRAS

AND

NINE PEAKS GOLF COURSE

FOR USE AND DELIVERY OF RECLAIMED WATER

WHEREAS, the Nine Peaks Golf Course is desirous of receiving reclaimed water from the City of Madras' wastewater treatment facility for irrigation of it's landscaping and associated City owned agricultural lands near the golf course; and

WHEREAS, the City is desirous of utilizing the Nine Peaks Golf Course as a reclaimed water use site and believes that irrigation of the golf course is a beneficial use of such water.

NOW THEREFORE, the parties do hereby agree to the following terms and conditions for the use and delivery of such reclaimed water:

1. The City agrees to supply reclaimed water for golf course irrigation subject to the available supply of such reclaimed water which can meet the standards for Level IV effluent quality as described in OAR Chapter 340, Division 55, Table 1.

2. The City agrees to supply reclaimed water for golf course irrigation subject to available supply of such reclaimed water which can meet the standards for Level II effluent quality as described in OAR Chapter 340, Division 55, Table 1, when the above described Level IV reclaimed water is not available. Provided however, that the golf course will ensure that when applying effluent at Level II no reclaimed water will be used within 100 feet of any residence, drinking fountain, or where food is being prepared.

3. The City agrees to supply reclaimed water for agricultural crops upon City owned lands leased to the golf course which lie wholly outside the boundaries of the actual golf course, and which are not open to the public, subject to available supply of such water. The

level of treatment of such water supplied shall be determined by the crop grown. In no event shall the City supply reclaimed water for agricultural use when such use would not conform to the standards established in OAR Chapter 340, Division 55, Table 1.

4. The reclaimed water will be delivered to a location determined by the City at the rate of flow available through City facilities. Such flow is estimated to be approximately 500 GPM but no guarantee is expressed or implied for the actual rate of delivery.

5. Such deliveries of reclaimed water will be preferentially supplied to the golf course when all applicable conditions of this agreement can be met.

6. The City reserves the right to divert from delivery any quantity of reclaimed water as may be necessary or desirable to provide for optimum operation of the City's wastewater facilities.

7. The City reserves the right to terminate deliveries to the golf course:

   a) If appropriate water quality standards cannot be met, or

   b) If the user fails to meet any condition required by this agreement, or

   c) Should equipment failure occur,

   d) Should the golf course fail to manage the irrigation system in compliance with Oregon Administrative Rules, Chapter 340, Division 55.

8. The Nine Peaks Golf Course may transfer deliveries of reclaimed water to other parties, provided that each succession of ownership of the reclaimed water shall first be established by a legally enforceable contract on file with the City and which notifies the succeeding reclaimed water user of the requirements of Oregon Administrative Rules, Chapter 340, Division 55, and the

permit for the sewage treatment system. The contract shall also require the succeeding user to so contract with any additional succeeding reclaimed water users.

9. Deliveries of reclaimed water for use upon any portion of golf course property open to the public shall be at treatment Level IV as defined in OAR Chapter 340, Division 55, except as provided in paragraph 2 in this agreement. Deliveries shall not exceed the requirements of the landscaping, estimated to be a maximum of 44.5 inches per year, or 3.71 acre feet per acre. The total amount estimated to be available in 1992 is approximately 300 acre feet. The application of supplemental fertilizer, when combined with the nutrients contained in the reclaimed water, shall not exceed the requirements of the turf irrigated as referenced in the Effluent Reuse Plan.

Deliveries of reclaimed water for use upon agricultural lands outside the boundaries of the golf course not open to the public but under the control of the golf course ownership, may be made at treatment Level II as defined in OAR Chapter 340, Division 55, when not in conflict with the provisions of such OAR Chapter 340, Division 55.

10. The City will make reasonable effort to provide adequate quantities of treatment Level IV reclaimed water for golf course use. When such deliveries are not possible or practical, the City will endeavor to furnish reclaimed water at treatment Level II for use by the golf course where such use is in conformance with this agreement and not in violation of OAR Chapter 340, Division 55. The Golf Course agrees to receive and apply such reclaimed water as fully as may be practical within requirements of OAR Chapter 340, Division 55.

11. The Golf Course may apply reclaimed water to crops upon leased agricultural lands outside the perimeter of the golf course in conformance with guidelines for water and nutrient requirements as referenced in the applicable table in the Effluent Reuse Plan. The owner shall provide the City with a map showing all areas to receive reclaimed water and the crops to be grown thereon. Such map, as well as, a crop rotation schedule and an estimation of reclaimed effluent application and nutrient

needs, shall be submitted annually for each site prior to the application of reclaimed water.

When crops not specified within the Effluent Reuse Plan are to be grown, the owner shall provide the City with a schedule of water and nutrient requirements for the crop proposed to be grown. All applications of reclaimed water shall be at agronomic rates and in no event shall the owner apply reclaimed water in excess of the requirements of the crop for water and nutrients.

12. The City shall be allowed to inspect owner's plumbing and storage facilities at any time to assure compliance with any regulation or agreement. Such plumbing facilities shall be approved by the Oregon Health Division for use with reclaimed water.

13. The City may meter deliveries to the premises for recording purposes and may, at the expiration of any lease period which may be agreed upon, set charges for the use of such reclaimed water.

14. Direct release of any reclaimed water to surface waters of the State of Oregon shall be prohibited.

15. The owner of the Nine Peaks Golf Course and the Public Works Director of the City of Madras shall be responsible for compliance with this agreement, the Oregon Administrative Rules Chapter 340, Division 55, and the sewage treatment system discharge permit.

16. The owner of the Nine Peaks Golf Course shall report to the City any and all violations of the terms of OAR Chapter 340, Division 55, and this agreement.

17. The Golf Course agrees to install and maintain any necessary equipment and piping from point of delivery to all points of use.

18. The Golf Course agrees to receive and make use of the reclaimed water in such qualities and times, within reasonable limits, as the City is able to deliver.

19. The Golf Course agrees to install appropriate backflow devices on all potable water service lines when required, and agrees that no connection shall be made between any potable water lines, and lines containing reclaimed water.

20. The Golf Course will provide the City with as-built drawings of all piping for both domestic and reclaimed water. Installation shall conform to requirements of the Oregon Health Division and Oregon Administrative Rules, Chapter 340, Division 55, for use of reclaimed water.

21. The Golf Course agrees to maintain all reclaimed water use facilities in a state of good condition.

22. The Golf Course further agrees that should future regulations require a higher level of treatment of the reclaimed water for golf course irrigation than may be possible with the existing City treatment facilities, the City may terminate deliveries until such higher standards can be met.

The provisions of this agreement are for the purpose of providing conditions upon which the City may deliver reclaimed water and on usage of such reclaimed water by the Nine Peaks Golf Course. By affixing signatures the parties of this agreement certify that they have read and understand the provisions contained in Oregon Administrative Rules, Department of Environmental Quality, Chapter 340, Division 55.

CITY OF MADRAS

Jolene Holcomb — 3/20/92

Jo Anne Holcomb, City Administrator — Date

NINE PEAKS GOLF COURSE

Kevin O'Meara — 3-20-92

Kevin O'Meara, Owner — Date

Appendix B
SOILS EVALUATION OF THE PROPOSED EFFLUENT REUSE LAND APPLICATION SITE CITY OF MADRAS, OREGON

Soils Evaluation of the Proposed Effluent Reuse Land Application Site City of Madras, Oregon

Prepared by
CH2M HILL

February 1993

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Introduction

The City of Madras, Oregon, is proposing a land application program of Level IV municipal effluent for irrigation of an 18-hole golf course and adjacent properties. The 18-hole course covers an area of approximately 67.5 acres; an additional 1,190 acres of adjacent City-owned land is also available for land application. The land application site is about 1 mile northwest of the City of Madras, west of Highway 26, and includes properties directly adjacent to and within the Nine Peaks Golf Course and the City-County airport. Specifically, the proposed site is in Township 10 South, Range 13 East, in portions of Sections 26, 27, 28, 33, 34, and 35.

The city owns a pivot irrigation system and two big gun sprinklers for irrigation of adjacent agricultural land. The amount of annual effluent available for irrigation is approximately 90 million gallons, or about 276 acre-feet of water. By the year 2010, approximately 170 million gallons or 522 acre-feet of effluent will be produced per year.

During the week of February 23, 1992, a CH2M HILL soil scientist investigated the proposed 1,257 acres. Eleven backhoe test pits were examined. Because of the physical uniformity of the soil mapping unit, only 3 of the 11 pits were sampled and described in detail. Twelve soil samples, taken from various depths from the three pits, were analyzed for various physical and chemical parameters. Laboratory analysis was performed at CH2M HILL's Quality Analytic Laboratory in Redding, California. No field measurements of soil permeability or infiltration rates were taken. These determinations can actually be derived more accurately during irrigation with the proper adjustments. This report presents general information from the United States Department of Agriculture (USDA)—Soil Conservation Service (SCS) Upper Deschutes Soil Survey; a summary of field observations; full soil profile descriptions for three representative soil pits; laboratory results of various evaluated physical and chemical parameters; and evaluation of the overall suitability for wastewater and sludge application.

Soil Conservation Service General Description of Soil Mapping Unit

The entire proposed land application area is composed of two separate mapping unit numbers: 502 and 592. However, the SCS has recently grouped these two mapping units, along with Mapping Unit 504, into a single collective mapping unit, the Madras loam with 0 to 3 percent slopes.

The Madras series consists of moderately deep, well-drained soils on upland terraces and plateaus. These soils formed in windblown deposits and volcano-clastic semi-consolidated sediments. The mean annual precipitation is about 10 inches, the frost-free period is about 120 to 140 days, and the mean annual temperature is about 48 degrees Fahrenheit (°F). Elevation ranges from 2,000 to 3,000 feet above mean sea level, and the native vegetation includes western juniper, basin big sagebrush, antelope bitterbrush, bluebunch wheatgrass, and Idaho fescue.

The Madras soils are well drained and have a moderately slow permeability (0.2—0.6 inches per hour) and an available water capacity of about 3.5 inches for a 27-inch-thick soil profile. The depth to basalt bedrock of the Deschutes Formation ranges from 20 to 40 inches.

The collective mapping unit of the Madras soil and similar inclusions contain about 15 percent contrasting inclusions. Contrasting inclusions are composed of the Era soils in the swales, Cullius soils on the plateaus, and soils with silt loam surface textures. The Madras soils are classified as fine-loamy, mixed, mesic, and Xerollic Durargids. Table 1 lists a summary of SCS information on the Madras soil mapping unit. These soils are used for both cropland and livestock grazing. Farmers will rip the hardpan provided this extends the rooting depth of 15 to 20 inches to bedrock. Estimates for alfalfa, wheat, barley, oats, and pasture grown on the Madras soils are as follows:

- Alfalfa—4.5 tons per acre
- Spring wheat—50 bushels per acre
- Barley—70 bushels per acre
- Oats—80 bushels per acre
- Pasture—250 cow-acre days

Field Observations

Table 2 summarizes soil characteristics for the 11 backhoe pits dug by the City of Madras. All of the soil pits were very similar, with soil depths to restrictive layers ranging from 13 inches to as deep as 31 inches. The average depth to a restrictive layer usually was found to be about 20 inches below the ground surface. The depth to the basalt bedrock below the pan was difficult to determine in most places because the pan was quite indurated and difficult to penetrate. Where the pan was absent, there was decomposed, paralithic (weathered) basaltlike material at a depth of 18 to 24 inches above unweathered, lithic vesicular basalt. Surface and subsurface soil textures ranged from a heavy sandy loam to a silty clay loam; a loam texture was the most common.

The presence of the restrictive hardpan, paralithic, or lithic contact could lead to a perched water table from overirrigation. However, no mottling or gleying of soils was observed in the field, including soil pits on the golf course, an indication that these soils are moderately well drained and properly irrigated. Under present conditions, it is unlikely that water is ponding for extended periods above the basalt bedrock, duripan, or paralithic material.

Soil Pedon Descriptions

The locations of the eleven soil pits are illustrated in Figure 1, which is included at the end of this appendix. Of the eleven, three representative soil pits were selected for full soil pedon descriptions. These descriptions follow.

Table 1.
SCS Soil Survey Information for Madras Soil Mapping Unit,
City of Madras Proposed Effluent Reuse
Land Application[1]

Soil Mapping Unit	Texture		Permeability (inches/hour)		Drainage Class	Reaction (pH)	Depth to pan/bedrock (feet)	Available Water Capacity (inches)	Irrigated Land Capability Class and Subclass	Depth to Groundwater (feet)	Moist Bulk Density (grams per cubic centimeter [g/cm^3])
	Surface	Subsoil[2]	Surface	Subsoil							
Madras silt loam	loam	clay loam	0.6-2.0 (moderate)	0.2-0.6 (moderately slow)	moderate	neutral to mildly alkaline	1.7 to 3.3	2.5 to 3.0	IIs	>6	0-11 (inches) 1.10-1.35 11-20 (inches) 1.10-1.50

[1]All interpretations and information are based on a 20-inch-thick soil profile.
[2]Subsoil texture of the Madras soils can be a loam, clay loam, cobbly loam, or cobbly clay loam. For a complete range of soil characteristics for the Madras soils, see Appendix A.
[3]Depth to duripan ranges from 18 to 24 inches.

Table 2
Summary of Soil Characteristics from Field Observations, City of Madras

Pit # and Mapping Unit #	Location (T10S R13E)	Depth (inches) to:			Soil Texture		Comments
		Duripan	Paralithic	Basalt	Surface	Subsurfaces	
1/502	Sec 35 SE 1/4 SE1/4 (golf course)	22			l (heavy)	Sicl (20-22 inches)	Except above pan, soil gets coarser downward
2/502*	Sec 35 SE 1/4 SW1/4			13-15	l	l	Thin pan over basalt bedrock; 3 major soil horizons; surface soil color 10 YR 4/3
3/592	Sec 35 SW 1/4 SW 1/4		24		l (heavy)		Surface color 10 YR 3/3; soil directly above paralithic materials; contains faint clayskins
4/592*	Sec 35 NE 1/4 SW 1/4		15-18	26	l (heavy)		Pit 300 feet south to southwest of center pivot; surface color 10 YR 4/3
5/592	Sec 35 NW 1/4 SE 1/4		18		l (heavy)		Soil pit out on golf course; surface soil is fill and has been disturbed
6/592	Sec 34 SE 1/4 NE 1/4	20-21			Sl (heavy)	Sil	Surface structure very coarse platy
7/592	Sec 27 SE 1/4 SE 1/4	31-34			l (heavy)	l	Pit in disturbed agricultural field with residual wheat stubble; upper 21 inches disturbed; surface color 10 YR 3/3
8/592	Sec 27 NE 1/4 NW 1/4	18-20			l	Sl (heavy—just above pan)	Abundant cobbles above pan (floaters) ±20%
9/502*	Sec 33 NE 1/4 NE 1/4	20			l	l (above pan)	Well-developed duripan with thin laminar cap; soil pit in disturbed agricultural field; plow layer (Ap) from 0 to 14 inches; drastic decrease in roots at 8 inches (no restrictions observed—probably common wetting depth)
10/502	Sec 34 NE 1/4 SW 1/4	17-21			l	—	Site in Conservation Reserve Program land planted in rye; surface 5 inches is very coarse platy structured soil with vesicular pores; pan at least 1 foot thick
11/592	Sec 34 NE 1/4 SW 1/4	25			l	—	Weakly to strongly cemented pan well developed—looks like conglomerate—contains large quantities of pumice and possibly biotite

*Full soil pedon description completed and soil pit sampled.

Soil Pit Identification Number: 502-2 (Pit 2).

Location: Township 10 South, Range 13 East, in the southeast one-quarter of the southeast one-quarter of the southeast one-quarter of Section 35, adjacent to the City-County Airport and the Nine Peaks Golf Course.

This shallow, moderately well-drained soil is on an upland basalt plateau. The site is relatively flat with slopes of 1 to 2 percent. The elevation at this specific soil pit is about 2,440 feet above mean sea level. The area has been disturbed by agricultural production, and the site currently is planted in a barley cover crop. Permeability is moderate. The available water capacity is 1.5 inches. The effective rooting depth is 15 inches to basalt bedrock. Runoff is slow. This soil is suited for irrigation crops, and its main limitation is the shallow depth to bedrock.

Taxonomic Class: Loamy, mixed, mesic, shallow, Xerollic Camborthids.

Colors are for moist soils unless otherwise indicated. The soil pedon description for this specific location is as follows:

Ap_1—0 to 2 inches; very dark grayish brown (10 YR 3/2) loam (S—51 percent, Si—35 percent, C—14 percent); moderate, very fine, and fine granular structure; soft, very friable, and slightly sticky and slightly plastic wet; many very fine and few fine roots; common very fine and few fine tubular pores; neutral (pH of 6.9); cation exchange capacity (CEC) of 23.4 milliequivalents per 100 grams of soil (meq/100 g) and available water capacity (AWC) of 0.13 inch; 2 percent pebbles; abrupt smooth boundary.

Ap_2—2 to 5 inches; very dark grayish brown (10 YR 3/2), loam (S—51 percent, Si—35 percent, C—14 percent); moderate very fine and fine granular structure and moderate medium subangular blocky structure; slightly hard to hard dry, friable to firm moist, and slightly sticky and slightly plastic wet; many very fine and few fine roots; common very fine tubular pores; neutral (pH of 6.9); CEC of 23.4 meq/100 g and AWC of 0.19 inch; disturbed horizon containing abundant charcoal, rusty nails, and pieces of brick; few fine, prominent black and yellowish brown mottles, possibly staining from brick fragments and residual nails; 3 percent pebbles; gradual wavy boundary (2 to 3 inches thick).

B_1—5 to 8 inches; very dark grayish brown (10 YR 3/2.5) loam (S—50 percent, Si—36 percent, C—14 percent); medium and strong, coarse subangular blocky structure; hard, firm, and slightly sticky and slightly plastic wet; common very fine roots; common very fine tubular pores; common, thin clay films on ped faces, lining pores, root channels, and worm holes; CEC of 21.8 meq/100 g and AWC of 0.27 inch; horizon containing abundant charcoal; 6 percent pebbles; clear wavy boundary (2 to 4 inches thick).

B_2—8 to 15 inches; dark brown (10 YR 4/3) loam (S—53 percent, Si—36 percent, C—11 percent); weak medium and coarse subangular blocky structure; slightly hard, firm, and slightly sticky and slightly plastic wet; few very fine roots; common very fine tubular and few very fine interstitial pores; few, faint, thin clay films on ped faces, lining old root channels,

and bridging sand grains; mildly alkaline (pH of 7.6); CEC of 25 meq/100 g and AWC of 0.94 inch; horizon containing an old, oxidized nail and abundant charcoal; thin coating of illuviated material, consisting of loose volcanic ash, carbonates, and illuviated clay directly above consolidated basalt bedrock; abrupt smooth boundary (6 to 8 inches thick).

2R—15 inches thick; black vesicular basalt bedrock.

Samples: Three samples were taken with the following identification numbers: 502-2-0-5"; 502-2-5-8"; and 502-2-8-15". Soil samples were analyzed for pH, CEC, and moisture retention to determine plant AWC (1/3 and 15 bar) and particle size distribution. Table 3 summarizes these laboratory results.

Soil Pit Identification Number: 592-4 (Pit 4).

Location: Township 10 South, Range 13 East, Section 35 in the northeast one-quarter of the southwest one-quarter of Section 35, adjacent to the City-County Airport and the Nine Peaks Golf Course. Soil pit is 300 feet south-to-southwest of the center pivot.

This shallow, moderately well-drained soil is on an upland basalt plateau. The site is relatively flat with slopes of 1 to 2 percent and a south-to-southwest aspect. The elevation at this specific soil pit is about 2,436 feet above mean sea level. The area is planted in turf grass and is on the edge of the proposed golf course expansion zone. Before the land was used for agriculture or the golf course, the surface had basalt cobbles and stones, as indicated by a linear pile of basalt cobbles and stones separating the fairways. Permeability is moderate; the AWC to the crop for consumptive use, in the upper 18 inches of soil, is 2.1 inches. The effective rooting depth is 18 inches under current irrigation practices; however, it is still possible that with increased water application, the highly weathered basalt could weaken to allow root penetration and subsequent plant root-soil water extraction. Runoff is slow. This soil is suited for turf grass; its main limitation is shallowness.

Taxonomic Class: Loamy, mixed, mesic, shallow, Xerollic Haplargids.

Colors are for moist soils unless otherwise indicated. The soil pedon description for this specific location is as follows:

Ap_1—0 to 3 inches; very dark grayish brown (10 YR 3/2) loam (S—49 percent, Si—39 percent, C—12 percent); strong very fine and fine granular structure; soft, very friable, and slightly sticky and slightly plastic wet; many very fine roots; many very fine tubular and few fine interstitial pores; mildly alkaline (pH of 7.6); CEC of 18.5 meq/100 g and AWC of 0.19 inch; 1 percent pebbles; abrupt smooth boundary.

Ap_2—3 to 6 inches; very dark grayish brown (10 YR 3/2.5) loam (S—49 percent, Si—39 percent, C—12 percent); strong very fine and fine granular, and strong, medium, and coarse platy structures; slightly hard, friable, and slightly sticky and slightly plastic wet; many very fine roots; many very fine tubular pores; mildly alkaline (pH of 7.6); CEC of 18.5 meq/100 g and AWC of 0.18 inch; 1 percent pebbles; abrupt wavy boundary (2 to 4 inches thick).

Table 3
Effluent Reuse, City of Madras

Sample Description		Satur. Paste	Hydrometer				meq/100 g NH_4 Acetate	Percent Water Capacity		Estimated Moist Bulk Density (g/cm^3)
Reference Number	Client ID	pH	Sand	Silt	Clay	Texture	CEC	1/3 Bar	15 Bar	
32292-1	502-2-0-5"	6.9	51	35	14	L/SL	23.4	30.7	25.4	1.10-1.35
32292-2	502-2-5-8"	7.0	50	36	14	L	21.8	31.8	24.6	1.20-1.30
32292-3	502-2-8-15"	7.6	53	36	11	SL/L	25.0	35.0	24.7	1.2-1.40
32292-4	592-4-0-6"	7.6	49	39	12	L	18.5	27.4	22.2	1.10-1.30
32292-5	592-4-6-11"	8.0	49	41	10	L	20.0	29.4	23.4	1.30-1.50
32292-6	592-4-11-15"	8.0	44	48	8	L/SL	24.0	31.5	23.4	1.1-1.3
32292-7	592-4-15-18"	8.2	64	29	7	SL	26.6	25.8	19.0	1.2-1.35
32292-8	502-9-0-8"	6.2	54	36	10	SL	19.2	26.2	17.3	1.1-1.25
32292-9	502-9-8-16"	7.1	56	35	9	SL	21.4	29.7	17.9	1.2-1.35
32292-10	502-9-16-25"	7.7	45	43	12	L	25.2	32.5	23.2	1.30-1.50
32292-11	502-9-25-35"	7.9	54	40	6	SL	28.6	35.7	23.5	1.20-1.40
32292-12	592-4-18-26"	8.1	72	21	7	SL	35.2	27.2	19.6	1.20-1.35

Bt_1—6 to 11 inches; dark brown (10 YR 3/3) loam (S—49 percent, Si—41 percent, C—10 percent); strong, fine, and medium subangular blocky structure; slightly hard, friable, and slightly sticky and slightly plastic wet; many very fine roots; common very fine tubular pores; common, faint, thin clay films on ped faces, lining pores, root channels, and worm holes, and common clay bridging sand grains; moderately alkaline (pH of 8.0); CEC of 20 meq/100 g and AWC of 0.39 inch; 2 percent pebbles; gradual wavy boundary (3 to 6 inches thick).

Bt_2—11 to 15 inches; brown (10 YR 4/3) loam (S—44 percent, Si—48 percent, C—8 percent); strong very fine and fine subangular, and medium very fine and fine granular structures; slightly hard, friable, and slightly sticky and slightly plastic wet; many very fine roots; common very fine tubular pores; many prominent clay films on ped faces, lining pores, and common clay bridging sand grains; moderately alkaline (pH of 8.0); CEC of 24 meq/100 g and AWC of 0.44 inch; 2 percent pebbles; abrupt broken boundary (broken by some underlying durinodes) (0 to 5 inches thick).

2Crk—15 to 18 inches; consolidated sediments of Deschutes Formation; variegated color consisting of light yellowish brown (10 YR 6/4) and yellowish brown (10 YR 5/6) gravelly loam or sandy clay loam; massive except in small areas where roots penetrate and soil is moderate; very fine granular structure; soft soil (where roots are) and hard, very friable (where roots are), and slightly sticky and slightly plastic wet; common very fine roots; common very fine tubular pores; where roots are located there are common, thin clay films on ped faces, lining pores, root channels, and common clay bridging sand grains; common lime filaments, seams, and concretions; many strongly cemented durinodes, generally 1 to 2 inches long and 1/2 inch wide, containing lime filaments; 15 percent pebbles and 5 percent cobbles (mostly basalt); most coarse fragments have well-developed lime-silica pendants on undersides; abrupt smooth boundary (3 to 4 inches thick).

3Crk—18 to 26 inches; primarily decomposed paralithic basalt (weather basalt) with a fraction of the Deschutes Formation mixed with the soil matrix; variegated color consisting of light yellowish brown (10 YR 6/4) and yellowish brown (10 YR 5/6) paralithic material and consolidated sand, clay, gravel, and cobbles; massive, very hard, very firm, and slightly sticky and slightly plastic wet; common very fine interstitial pores; no roots observed; thin (2- to 5-mm-thick) discontinuous, laminar cap of silica carbonates at 18 inches; few lime filaments, seams, and lime concretions; moderately alkaline (pH of 8.1); CEC of 35.2 meq/100 g and AWC of 0.90 inch; gradual, irregular boundary (8 to 14 inches thick).

4R—26 inches; black vesicular basalt; depth to basalt ranges from 26 inches below the ground surface to 32 inches.

Samples: Five samples were taken with the following identification numbers: 592-4--06"; 592-4-6-11"; 592-4-11-15"; 592-4-15-18"; and 592-4-18-26". Soil samples were analyzed for pH, CEC, AWC, and particle size distribution. Table 3 summarizes these laboratory results.

Soil Pit Identification Number: 502-9 (Pit 9).

Location: Township 10 South, Range 13 East, in the northeast one-quarter of the northeast one-quarter of Section 33, adjacent to the City-County Airport.

This moderately deep, well-drained soil is on an upland basalt plateau. The site is relatively flat with slopes of 1 to 2 percent and a south-to-southwest aspect. The elevation at this specific site is about 2,420 feet above mean sea level. The area was planted in mint during the previous growing season and contains a large amount of surface residual mint organic matter. A side-roll irrigation system is used for this field. Permeability is moderate; the AWC to the crop for consumptive use, in the upper 35 inches of soil, is 4.94 inches. The effective rooting depth is 35 inches. Between Inches 25 and 35, the soil horizon consists of about 75 percent plant fragments. This fragmentation is quite likely the result of the pan being ripped by a subsoiler tillage implement. Runoff is slow. The soil is suited for irrigated crops.

Taxonomic Class: Loamy, mixed, mesic, Xerollic Durargids.

Colors are for moist soils unless otherwise indicated. The soil pedon description for this specific location is as follows:

Ap_1—0 to 2 inches; very dark grayish brown (10 YR 3/2.5) sandy loam (S—54 percent, Si—36 percent, C—10 percent); strong, very coarse, and coarse platy structure; soft, very friable, and slightly sticky and slightly plastic wet; many very fine roots; many very fine vesicular and few very fine tubular pores; slightly acid (pH of 6.2); CEC of 19.2 meq/100 g and AWC of 0.23 inch; soil high in stubble (possibly rye); 3 percent pebbles; abrupt smooth boundary.

Ap_2—2 to 8 inches; very dark grayish brown (10 YR 3/2.5) sandy loam (S—54 percent, Si—36 percent, C—10 percent); weak, very coarse, and coarse subangular blocky structure; slightly hard, firm, and slightly sticky and slightly plastic wet; many very fine roots; slight evidence of organic matter illuviation; slightly acid (pH of 6.2); CEC of 19.2 meq/100 g and AWC of 0.70 inch; 8 percent pebbles, mostly basalt; clean wavy boundary (5 to 7 inches thick).

B_1—8 to 16 inches; brown (10 YR 4/3) fine sandy/loam (S—56 percent, Si—35 percent, C—9 percent); weak coarse subangular blocky structure; slightly hard, firm, and slightly sticky and slightly plastic wet; common very fine roots; many very fine vesicular and few fine tubular pores; common thin and moderate clay films on ped faces, lining pores, root channels, and clay bridging sand grains; neutral (pH of 7.1); CEC of 21.4 meq/100 g and AWC of 1.3 inches; few small white concretions that look like gypsum (could also be pumice); 5 percent pebbles, mostly basalt; gradual wavy boundary (6 to 10 inches thick).

Bt_2—16 to 25 inches; yellowish brown (10 YR 5/4) loam (S—45 percent, Si—43 percent, C—12 percent) and dark yellowish brown moist (10 YR 4/4); massive; slightly hard, firm, and slightly sticky and slightly plastic wet; common very fine roots; many very fine vesicular and common fine tubular pores; common thin and moderately thick clay films on ped faces, lining pores, and clay bridging sand grains; mildly alkaline (pH of 7.7); CEC of 25.2 meq/100 g and AWC of 1.1 inches; few small (1/4 to 1/8 inch in diameter) white concretions that look like gypsum (could also be pumice); lower portion containing a few weakly cemented durinodes

and common lime filaments in durinodes; 10 percent gravel and 3 percent cobbles; abrupt wavy boundary (7 to 10 inches thick).

2Crk—25 to 35 inches; yellowish brown (10 YR 5/4) extremely gravelly fine sandy loam (S—54 percent, Si—40 percent, C—6 percent); dark yellowish brown (10 YR 4/4) moist; massive, loose, and slightly sticky and slightly plastic wet; common very fine roots; common fine interstitial pores; horizon consisting of approximately 75 percent pan fragments with well-developed laminar caps—probably the Deschutes Formation; small lime nodules, lime filaments, and concretions in the soil matrix; moderately alkaline (pH 7.9); CEC of 28.6 meq/100 g and AWC of 1.65 inches; thin, well-developed, continuous pan over basalt bedrock; 50 percent pebbles, 20 percent cobbles, and 5 percent stones; abrupt wavy boundary (8 to 12 inches thick).

3R—35 inches; black vesicular basalt.

Samples: Four samples were taken with the following identification numbers: 502-9-0-8"; 502-9-8-16"; 502-9-16-25"; and 502-9-25-35". Soil samples were analyzed for pH, CEC, AWC, and particle size distribution. Table 3 summarizes these laboratory results.

Laboratory Findings

These three locations are representative of the range in physical characteristics encountered during the field investigation. The following is a list of methods used in testing the soils.

Analysis	Method
pH (saturated paste)	U.S. Bureau of Reclamation (USBR) 514.8.3
Percent sand, silt, clay (hydrometer)	USBR 514.4.
CEC (ammonium acetate)	USBR 514.8.4. and 6
Percent water capacity (1/3 and 15 moisture)	American Society of Agronomy (ASA) Monogram #9 PI 18-2

Table 4 provides the basic moisture storage characteristics of each of the three soil pits. These data are important for mitigating downward percolation of reuse water.

Site Suitability

The DEQ May 18, 1981, guidelines for land application of both wastewater and sludge are essentially the same criteria outlined above. These guidelines are flexible with regard to potentially limiting criteria (e.g., shallow soils).

The following is a summary of site selection and approval criteria for application or disposal of sludge and septage according to Oregon Administrative Rule (OAR) Chapter 340, Division 50-070, Oregon Department of Environmental Quality (DEQ) (December 1984):

- There should be a stable geologic formation not subject to flooding or excessive runoff from adjacent land.
- At the time of application, the minimum depth should be 4 feet to permanent groundwater and 1 foot to temporary groundwater.
- Slopes should not exceed 12 percent for surface application of liquid sludge. Slopes up to 20 percent are permissible if the sludge is dried or dewatered.
- Soils should have a minimum rooting depth of 24 inches.
- Underlying substratum should not be rapidly draining; rapid draining might allow leachate contamination of groundwater.
- In areas close to residential homes, the following buffer strips should be included, such as:
  - Direct injection—no buffer required
  - Truck spreading—0 to 50 feet
  - Spray irrigation—300 to 500 feet

  Buffers should be large enough to prevent nuisance odors or wind drift problems.
- No sludge should be spread closer than 50 feet to any ditch, canal, pond, or waterway or within 200 feet of a domestic water source or well.
- Crops considered accumulators of heavy metals (e.g., Swiss chard, lettuce, spinach, and carrots) should have a soil pH between 6.5 and 8.2.
- Saline or alkali soils should be avoided.

Cumulative loading limits for heavy metals depend upon the soil CEC. Table 5 presents total cumulative limits to metal loadings based on the CEC. Generally, the higher the CEC, the more various metals will be adsorbed onto the soil complex and unavailable for plant root uptake and subsequent plant metal accumulation.

Table 4
Total Water Storage Capacity (Moisture Retention) and Plant Available Water Capacity for Madras Effluent

Soil Pit No.	Texture	Soil Depth (inches)	Mean Moisture Retention % (gravimetric)		Estimated Mean Moist Bulk Density (g/cm^3)[a]	Total Soil[b] Water Storage (inches) at 1/3 Bar	Crop Rooting Depth	Plant Available[c] Water Capacity (inches of water)
			1/3 Bars	15 Bars				
2	L/SL	0-5	30.7	25.4	1.22	1.9	15	0.32 (or 0.06 inch/inch)
2	L	5-8	31.8	24.6	1.25	1.2	15	0.27 (or 0.09 inch/inch)
2	SL/L	8-15	35.0	24.7	1.30	3.2 Σ=6.3	15	0.94 (or 0.13 inch/inch) Σ=1.53 (or 0.10 inch/inch)
4	L	0-6	27.4	22.2	1.20	2.0	26	0.37 (or 0.06 inch/inch)
4	L	6-11	29.4	23.4	1.30	1.9	26	0.39 (or 0.08 inch/inch)
4	L/SL	11-15	31.5	23.4	1.35	1.7	26	0.44 (or 0.11 inch/inch)
4	SL	18-26	35.2	27.2	1.40	3.9 Σ=9.5	26	0.90 (or 0.11 inch/inch) Σ=2.1
9	SL	0-8	26.2	17.3	1.30	2.7	35	0.93 (or 0.11 inch/inch)
9	SL	8-16	29.7	17.9	1.35	2.4	35	1.27 (or 0.16 inch/inch)
9	L	16-25	32.5	23.2	1.30	2.9	35	1.09 (or 0.12 inch/inch)
9	SL	25-35	35.7	23.5	1.35	1.2[d] Σ=9.20	35	0.41[d] (or 0.04 inch/inch) Σ=3.70

[a]Bulk density estimates are from the Umatilla County, Oregon, SCS Soil Survey and are based on similar soil textures and similar depths.
[b]Total water storage (in inches) is calculated as the percent of moisture retention by the thickness of the soil horizon times the moist bulk density to yield volumetric storage (in inches) (e.g., 10% moisture retention x 20 inches of soil x 1.40 (moist BD) = 2.8 inches of water stored in 20 inches of soil. All sources of water (e.g. precipitation, runon) must be accounted for when estimating total storage at 1/3 bar.
[c]Available water capacity (AWC) is that water available for crop use. It is calculated from the following equation: [1/3 bar % moisture retention) (bulk density) - (15 bar % moisture retention) (bulk density)] x soil thickness = AWC (in inches of water).
[d]Adjusted for coarse fragment contents.

Table 5
Cumulative Limits of Metal Loadings
(from Huddleston and Ronayne, 1990)

Metal	Soil CEC (pounds/acre)		
	<5 meq/100 g	5-15 meq/100 g	>15 meq/100 g
Lead (Pb)	500	1,000	2,000
Zinc (Zc)	250	500	1,000
Copper (Cu)	125	250	500
Nickel (Ni)	50	100	200
Cadmium (Cd)	5.0	10[a]	20[a]

[a]If the soil pH is less than 6.5, use 5.0 pounds/acre for Cd, regardless of the CEC.

A successful land application program is strongly dependent on the operator's commitment to proper management of irrigation and sludge application frequency, timing, and duration, as well as to provision of a sufficient land area to apply nutrients at agronomic rates without hydraulic overloading of the soils.

The main limitations for the Madras loam mapping unit in a land application program include a shallow to moderately deep soil over a duripan and/or basalt bedrock and a low AWC. Through proper management with a sufficient land area, these two factors should not inhibit a successful land application program. Table 6 presents the USDA SCS rating for wastewater application on the Madras soil mapping unit. Soil nitrogen content, as reported by Soil Test Farm Consultants, Inc., in invoice 515-02 sampled March 5, 1990, from field 1A and B pivot, shows a nitrate-nitrogen content of 333 pounds per acre (lbs/acre). Therefore, no additional sources of nitrogen (i.e. municipal wastewater) should be added until future soil tests indicate that nitrogen levels have decreased to the "deficiency" range as defined by crop requirements.

Another area of concern at this arid location is the potential for salt accumulation within the soil. Residual carbonate deposits were observed in most soil pits. The types of residual salts found in the soil and those applied could strongly influence crop growth and a successful reclamation program.

No tests for carbonates, sodium adsorption ratio (SAR), or exchangeable sodium percentage (ESP) were performed. Soils in the proposed 1,257-acre application area have pH values ranging from 6.2 to 8.1, as shown in Table 3.

Table 6
SCS Soil Rating for Wastewater Irrigation
for Madras Soil Mapping Unit
(from SCS National Soils Handbook, Pages 603-125)

Property	Rating
Texture	No limitations
Salinity	Slight (<2 micromhos/cm)
Slope	No limitation
Depth to high water table (feet)	No limitation
Depth to bedrock (inches)	(20 to 40 inches)
Depth to cemented pan (inches)	(20 to 40 inches)
Permeability	Slight (0.2 to 2.0 inches/hour)
AWC (inches)	Severe (3 inches)
Stones	No limitations
Flooding	No limitations
Wind erodability group	Moderate (Groups 3 and 4C) for sandy loam surface Slight (Groups 4, 5, 6, 7, 8) for loam surface
Soil reaction (pH)	Moderate (pH range of 3.6 to 6.5)
CEC (average meq/100 g)	No limitations

In the future, if salts do adversely affect crop productivity, the salts must be leached out of the shallow soils, the pH must be lowered, and a favorable balance between calcium and sodium should be restored. One way to increase crop rooting depth and subsequent leaching depth is to rip the hardpan (where possible). In areas where future golf course development is planned, a minimum of two feet of topsoil should be required.

Generally, reclamation involves sulfur or gypsum application followed by deep tillage and the planting of a salt-tolerant crop such as barley. As a standard practice irrigation must exceed normal irrigation requirements, generally by 15 to 20 percent of the actual irrigation requirement. This is commonly referred to as the "leaching fraction" and is performed in order to leach salts below the crop root zone (if possible). Where feasible, this leaching fraction should be incorporated into the standard irrigation requirements. Adequate drainage should be provided, but leached waters high in total dissolved solids should be managed properly to minimize total

dissolved solids (TDS) increases in local groundwater. A detailed procedure for reclamation of saline and/or sodic soils is beyond the scope of this evaluation.

Recommendations and Conclusions

Nutrient uptake by a growing crop is essential for treatment. The irrigated land capability classification (and subclass) for the Madras soil is IIs. Owing to the shallow nature of the Madras soil, the site should receive intensive irrigation management to avoid soil saturation, ponding, and salt accumulation. This includes frequent light irrigation applications not to exceed 0.75 inches (or one-half the total plant available water capacity of 1.53 inches) to avoid excessive leaching. Irrigation application rates should not exceed 0.1 inch/hour. This is a conservative recommendation and is based on taking 1/2 of the lowest permeability rate, which is 0.2 inches/hour. The lack of distinct mottling, which indicates perched waters, discovered during the field evaluation demonstrates that under current climatic and irrigation conditions, the unit is well drained. So long as the operator maintains a proper irrigation program and meets crop nutrient requirements at agronomic rates, the proposed Madras reuse plan can be a successful effluent reuse program with minimal environmental impacts.

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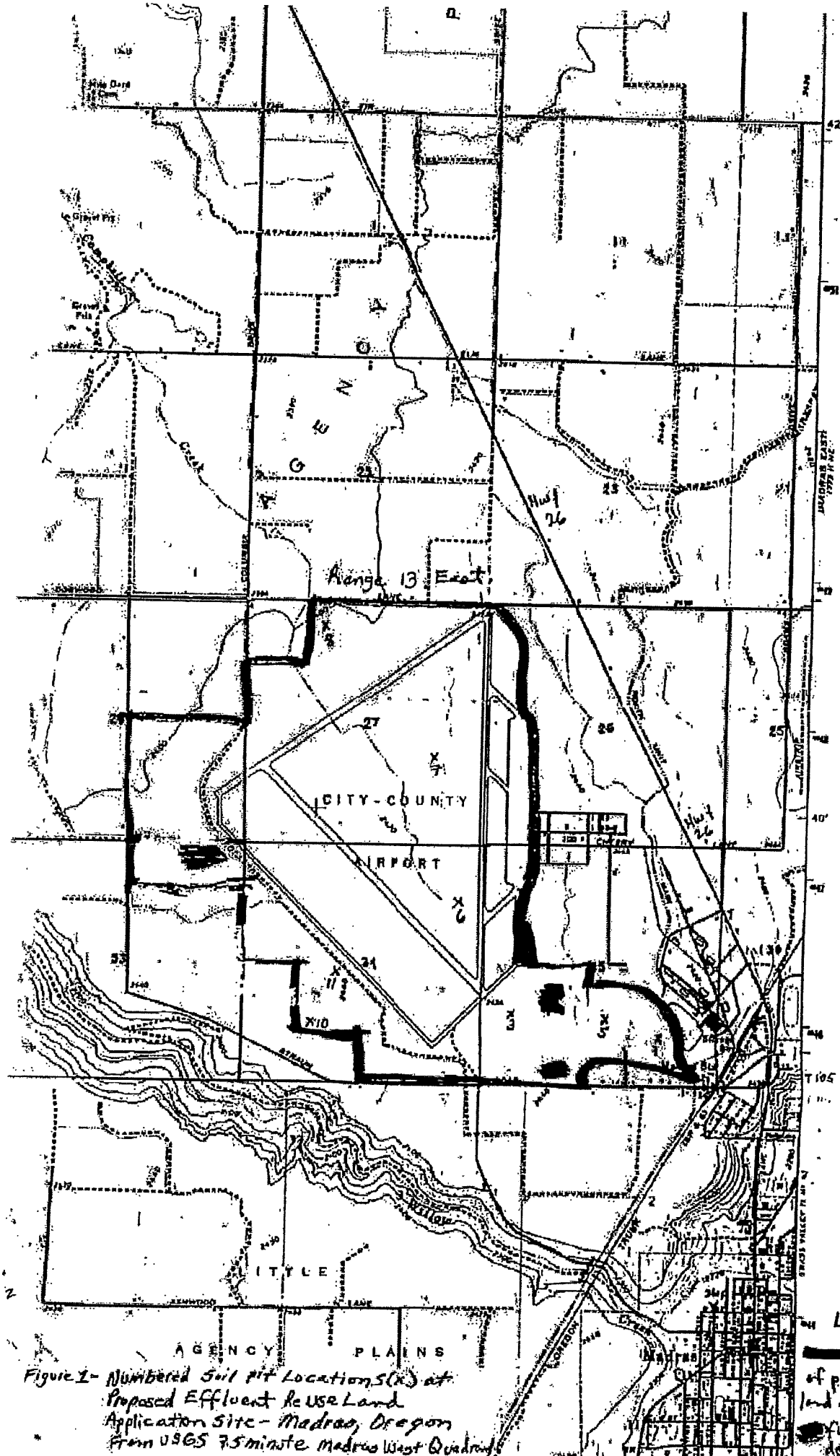

Figure 1- Numbered Soil pit Locations(x) at Proposed Effluent Reuse Land Application Site - Madras, Oregon From USGS 7.5 minute Madras West Quadrangle

Appendix A
SCS Soil Pedon Description for Madras Soil Series

Madras Series

The Madras series consists of moderately deep, well-drained soils on upland terraces and plateaus. They formed in windblown deposits and volcano-clastic sediments. Slopes are 0 to 15 percent. The mean annual precipitation is about 10 inches and the mean annual temperature is about 48 degrees Fahrenheit (°F).

Typical pedon of Madras loam, in an area of Madras loam, has 0 to 3 percent slopes and is located 100 feet east and 50 south of the northwest corner of the southwest quarter of the southwest quarter to Section 23, Township 10 South, Range 13 East.

Ap_1—0 to 4 inches; brown (10 YR 5/3) loam, dark brown (10 YR 3/3) moist; massive; slightly hard, very friable, and nonsticky and nonplastic; few very fine and fine roots; many very fine interstitial pores; neutral (pH 6.8); abrupt smooth boundary.

Ap_2—4 to 10 inches; brown (10 YR 5/3) loam, dark brown (10 YR 3/3) moist; coarse platy structure; hard, friable, and nonsticky and nonplastic; common very fine roots; many very fine interstitial pores; neutral (pH 6.8); abrupt smooth boundary.

Bt_1—10 to 16 inches; yellowish brown (10 YR 5/4) loam, dark brown (10 YR 4/3) moist; weak coarse subangular blocky structure; hard, friable, and nonsticky and nonplastic; many very fine roots; many very fine tubular pores; few faint clay films lining pores and faces of peds; 25 percent clay (estimated); neutral (pH 7.2); clear smooth boundary.

Bt_2—16 to 23 inches; yellowish brown (10 YR 4/3) clay loam, dark brown (10 YR 4/3) moist; weak coarse subangular blocky structure; hard, friable, and slightly sticky and slightly plastic; common very fine roots; many very fine tubular pores; common very fine roots; many very fine tubular pores; common prominent clay films lining pores and faces of peds; 35 percent clay (estimated); mildly alkaline (pH 7.6); clear wavy boundary.

2Crk—23 to 27 inches; consolidated gravel, cobble, and sand sediments of the Deschutes Formation (see Remarks) (3 to 6 inches thick).

3R—27 inches; basalt bedrock.

The depth to the Deschutes Formation is 20 to 40 inches. The profile contains 10 to 30 percent volcanic glass and glass-coated aggregates.

The A horizon has a hue of 10YR, values of 5 dry and 3 moist, and chroma values of 3 dry and 2 or 3 moist. It is sandy loam or loam. It is neutral to mildly alkaline.

The Bt horizon has a hue of 10YR, values of 5 dry and 3 moist, and chroma of 4 dry and moist. It is loam, clay loam, cobbly loam, or clay loam. The rock fragment content ranges

from 0 to 20 percent gravels and 0 to 25 percent cobbles. The total rock fragments range from 5 to 30 percent. It is neutral to mildly alkaline.

502, 504, 592 = Madras Loam, 0 to 3 Percent Slopes

Composition

Madras soil and similar inclusions = 85 percent
Contrasting inclusions = 15 percent

Setting

Landform—terraces and plateaus

Parent material—windblown deposits and semiconsolidated sediments

Elevation—2,000 to 3,000 feet

Native plants—western juniper, basin big sagebrush, antelope bitterbrush, bluebunch, wheatgrass, and Idaho fescue

Climatic factors—mean annual precipitation = 8 to 10 inches; mean annual air tempera- ture = 47 to 50°F; frost-free period = 120 to 140 days

Typical Profile

0 to 16 inches—brown and yellowish brown loam
16 to 23 inches—yellowish brown clay loam
23 to 27 inches—semiconsolidated gravel, cobbles, and sand sediments
27 inches—basalt bedrock of the Deschutes Formation

Soil Properties and Qualities

Depth—bedrock at a depth of 20 to 40 inches
Drainage class—well drained
Permeability—moderately slow
Available water capacity—about 3.5 inches

Contrasting Inclusions

Era soils in swales
Cullius soils on plateaus
Soils with silt loam surfaces

Major Uses

Irrigated cropland and livestock grazing

Major Management Limitations

Permeability, low precipitation

Use and Management

Irrigated Cropland

Care should be taken to prevent excessive irrigation application rates that may lead to overland flow because water-soluble chemicals may be carried in the runoff.

Livestock Grazing

- Pond development on this soil is generally impractical because of the soil depth.
- Low annual precipitation limits the choice of species for range reseeding to drought-tolerant varieties.
- The range site is Droughty Loam 8-10PZ.

Appendix B
Glossary of Soil Terms[1]

[1]Terms are defined according to United States Department of Agriculture (USDA) Soil Conservation Service (SCS) Standards.

Absorption

Filling up of soil pores with water, much as a sponge soaks up water.

Adsorption

Retention of water in soil by attraction between water molecules and the surfaces of soil particles. Also, retention of cations in soil by attraction between their positive charges and the negatively charged surfaces of clay and organic matter particles.

Aspect

Direction to which slope faces.

Available Water Capacity (AWC)

The maximum amount of water a soil can store for plant use. A good soil can provide 9 to 12 inches of available water. A poor soil might provide only 2 or 3 inches of available water.

Beneficial Use

Taking advantage of the nutrient content and soil conditioning properties of an organic waste product to supply some or all of the fertilizer needs of an agronomic crop or stabilizing vegetative cover.

Capability

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made based on the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, and other characteristics of the soils; it does not take into consideration possible but unlikely major reclamation projects; and it does not apply to rice, cranberries, horticulture crops, or other crops requiring special management.

In the capability system, all kinds of soils are grouped at two levels: the capability class and the capability subclass.

Capability Classes

Capability classes, the broadest groups, are designated by Numbers 1 through 8. The numbers indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class 1 soils have few limitations that restrict their use.

Class 2 soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class 3 soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class 4 soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class 5 soils are not likely to erode but have other limitations that are impracticable to remove or that limit their use largely to pasture, range, woodland, or wildlife.

Class 6 soils have severe limitations that make them generally unsuited to cultivation and that limit their use largely to pasture, range, woodland, or wildlife.

Class 7 soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, range, woodland, or wildlife.

Class 8 soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, water supply, or aesthetic purposes.

Capability Subclasses

Capability subclasses are soil groups within one class; they are designated by a small letter, e, w, s, or c, added to the class number. For example:

e—The main limitation is risk of erosion unless close-growing plant cover is maintained.

w—Water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partially corrected by artificial drainage).

s—The soil is limited mainly because it is shallow, droughty, or stony.

c—The chief limitation is climate that is too cold, too dry, or too cloudy for production of many crops.

There are no subclasses in Class 1 because the soils of this class have no limitations.

Cation

A positively charged ion in the soil solution.

Cation Exchange Capacity (CEC)

The amount of positively charged cations such as calcium, potassium, copper, and nickel that can be retained in the soil by attraction to the negatively charged surfaces of soil clays and organic matter. CEC is expressed in terms of milliequivalents per 100 grams of soil.

Cemented Pan

A cemented pan prevents or restricts root and water penetration. It is a product of soil formation.

Clay Films

Coatings of clay on the surfaces of soil peds and mineral grains, and in soil pores (also called clayskins, clay flows, illuviation cutans, or argillans).

Coarse-Textured Soil

A soil whose texture is sand or loamy sand.

Coarse Fragments

Rock fragments larger than 2 millimeters (mm) in diameter—gravel, cobbles, and channers are the most common kinds of coarse fragments in soils.

Cobbles

Large, rounded coarse fragments in soils, ranging in diameter from 3 to 10 inches.

Depth—Soil

Classes are based on soil depth to hard bedrock (R horizon), soft or weathered bedrock (Cr), or a cemented horizon such as duripan (Bkqm horizon) or petrocalic (Bkm) horizon.

The following are the soil depth classes:

Depth (inches)	Class
<10	Very shallow
10 to 20	Shallow
20 to 40	Moderately deep
40 to 60	Deep
>60	Very deep

Drainage Class

The degree of wetness of a soil, as determined by the depth to a water table and the length of time the soil remains saturated. Common drainage classes include excessively drained, well drained, moderately well drained, somewhat poorly drained, and poorly drained, and are defined as follows:

Very poorly drained. Water is removed from the soil so slowly that the water table remains at or on the surface the greater part of the time.

Poorly drained. Water is removed so slowly that the soil remains wet for a large part of the time.

Somewhat poorly drained. Water is removed from the soil slowly enough to keep it wet for significant periods but not all of the time.

Moderately well drained. Water is removed from the soil somewhat slowly, so that the profile is wet for a small but significant part of the time.

Well drained. Water is removed from the soil readily but not rapidly.

Somewhat excessively drained. Water is removed from the soil rapidly.

Excessively drained. Water is removed from the soil very rapidly.

Durinodes

Weakly cemented to indurated soil modules cemented with silica dioxide. Durinodes break down in concentrated potassium hydroxide after treatment with hydrochloric acid (HCl) to remove carbonates, but do not break down upon treatment with concentrated HCl alone.

Duripan

A mineral soil horizon that is cemented by silica, usually opal or microcrystalline forms of silica, to the point that air-dry fragments are not slaked in water or HCl. A duripan may also have accessory cement such as iron oxide or calcium carbonate.

A restrictive layer, also denoted Bkqm horizon, that is so thoroughly cemented with silica, with or without calcium carbonate, that it resembles a layer of rock in the soil.

Field Capacity

The moisture content of a soil when free drainage immediately after a rain or an irrigation has virtually ceased. It represents the maximum amount of water a soil can retain against the force of gravity.

Fine-Textured Soil

A soil whose texture is silty clay, sandy clay, or clay.

Gleyed

Soil that is very wet for long periods of time and is characterized by gray colors, with or without mottles.

Gravel

Small, rounded coarse fragments in soils, ranging in diameter from 2 millimeters to 3 inches.

Hardpan

A generic term for a very dense or cemented layer in soils. Very dense hardpans include fragipans, claypans, tillage pans, and compacted layers. Cemented hardpans include duripans and petrocalcic horizons.

Heavy Texture

A general term that refers to soils that have a high clay content. The higher the clay content, the heavier the soil. Clays, silty clays, and some silty clay loams are all considered heavy soils.

Inclusion

An area of soil that is too small to show separately on a soil map at the scale at which the map is being made. Inclusions are present only because of limitations of the scale of mapping, and they are normal parts of the definition of map units. One can map inclusions separately only by making very detailed maps at very large scales.

Infiltration

The rate at which water *enters* the soil. Infiltration depends on the size of pores and the stability of soil aggregates right at the soil surface. If water cannot infiltrate, it either ponds on the surface or runs off over the surface.

Leaching

Removal of soluble minerals, nutrients, organic chemicals, and pesticides from the soil as a result of water passing through the soil.

Lithic Contact

A boundary between soil and continuous, coherent, underlying material. The underlying material must be sufficiently coherent to make hand digging with a spade impractical. If mineral, it must have a hardness of 3 or more (Mohs scale); gravel-size chunks that can be broken out do not disperse with 15 hours of shaking in water or a sodium hexametaphosphate solution.

Loam

A specific class of soil texture that contains a balanced mixture of sand, silt, and clay. Generally the sand content is between 30 and 50 percent, the silt content is between 30 and 50 percent, and the clay content is between 10 and 27 percent.

Map Unit

A collection of all soil-landscape areas shown on a soil map that have the same name and the same kind or kinds of soils. Map units contain one or two dominant soils, plus small areas of other kinds of soils of minor extent. Map unit names identify the dominant soil or soils. The minor components collectively are called inclusions, and they are identified in the map unit description.

Map Unit Description

The part of the text of a soil survey report that describes the characteristics of the soil and landscape of the dominant soils in a map unit. The map unit description also tells the kind and amount of the inclusions in the map unit, and it gives general information on use and management of the map unit for agriculture, forestry, and urban development.

Medium-Textured Soil

A soil whose texture is loam or silt loam.

Milliequivalent (meq)

One one-thousandth of an equivalent. In soil science, milliequivalents are used to quantify the capacity of a soil to adsorb positively charged ions independently of the particular kind of substance.

Moderately Fine-Textured Soil

A soil whose texture is silty clay loam, clay loam, or sandy clay loam.

Paralithic Contact

Similar to a lithic contact except that the mineral material below the contact has a hardness of less than 3 (Mohs scale); gravel-size chunks that can be broken out partially disperse within 15 hours of shaking in water or a sodium hexametaphosphate solution.

Ped

An aggregate of individual grains of sand, silt, and clay in a single unit of soil structure. Ped shapes include granular, platy, blocky, and prismatic. Ped sizes may vary from 1-milli-meter granules to 40-centimeter (40-cm) prisms.

Pedon

A three-dimensional body of soil with lateral dimensions large enough to permit the study of horizon shapes and relations. Its area ranges from 1 to 10 square meters (m^2). Where horizons are intermittent or cyclic, and recur at linear intervals of 2 to 7 meters (m), the pedon includes one-half of the cycle. Where the cycle is less than 2 m, or all horizons are continuous and of uniform thickness, the pedon has an area of approximately 1 m^2. If the horizons are cyclic, but recur at intervals greater than 7 m, the pedon reverts to the 1-m^2 size, and more than one soil will usually be represented in each cycle.

Permeability

The rate that water moves *through* the soil. Permeability depends on the amount, size, and interconnectedness of soil pores. These in turn are related to soil texture, soil structure, and soil density. Table B-1 presents the classes, rates, and estimated generalized soil texture.

Table B-1 SCS Soil Permeability Class Definitions		
Permeability Class	Numerical Range (inches per hour through saturated undisturbed cores under 1/2 inch head of water)	General Soil Textures
Very slow	Less than 0.06	Very fine clay >60% clay
Slow	0.06 to 0.2	Fine clay with 40-60% clay
Moderately slow	0.2 to 0.6	Clay loam, silt loam
Moderate	0.6 to 2.0	Very fine sandy loam, fine sandy loam
Moderately rapid	2.0 to 6.0	Fine sandy loam, sandy loam
Rapid	6.0 to 20.0	Loamy sand
Very rapid	More than 20	Sand and gravel

Petrocalcic Horizon

A restrictive layer, also denoted Bkm horizon, that is enriched with calcium carbonate, and in which the calcium carbonate has cemented the horizon into a rocklike layer. A continuous, indurated calcic horizon that is cemented by calcium carbonate and, in some places, by magnesium carbonate. It cannot be penetrated with a spade or auger when dry; dry fragments do not slake in water; and it is impenetrable to roots.

pH—Soil

A number that indicates the relative acidity or alkalinity of a soil. A pH of 7.0 indicates a neutral soil. Lower numbers indicate acid soils; higher numbers indicate alkaline soils.

The following are the descriptive terms used to delineate soil reaction and the associated soil pH values.

Extremely acid—below pH 4.5
Very strongly acid—4.5 to 5.0
Strongly acid—5.1 to 5.5
Medium acid—5.6 to 6.0
Slightly acid—6.1 to 6.5
Neutral—6.6 to 7.3
Mildly alkaline—7.4 to 7.8

Moderately alkaline—7.9 to 8.4
Strongly alkaline—8.5 to 9.0
Very strongly alkaline—above pH 9.0

Pores—Soil

Spaces, or voids, between mineral grains and aggregates in the soil. The number, size, shape, and continuity of soil pores control the rates of air and water movement into and throughout the soil.

Number

Three classes are defined in terms of numbers per 1 square decimeter (dm^2) of an exposed surface. An area of 1 dm^2 is roughly the size of the palm of the hand. The surface observed should be either roughly horizontal or vertical; the angle depends on the character of the pores, and the orientation of the surface should be specified.

Abundance of Pores by Number and Size
(average number/dm^2)

Code	Class	Very Fine (0.1-0.5 mm)	Fine (0.5-2 mm)	Medium (2-5 mm)	Coarse (5-10 mm)
1	Few	<25	<10	<1	<1
2	Common	25 to 200	10 to 50	1 to 5	1 to 25
3	Many	≥50	≥50	≥5	≥2.5

Size

Four classes are described, as follows:

vf (very fine)—0.1 to 0.5 mm across in the small dimension
f (fine)—0.5 to 2 mm across in the small dimension
m (medium)—2 to 5 mm across in the small dimension
co (coarse)—>5 mm

Shape

v (vesicular)—approximately spherical or elliptical; commonly enclosed and not continuous

i (irregular or interstitial)—irregular in shape and bounded by curved or angular surface of mineral grains or peds, or both

t (tubular)—approximately cylindrical; greatly elongated in one direction

Restrictive Layer

A general term for any soil horizon that is slowly or very slowly permeable and that underlies more permeable soil horizons. Restrictive layers slow down or stop the downward movement of water in soils and they impede plant root penetration.

Roots

Number

Classes are defined in terms of numbers per unit of cross-sectional area through the horizon. This action should be approximately at right angles to the dominant orientation of roots and large enough to intersect a representative sample for the pedon.

Abundance of Roots by Number and Size
(average number/dm^2)

Code	Class	Very Fine (1 mm)	Fine (1-2 mm)	Medium (2-5 mm)	Coarse (5-10 mm)
1	Few	<25	<10	<1	<1
2	Common	10 to 100	10 to 100	1 to 100	1 to 5
3	Many	≥100	≥100	≥10	≥5

Size

vf (very fine)—less than 1 mm in diameter
f (fine)—1 to 2 mm in diameter
m (medium)—2 to 5 mm in diameter
co (coarse)—larger than 5 mm in diameter

Runoff (or External Drainage)

Water that flows over the surface of soil toward a stream or lake without sinking into the soil. Appropriate class names are:

Ponded. None of the water added to the soil as precipitation or by flow from higher land escapes as runoff, but must pass through the soil or evaporate. Areas are usually distinct depressions (ponding should be of sufficient duration to injure crops).

Very slow. Surface water flows away so slowly that free water lies on the surface for a long time or enters immediately into the soil. Soils are usually nearly level or very open and porous. Water either evaporates or percolates through the soil.

Slow. Surface flows away so slowly that free water covers the soil for significant periods or enters the soil rapidly and a large part of the water passes through the profile or evaporates. Slopes are very gentle, and the water erosion hazard is slight.

Medium. Surface water flows away at such a rate that most of the water enters the soil profile and free water lies on the surface for only short periods. Most of the water is absorbed by the soil, where it is used for plant growth or is lost by evaporation or percolation. Under cultivation the water erosion hazard may be slight or moderate.

Rapid. A large portion of the water moves rapidly over the surface of the soil and a small part moves through the soil profile. Soils are usually moderately steep to steep and have low infiltration capacities. The erosion hazard is moderate to high.

Very rapid. Surface water runs off nearly as fast as it is added and only a very small proportion of the water enters the soil. Soils are usually steep or very steep, and have low infiltration capacities and a high to very high erosion hazard.

Soil Horizon

A layer of soil that is approximately parallel to the earth's surface. Each horizon results from specific soil-forming processes, and each is distinguished from horizons above and below by a unique set of physical, chemical, and biological properties.

Soil Profile

A vertical exposure that allows all of the soil horizons to be seen.

Soil Profile Description

A technical record of the soil properties that can be observed and measured in the field for each and every horizon in the entire soil profile.

Soil Series

The set of all soils whose profiles are essentially alike within narrowly defined ranges of variability. The soil series is the lowest unit of soil classification. Names of soil series are usually taken from geographic entities in areas where the soil was first described, for example, the Appling Series, the Tama Series, and the Willamette Series.

Soil Structure

The arrangement of individual grains of sand, silt, and clay into larger units called aggregates, or peds. Plant roots, humus, and soil clays all help to hold soil peds together. Soil structure is characterized by the size, shape, and strength of the peds.

The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades, respectively.

Type

There are six types of structure, each with its own distinctive shape and arrangement:

gr (granular)—approximately spherical with no accommodation of faces to surrounding peds

pl (platy)—vertical dimension small with regard to horizontal dimensions; faces accommodate with those of adjacent peds

pr (prismatic)—without rounded caps, vertical faces well defined with angular vertices, vertical length relatively long with respect to horizontal dimensions; faces accommodate with those of adjacent peds

cpr (columnar)—rounded caps; otherwise similar to the prismatic

abk (angular blocky)—blocklike with all three dimensions of the same order of magnitude, faces flattened, most vertices sharply angular; faces accommodate with those of adjacent peds

sbk (subangular blocky)—similar to angular blocky but both rounded and flattened faces occur with many rounded vertexes

Size

Size differs with each kind of structure, as follows:

Class	Diameter of granules (mm)	Thickness of plates (mm)	Diameter of blocks (mm)	Diameter of prisms (mm)
vf—very fine or very thin[a]	<1	<1	<5	<10
f—fine or thin[a]	1 to 2	1 to 2	5 to 10	10 to 20
m—medium	2 to 5	2 to 5	10 to 20	20 to 50
c—coarse or thick[a]	5 to 10	5 to 10	20 to 50	50 to 100
vc—very coarse or very thick	>10	>10	>50	>100

[a]Use for platy structure only.

Grade

Four grades of structure designated from 0 to 3 are recognized, as follows:

(0) **Structureless.** No observable aggregation or no definite and orderly arrangement of natural lines of weakness. Massive if coherent; single-grain if noncoherent.

(1) **Weak.** Poorly formed indistinct peds, barely observable in place.

(2) **Moderate.** Well-formed distinct peds; moderately durable and evident but not distinct in undisturbed soil.

(3) **Strong.** Durable peds that are quite evident in undisturbed soil, adhere weakly to one another, withstand displacement, and become separated when the soil is disturbed.

Soil Survey

The process by which a soil map is made. Soil scientists walk over the land, observe soil and landscape properties, classify the soils, and locate soil boundaries in the field. They use air photo base maps to record the locations of soil boundaries and to label each delineation with a map unit symbol.

The systematic examination, description, classification, and mapping of soils in an area. Soil surveys are classified according to the kind and intensity of field examination.

Texture—Soil

The amounts of sand, silt, and clay that make up a soil. Specific combinations of sand, silt, and clay form textural classes, each of which is named with a term such as silt loam, clay loam, or sandy loam.

In the USDA textural classification, texture of the soil is determined by the percent of sand (0.05 to 2.0 mm), silt (0.05 to 0.002 mm), and clay (less than 0.002 mm) after the particles larger than 2 mm have been removed.

The textural classes may be modified by the addition of suitable adjectives when coarse fragments are present in substantial amounts; for example, "stony silt loam" or "silt loam, stony phase." Soil textural modifiers are delineated as follows:

<15 percent by volume rock fragments—nongravelly, noncobbly, nonstony
15 to 35 percent by volume—gravelly, cobbly, stony
35 to 60 percent by volume—very gravelly, very cobbly, very stony
>60 percent by volume—extremely gravelly, extremely cobbly, extremely stony

Soil texture is described by the abbreviations given in Table B-2 according to this pattern:

(Texture modifier)—(texture term)
or
(Texture modifier)—(term in lieu of texture)

For example, gr-ls = gravelly loamy sand

Table B-2
List of Abbreviations for Soil Texture

Texture Modifiers		Texture Terms	
by	bouldery	cos	coarse sand
cb	cobbly	s	sand
cn	channery	fs	fine sand
cr	cherty	vfs	very fine sand
fl	flaggy	ms	medium sand
gr	gravelly	lcos	loamy coarse sand
grc	coarse gravelly	ls	loamy sand
grf	fine gravelly	lfs	loamy fine sand
grv	very gravelly	lvfs	loamy fine sand
grx	extremely gravelly	cosl	coarse sandy loam
mk	mucky	sl	sandy loam
pt	peaty	fsl	fine sandy loam
rb	rubbly	vfsl	very fine sandy loam
sh	shaley	l	loam
sr	stratified	sil	silt loam
st	stony	si	silt
stv	very stony	scl	sandy clay loam
sy	slatey	cl	clay loam
		sicl	silty clay loam
		sc	sandy clay
		sic	silty clay
		c	clay

The sand, loamy sand, and sandy loam are further subdivided on the basis of the proportions of the various sand separates that are present. The limits of the various classes and subclasses are as follows:

Sand. Soil material that contains 85 percent or more of sand; percentage of silt, plus 1.5 times the percentage of clay, shall not exceed 15.

Loamy sand. Soil material that contains at the upper limit 85 to 90 percent sand, and the percentage of silt plus 1.5 times the percentage of clay is not less than 15; at the lower limit, it contains not less than 70 to 85 percent sand and the percentage of silt plus twice the percentage of clay does not exceed 30.

Sandy loam. Soil material that contains either 20 percent clay or less and the percentage of silt plus twice the percentage of clay exceeds 30, and 52 percent or more sand; or less than 7 percent clay, less than 50 percent silt, and between 43 percent and 52 percent sand.

Loam. Soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

Silt loam. Soil material that contains 50 percent or more silt and 12 to 27 percent clay or 50 to 80 percent silt and less than 12 percent clay.

Silt. Soil material that contains 80 percent or more silt and less than 12 percent clay.

Sandy clay loam. Soil material that contains 20 to 35 percent clay, less than 28 percent silt, and 45 percent or more sand.

Clay loam. Soil material that contains 27 to 40 percent clay and 20 to 45 percent sand.

Silty clay loam. Soil material that contains 27 to 40 percent clay and less than 20 percent sand.

Sandy clay. Soil material that contains 35 percent or more clay and 45 percent or more sand.

Silty clay. Soil material that contains 40 percent or more clay and 40 percent or more silt.

Clay. Soil material that contains 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Soil Type

The lowest unit in the natural system of soil classification; a subdivision of a soil series, consisting of or describing soils that are alike in all characteristics, including the texture of the A horizon. In Europe, roughly equivalent to a great soil group.

Soil Variant

A soil whose properties are believed to be sufficiently different from those of other known soils to justify a new series name but comprising such a limited geographic area that creation of a new series is not justified.

Appendix C
ESTIMATED SOILS PROPERTIES AND RESULTS OF SOIL CONSERVATION SERVICE SOILS TESTS

MLRA(S): 6, 10
REV. GLG-MSA, 8-89
XEROLLIC DURARGIDS, FINE-LOAMY, MIXED, MESIC

THE MADRAS SERIES CONSISTS OF MODERATELY DEEP WELL DRAINED SOILS FORMED IN COLLUVIUM ON PLATEAUS. TYPICALLY, THE SURFACE LAYER IS LOAM ABOUT 11 INCHES THICK. SUBSOIL IS CLAY LOAM ABOUT 9 INCHES THICK. DEPTH TO HARDPAN IS 20 TO 30 INCHES AND DEPTH TO BEDROCK IS 25 TO 40 INCHES. ELEVATION IS 2000 TO 2300 FEET. MEAN ANNUAL PRECIP. IS 9 TO 12 INCHES. MEAN ANNUAL AIR TEMP. IS 46 TO 50 DEGREES F. THE FROST-FREE PERIOD IS 50 TO 80 DAYS. SLOPES RANGE FROM 0 TO 40 PERCENT.

ESTIMATED SOIL PROPERTIES

DEPTH (IN.)	USDA TEXTURE	UNIFIED	AASHTO	FRACT (>3 IN) (PCT)	PERCENT OF MATERIAL LESS THAN 3" PASSING SIEVE NO. 4	10	40	200	LIQUID LIMIT	PLASTICITY INDEX
0-11	SL	SM	A-2, A-4	0	95-100	95-100	55-70	30-40	-	NP
0-11	L	SM, ML	A-4	0	80-100	75-100	50-95	40-75	25-30	NP-5
0-11	GR-L	ML	A-4	15-20	100-95	75-90	55-70	50-65	25-30	NP-5
11-20	CL, GR-CL, CB-CL	GC, CL	A-6	0-20	65-100	55-90	50-85	40-80	30-40	10-15
20-25	IND									
25	IND									

DEPTH (IN.)	CLAY (PCT)	MOIST BULK DENSITY (G/CM3)	PERMEABILITY (IN/HR)	AVAILABLE WATER CAPACITY (IN/IN)	SOIL REACTION (PH)	SALINITY (MMHOS/CM)	SHRINK-SWELL POTENTIAL	EROSION FACTORS K	EROSION FACTORS T	WIND (GROUP)	ORGANIC MATTER (PCT)	CORROSIVITY STEEL	CORROSIVITY CONCRETE
0-11	10-20	1.10-1.20	2.0-6.0	0.11-0.13	6.1-7.3	-	LOW	.20	2	3	1-2	HIGH	LOW
0-11	18-27	1.10-1.25	0.6-2.0	0.13-0.18	6.1-7.3	-	LOW	.20	2	5	1-2		
0-11	10-27	1.10-1.20	0.6-2.0	0.12-0.15	6.1-7.3	-	LOW	.20	2	5	1-2		
11-20	27-30	1.10-1.30	0.2-0.6	0.14-0.19	6.6-8.4	<2	MODERATE	.28					
20-25													
25													

FLOODING FREQUENCY	FLOODING DURATION	FLOODING MONTHS	HIGH WATER TABLE DEPTH (FT)	HIGH WATER TABLE KIND	HIGH WATER TABLE MONTHS	CEMENTED PAN DEPTH (IN)	CEMENTED PAN HARDNESS	BEDROCK DEPTH (IN)	BEDROCK HARDNESS	SUBSIDENCE INIT. (IN)	SUBSIDENCE TOTAL (IN)	HYDROPOTENTIAL GRP	FROST ACTION
NONE			>6.0			20-30	THIN	25-40	SOFT	-	-	C	MODERATE

SANITARY FACILITIES

SEPTIC TANK ABSORPTION FIELDS	0-15%: SEVERE-DEPTH TO ROCK,CEMENTED PAN 15+%:SEVERE-DEPTH TO ROCK,CEMENTED PAN,SLOPE	
SEWAGE LAGOON AREAS	0-7%: SEVERE-DEPTH TO ROCK,CEMENTED PAN 7+%: SEVERE-DEPTH TO ROCK,CEMENTED PAN,SLOPE	
SANITARY LANDFILL (TRENCH)	0-15%: SEVERE-DEPTH TO ROCK 15+%: SEVERE-DEPTH TO ROCK,SLOPE	
SANITARY LANDFILL (AREA)	0-15%: SEVERE-DEPTH TO ROCK,CEMENTED PAN 15+%:SEVERE-DEPTH TO ROCK,CEMENTED PAN,SLOPE	
DAILY COVER FOR LANDFILL	0-15%: POOR-DEPTH TO ROCK,SMALL STONES 15+%: POOR-DEPTH TO ROCK,SMALL STONES,SLOPE	

CONSTRUCTION MATERIAL

ROADFILL	0-25%: POOR-DEPTH TO ROCK,LOW STRENGTH 25+%: POOR-DEPTH TO ROCK,LOW STRENGTH,SLOPE
SAND	IMPROBABLE-EXCESS FINES
GRAVEL	IMPROBABLE-EXCESS FINES
TOPSOIL	0-15%: POOR-SMALL STONES 15+%: POOR-SMALL STONES,SLOPE

WATER MANAGEMENT

POND RESERVOIR AREA	0-3%: MODERATE-DEPTH TO ROCK,CEMENTED PAN 3-8%: MODERATE-DEPTH TO ROCK,CEMENTED PAN, SLOPE 8+%: SEVERE-SLOPE
EMBANKMENTS DIKES AND LEVEES	SEVERE-THIN LAYER
EXCAVATED PONDS AQUIFER FED	SEVERE-NO WATER
DRAINAGE	DEEP TO WATER
IRRIGATION	L,CB-L: DEPTH TO ROCK,CEMENTED PAN SL: SOIL BLOWING,DEPTH TO ROCK,CEMENTED PAN
TERRACES AND DIVERSIONS	0-8% SL,L: DEPTH TO ROCK 8+% SL,L: SLOPE,DEPTH TO ROCK 0-8% CB: LARGE STONES,DEPTH TO ROCK 8+% CB: SLOPE,LARGE STONES,DEPTH TO ROCK
GRASSED WATERWAYS	0-8% SL,L: DEPTH TO ROCK 8+% SL,L: SLOPE,DEPTH TO ROCK 0-8% CB: LARGE STONES,DEPTH TO ROCK 8+% CB: LARGE STONES,SLOPE,DEPTH TO ROCK

BUILDING SITE DEVELOPMENT

SHALLOW EXCAVATIONS	0-8%: MODERATE-DEPTH TO ROCK,CEMENTED PAN 8-15%: MODERATE-DEPTH TO ROCK,CEMENTED PAN, SLOPE 15+%: SEVERE-SLOPE
DWELLINGS WITHOUT BASEMENTS	0-8%: MODERATE-SHRINK-SWELL 8-15%: MODERATE-SHRINK-SWELL,SLOPE 15+%: SEVERE-SLOPE
DWELLINGS WITH BASEMENTS	0-8%: MODERATE-DEPTH TO ROCK,CEMENTED PAN 8-15%: MODERATE-DEPTH TO ROCK,CEMENTED PAN, SLOPE 15+%: SEVERE-SLOPE
SMALL COMMERCIAL BUILDINGS	0-4%: MODERATE-SHRINK-SWELL 4-8%: MODERATE-SHRINK-SWELL,SLOPE 8+%: SEVERE-SLOPE
LOCAL ROADS AND STREETS	0-15%: SEVERE-LOW STRENGTH 15+%: SEVERE-LOW STRENGTH,SLOPE
LAWNS, LANDSCAPING AND GOLF FAIRWAYS	0-8% SL,L: MODERATE-DEPTH TO ROCK 8-15% SL,L: MODERATE-SLOPE,DEPTH TO ROCK 0-8% CB: MODERATE-LARGE STONES,DEPTH TO ROCK 8-15% CB: MODERATE-LARGE STONES,SLOPE 15+%: SEVERE-SLOPE

REGIONAL INTERPRETATIONS

SOILTEST FARM CONSULTANTS, INC.

2925 WAPATO DR. (EXIT 176, I-90), MOSES LAKE, WASHINGTON 98837
PHONE (509)765-1622

FULL CIRCLE, INC.
BOX 49
MADRAS, ORE 97741

INVOICE # 515-02
DATE RECEIVED - 03/05/90
GROWER - BOB CROCKER
FIELD - 1 A & B PIVOT

SOIL TEST RESULTS

NITRATE NITROGEN	ppm	102	EFFERVESCENCE		0
	lbs/acre	333	pH		7.0
AMMONIUM NITROGEN	lbs/acre	10	ORGANIC MATTER	%	1.4
PHOSPHORUS	ppm	59	SOLUBLE SALTS	m.mhos/cm	4.4
POTASSIUM	ppm	550			
SULFUR	ppm	44			
BORON	ppm	2.0			
ZINC	ppm	0.6			
MANGANESE	ppm	7.7			
COPPER	ppm	1.1			
IRON	ppm	15.0			
CALCIUM	meg/100g	8.8			
MAGNESIUM	meg/100g	5.4			
SODIUM	meg/100g	1.9			

SUM OF TESTED NITROGEN	lbs/acre	343
TOTAL BASES (Ca + Mg + K + Na)	meg/100g	17.5

VERY HIGH NO3

list price 38.00

Report reviewed by VAUGHN HUNSAKER

soiltest farm consultants, inc.

2925 WAPATO DR. MOSES LAKE, WA 98837 TEL. 509-765-1622

FULL CIRCLE, INC.
BOX 49
MADRAS, ORE 97741

Date Received: 03/27/89
Report No: 596-12
Grower: BOB CROCKER
Field ID: 3
IRRIGATED
Last Crop:
Crop To Be Grown 19 9
Yield Goal:
Date Fertilized and Amount:

Effervescence with Acid | pH 7.60 | O.M. 2.24 | % Sol. Salts 0.55 mmhos/cm

FOOT DEPTH	NITROGEN NO_3N PPM	NITROGEN NO_3N LBS/A	NITROGEN NH_4N LBS/A	SOIL MOISTURE AVAILABLE INCHES
1	3	11		
TOTAL	3	11		
Estimated Nitrogen Release from Organic Matter				lbs

Elements		Soil Analyses	Interpretation Guide: Low	Optimum	High
Sum of Tested Nitrogen	lbs/A	N 1 1FT 2FT 3FT 4FT			
Phosphorus	ppm	P 50			
Potassium	ppm	K 375			
Sulfur	ppm	S 11			
Boron	ppm	B 1.2			
Zinc	ppm	Zn 0.7			
Manganese	ppm	Mn			
Copper	ppm	Cu			
Iron	ppm	Fe			
Soluble & Exchangeable:					
Sodium	meq/100g.	Na			
Calcium	meq/100g.	Ca			
Magnesium	meq/100g.	Mg			
Total Bases	meq/100g.	K, Ca, Mg			

This is your INVOICE
Please Pay Amount Indicated $22.00

Fertilizer recommendations for ARE AS FOLLOWS: following:

Lbs. of actual Nitrogen per acre
Lbs. of actual P_2O_5 per acre
Lbs. of actual K_2O per acre
Lbs. of actual Sulfur per acre
Lbs. of actual Boron per acre
Lbs. of actual Zinc per acre

DEALER COPY

This report reviewed by: VAUGHN [illegible] SAKER

Soilt t farm consultants, inc. 2925 WAP OR. MOSES LAKE, WA 98837 TEL. 509-76 12

FULL CIRCLE, INC.
BOX 49
MADRAS, ORE 97741

Date Received: 03/27/89
Grower: B CROCKER
Last Crop:
Crop To Be Grown 19 0
Date Fertilized and Amount:

Report No.: 596- 9
Field I.D.: 1A
IRRIGATED
Yield Goal:

Effervescence with Acid ; pH 6.20 ; O.M. 1.20 %; Sol. Salts 3.40 m.mhos/cm

FOOT DEPTH	NITROGEN NO_3N PPM	NITROGEN NO_3N LBS/A	NITROGEN NH_4N LBS/A	SOIL MOISTURE AVAILABLE INCHES
1	68	223		
TOTAL	68	223		
Estimated Nitrogen Release from Organic Matter				lbs

Elements		Soil Analyses	1FT	2FT	3FT	4FT
Sum of Tested Nitrogen	lbs/A	N	~~223~~ 170			
Phosphorus	ppm	P	55			
Potassium	ppm	K	550			
Sulfur	ppm	S	72			
Boron	ppm	B	1.0			
Zinc	ppm	Zn	0.5			
Manganese	ppm	Mn				
Copper	ppm	Cu				
Iron	ppm	Fe				
Soluble & Exchangeable						
Sodium	meq/100g.	Na				
Calcium	meq/100g.	Ca				
Magnesium	meq/100g.	Mg				
Total Bases	meq/100g.	K, Ca, Mg				

Interpretation Guide	Low	Optimum	High

This is your INVOICE
Please Pay Amount Indicated $22.00

Fertilizer recommendations for ARE AS FOLLOWS:

Lbs. of actual Nitrogen per acre
Lbs. of actual P_2O_5 per acre
Lbs. of actual K_2O per acre

following

Lbs. of actual Sulfur per acre
Lbs. of actual Boron per acre
Lbs. of actual Zinc per acre

VERY HIGH NO3, SALTS, & SULFER

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This report reviewed by: VAUGHN [illegible]SAKER

soiltest farm consultants, inc.

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FULL CIRCLE, INC.
BOX 49
MADRAS, ORE 97741

Date Received: 03/27/89 Report No: 596-10
Grower: BOB CROCKER Field ID: 1B
Last Crop: IRRIGATED
Crop To Be Grown 19 0 Yield Goal:
Date Fertilized and Amount:

Effervescence with Acid ; pH 7.00 ; O.M. 1.42 %; Sol. Salts 1.30 m.mhos/cm

ROOT DEPTH	NITROGEN NO_3N PPM	NITROGEN NO_3N LBS/A	NITROGEN NH_4N LBS/A	SOIL MOISTURE AVAILABLE INCHES
1	21	70		
TOTAL	21	70		
Estimated Nitrogen Release from Organic Matter				lbs

Elements		Soil Analyses		Interpretation Guide Low	Optimum	High
Sum of Tested Nitrogen	lbs/A	N 50 / 70	1FT 2FT 3FT 4FT			
Phosphorus	ppm	P	62			
Potassium	ppm	K	640			
Sulfur	ppm	S	39			
Boron	ppm	B	1.1			
Zinc	ppm	Zn	0.7			
Manganese	ppm	Mn				
Copper	ppm	Cu				
Iron	ppm	Fe				
Soluble & Exchangeable						
Sodium	meq/100g.	Na				
Calcium	meq/100g.	Ca				
Magnesium	meq/100g.	Mg				
Total Bases	meq/100g.	K, Ca, Mg				

This is your INVOICE
Please Pay Amount Indicated $22.00

Fertilizer recommendations for ARE AS FOLLOWS: following:

Lbs. of actual Nitrogen per acre
Lbs. of actual P_2O_5 per acre
Lbs. of actual K_2O per acre
Lbs. of actual Sulfur per acre
Lbs. of actual Boron per acre
Lbs. of actual Zinc per acre

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This report reviewed by: VAUGHN SAKER

Soil Farm Consultants, Inc. 2925 WAPA R. MOSES LAKE, WA 98837 TEL. 509-765-[illegible]2

FULL CIRCLE, INC.
BOX 49
MADRAS, ORE 97741

Date Received: 03/27/89
Report No: 596-11
Grower: BOB CROCKER
Field I.D.: 2
IRRIGATED
Last Crop:
Crop To Be Grown 19 0
Yield Goal:
Date Fertilized and Amount:

Effervescence with Acid ; pH 7.20 ; O.M. 2.00 %; Sol. Salts 1.05 m.mhos/cm

FOOT DEPTH	NITROGEN NO_3N PPM	NITROGEN NO_3N LBS/A	NITROGEN NH_4N LBS/A	SOIL MOISTURE AVAILABLE INCHES
1	15	48		
TOTAL	15	48		
Estimated Nitrogen Release from Organic Matter				lbs

Elements		Soil Analyses	1FT	2FT	3FT	4FT	Interpretation Guide Low	Optimum	High
Sum of Tested Nitrogen	lbs/A	N ~~48~~ 138							
Phosphorus	ppm	P	80						
Potassium	ppm	K	670						
Sulfur	ppm	S	26						
Boron	ppm	B	1.3						
Zinc	ppm	Zn	1.9						
Manganese	ppm	Mn							
Copper	ppm	Cu							
Iron	ppm	Fe							
Soluble & Exchangeable									
Sodium	meq/100g.	Na							
Calcium	meq/100g.	Ca							
Magnesium	meq/100g.	Mg							
Total Bases	meq/100g.	K, Ca, Mg							

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Fertilizer recommendations for following ARE AS FOLLOWS:

Lbs. of actual Nitrogen per acre.
Lbs. of actual P_2O_5 per acre
Lbs. of actual K_2O per acre.
Lbs. of actual Sulfur per acre.
Lbs. of actual Boron per acre.
Lbs. of actual Zinc per acre.

DEALER COPY

This report reviewed by: VAUGHN BAKER

DATE February 16, 1988
CLIENT Full Circle, Inc.
FARM Bob Crocker
SAMPLER Jim Carroll/ FCI

SOIL ANALYSIS REPORT

TECHNIserv INCORPORATED
P.O. Box 848 • 1713 S.W. Highway 97
Madras, Oregon 97741 • Phone: (503) 475-2209

Sample Number	Depth	Sample Identification	pH	Nitrogen NO_3 ppm	Nitrogen NH_4 ppm	Phosphorus ppm	Potassium ppm	Sulfur ppm	Calcium meq/100g	Magnesium meq/100g	Zinc ppm	Boron ppm	Cation Exchange Capacity
S4254	0-12"	Flood mint	7.5	2.9	5.1	36.9	300	15.5					
S4155	0-12"	Pivot mint	6.9	81.9	5.6	32.6	430	29.9					
S4156	0-12"	Wheel line mint	7.0	36.4	6.8	47.0	557	18.5					

This report is for the exclusive use of the client(s) to whom it is addressed. Its communication or disclosure to others or use in advertising is not authorized. These results refer only to the specific sample tested and not to other apparently similar material. Liability is limited to cost of analysis.

soiltest farm consultants, inc. 2925 WAPA[illegible]R. MOSES LAKE, WA 98837 TEL. 509-76[illegible]

FULL CIRCLE, INC.
BOX 49
MADRAS, ORE 97741

Date Received: 11/21/85
Report No.: 2473- 1
Grower: B CROCKER
Field I.D.: 2
IRRIGATED
Last Crop:
Crop To Be Grown 19 0
Yield Goal:
Date Fertilized and Amount:

Effervescence with Acid ; pH 6.80 ; O.M. 1.98 %; Sol. Salts 1.05 m.mhos/cm

FOOT DEPTH	NITROGEN NO_3N LBS./ACRE	NITROGEN NH_4N LBS./ACRE	SOIL MOISTURE AVAILABLE INCHES
1	72		
TOTAL	72		
Estimated Nitrogen Release from Organic Matter			lbs

Elements		Soil Analyses 1FT	2FT	3FT	4FT	Interpretation Guide Low	Optimum	High
Sum of Tested Nitrogen	lbs/A	N 72						
Phosphorus	ppm	P 50						
Potassium	ppm	K 670						
Sulfur	ppm	S 35						
Boron	ppm	B 1.7						
Zinc	ppm	Zn 1.3						
Manganese	ppm	Mn						
Copper	ppm	Cu						
Iron	ppm	Fe						
Soluble & Exchangeable meq/100g.								
Sodium		Na						
Calcium		Ca						
Magnesium		Mg						
Total Bases		K, Ca, Mg						

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Please Pay Amount Indicated [redacted]

Fertilizer recommendations for following are as follows:

Lbs. of actual Nitrogen per acre
Lbs. of actual P_2O_5 per acre
Lbs. of actual K_2O per acre
Lbs. of actual Sulfur per acre
Lbs. of actual Boron per acre
Lb actual Zinc per acre

GROWER COPY

This report reviewed by: F. L. B. [illegible]

soiltest farm consultants, inc.

2925 WAPATO DR. MOSES LAKE, WA 98837 TEL. 509-765-1622

FULL CIRCLE, INC.
BOX 49
MADRAS, ORE 97741

Date Received: 11/21/85
Report No.: 2473- 2
Grower: B CROCKER
Field I.D.: 3
IRRIGATED
Last Crop:
Crop To Be Grown 19 0
Yield Goal:
Date Fertilized and Amount:

Effervescence with Acid ; pH 7.20 ; O.M. 1.62 %; Sol. Salts 1.50 mmhos/cm

FOOT DEPTH	NITROGEN NO_3N LBS./ACRE	NITROGEN NH_4N LBS./ACRE	SOIL MOISTURE AVAILABLE INCHES
1	88		
TOTAL	88		
Estimated Nitrogen Release from Organic Matter			lbs

Elements		Soil Analyses	1FT	2FT	3FT	4FT
Sum of Tested Nitrogen	lbs/A	N	88			
Phosphorus	ppm	P	39			
Potassium	ppm	K	510			
Sulfur	ppm	S	32			
Boron	ppm	B	1.4			
Zinc	ppm	Zn	0.9			
Manganese	ppm	Mn				
Copper	ppm	Cu				
Iron	ppm	Fe				
Soluble & Exchangeable meq/100g.						
Sodium		Na				
Calcium		Ca				
Magnesium		Mg				
Total Bases		K, Ca, Mg				

Interpretation Guide	Low	Optimum	High

This is your INVOICE
Please Pay Amount Indicated

[redacted]

Fertilizer recommendations for following are as follows:

Lbs. of actual Nitrogen per acre

Lbs. of actual P_2O_5 per acre

Lbs. of actual K_2O per acre

Lbs. of actual Sulfur per acre

Lbs. of actual Boron per acre

Lb actual Zinc per acre

GROWER COPY

This report reviewed by: F. L. B[illegible]

MARR WADDOUPS & ASSOCIATES
Agricultural Consultants
2545 West Falls Kennewick Washington 99336 (309) 783 7450

Date Received and/or Sampled: May 31, 1984

Report No.: 6574-1 1p

Grower: Robert Crocker

Sampler: Gary W. Wing
Rt. 1 Box 234
Powell Butte, OR 97753

Last Year's Crop: 19

Fertilizer: 19

Soil Technology Corp.
P.O. Box 69245
Portland, OR 97201

Field No.: Field Name: Upper Mint

Crop To Be Grown: 84 Peppermint

Yield Goal:

SOIL CHEMICAL ANALYSES

DEPTH FOOT	SOIL MOISTURE % of Field Capacity	SOIL MOISTURE Available Inches	NITROGEN NO3 PPM	NITROGEN NO3 Lbs. Per Acre	NITROGEN NH4 Lbs. Per Acre	Sulfur S PPM	pH	Organic Matter Percent	Phosphorus P	Potassium K	Calcium Ca	Magnesium Mg	Total Bases	Soluble Salts mmhos/cm	Effervescence with acid
									Parts Per Million		meq. per 100 grams				
1				74	11	16	7.0	1.38	19	438	9.6	6.1	18.3	1.10	none
2															
3															
4															
5															
6															
Total															

MINOR ELEMENT ANALYSES

Depth Foot	Boron B	Zinc Zn	Manganese Mn	Copper Cu	Iron Fe	Cation Exchange Capacity	Sodium Na	Percent Base Saturation
	Parts Per Million			PPM		meq. per 100 grams		
1	1.68	.43					1.47	
2								

Estimated Nitrogen Release from Organic Matter	69
Estimated Total Nitrogen Available to Crop	271

Soil Series and Type: Clay Loam

Average Annual Rainfall: 8-12"

Dryland — Irrigated — Sprinkler X — Rill — Other

Comments and Recommendations:

The nitrogen level is high.
The sulfur and phosphorus levels are high. Recommend a maintenance application only.
The pH is in a desirable range and will not limit crop production.
The organic matter level is medium.
The potassium level is very high.
The solbule salts level and sodium levels are well below the toxic range.
The zinc level is low.
The boron level is very high.

Fertilizer recommendations for peppermint are as follows:

60 lbs. of actual nitrogen per acre.
40 lbs. of actual P_2O_5 per acre.
10 lbs. of actual sulfur per acre.
10 lbs. of actual zinc per acre.

Marr Waddoups
Agricultural Consultant

Appendix D
FERTILIZER GUIDES

Fertilizer Guide

FG 20
Revised July 1983

ALFALFA

(Eastern Oregon - East of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest.

Consult OSU Fact Sheet 253, "Growing Alfalfa for Forage" for establishment and management information.

Alfalfa removes substantial amounts of mineral nutrients. Field experiments have shown that under different conditions in eastern Oregon, alfalfa has profitably responsed to phosphorus, potassium, sulfur, boron, and lime. The need for nutrients can be determined with a soil test. With borderline test values, retest every year.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions and soil sample bags and information sheets.

INOCULATION

All alfalfa seed should be inoculated immediately before seeding to insure an adequate supply of nitrogen-fixing bacteria. A fresh, effective, live culture of the correct strain of Rhizobia should be used.

Additional details on legume seed inoculation are described in OSU Extension Circular 1055, "Inoculating Alfalfa and Clover Seed."

NITROGEN (N)

A response of alfalfa to applied N usually indicates that the alfalfa has not been effectively nodulated. N fertilizer can reduce effective nodulation. N is sometimes applied when monoammonium phosphate (11-48-0) is used as the P source. The small amount of N (usually less than 15 lb N/A) applied in this way should not interfere with nodulation. Grass grown in combination with alfalfa can respond to N fertilizer, but this may reduce the growth of alfalfa.

PHOSPHORUS (P)

The need for P fertilization can be determined by a soil test.

If the OSU soil test* for P reads (ppm)	Apply this amount of phosphate (P_2O_5) (lb/A):
0 - 5	80 - 120
5 - 15	40 - 80
Over 15	None

*This soil test is based on a 0-12" soil sample and the Olsen sodium bicarbonate procedure as outlined in the OSU Soil Analysis Methods Report.

P can be applied to alfalfa fields most effectively by banding 1 to 1" to the side or beneath the seed. Some soil should separate fertilizer from the seed. Do not include boron in band applications. Working P into the seedbed prior to planting is more effective than broadcasting following seeding.

Where soil tests on an established stand indicate a P deficiency, P should be broadcast during the fall to early spring period.

POTASSIUM (K)

Most of the soils in eastern Oregon contain adequate amounts of K for alfalfa production. The need for K fertilization can be determined by a soil test.

If the OSU soil test* for K reads (ppm):	Apply this amount of potash (K_2O) (lb/A)
0 - 75	100 - 200
75 - 150	50 - 100
Over 150	None

*This soil test is based on a 0-12" soil sample and the ammonium acetate procedure as outlined in the OSU Soil Analysis Methods Report.

K can be supplied most effectively by working into the seedbed prior to planting. On established stands, K should be applied in the fall to early spring period.

Alfalfa requires large amounts of K. Available soil K may decline rapidly under established alfalfa stands. Check soil tests every year on soils with borderline values.

Whenever K deficiency symptoms become apparent on the alfalfa leaves, at least 90 lbs K_2O/A should be applied to provide for the needs of the following crop.

A K deficiency is indicated by light colored spots around the margins of the leaves. Responses to K fertilizer are often obtained before leaf deficiency symptoms are apparent.

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Fertilizer Guide

FG 21
Revised May 1983

Irrigated Clover-Grass Pastures
(Eastern Oregon—East of Cascades)

This guide to fertilization is intended for pastures consisting of white clover in combination with orchard grass or tall fescue. The optimum response of irrigated pasture to fertilization is dependent on good management.

The following management factors are important:

1. Maintenance of a good stand of adapted, improved clovers and grass with estimated 30-50% of clover. Fifty percent or more clover might cause a bloat problem and care in grazing is needed.
2. Adequate irrigation without over-irrigation.
3. Harvesting at 5-8" height using rotation grazing or green chop. Green chop management results in more rapid depletion of soil fertility than grazing.
4. Close grazing to 2" height favors white clover and light grazing to 4" height or higher favors the grass.
5. Well fertilized grass will outgrow clover in the fall. Excessive grass growth could result in smothering the clover. Either grazing or clipping will reduce the problem.
6. Avoid soil compaction by eliminating grazing when surface soil is saturated with water.
7. Inoculate clover seed with the correct strain of fresh inoculum immediately prior to seeding.
8. Retest the soil and adjust fertilizer applications at least every two years.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions and soil sample bags and information sheets.

NITROGEN (N)

N fertilizer favors the growth of grass over that of clover. Excessive fertilization with N can result in a decrease in the clover stand.

Clover-Grass Pastures

For new seedings: An application of 40 lbs N/A is suggested where adequate available N is not present in the soil. Where the presence of residual available N in the soil is suspected because of heavy N fertilization the previous year or a previous legume crop, a soil test for N is useful in determining the N fertilizer requirement.

Should the nitrate-N level in the soil exceed 7 ppm in the surface foot, N fertilization should not be necessary. The N fertilization of new seedings is usually not practiced in northeast Oregon.

For established stands: An application of 30-40 lbs N/A in the spring will stimulate the grass and provide early feed. Single applications of N should not exceed 40 lbs/A.

If the clover stand is adequate, summer N applications seldom pay. In some lower altitude areas, an application of 30-40 lbs N/A in late August will stimulate grass growth and may provide additional fall grazing.

Pure Grass

Productive irrigated pure grass pastures require 125-300 lbs N/A each year. N should be applied in 2 or 3 equal applications in early spring and about June 1 and August 1. The higher rates of application are suggested for lower altitude, longer growing season areas such as Ontario and Hermiston.

PHOSPHORUS (P)

The need for P fertilizer can be estimated using a soil test. Adequate fertilization with P is particularly important to the maintenance of a good stand of clover.

If the OSU soil test for P reads (ppm):	Apply this amount of phosphate (P_2O_5) (lb/A):
0 - 5	60 - 80
6 - 10	40 - 60
Over 10	None

Broadcast P in fall or early spring on established pasture.

If possible, band phosphate ½" to 1" to the side or below seed when seeding. Some soil should separate the seed from the fertilizer.

POTASSIUM (K)

An adequate level of available K is essential to the optimum growth of clover-grass pastures. K is particularly important to the growth of clover. Grass competes vigorously with clover in the uptake of K.

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Fertilizer Guide

FG 22
Revised May 1985

NATIVE MEADOWS

(Eastern Oregon—East of Cascades)

Native meadows produce a significant portion of the hay used for winter feed in eastern Oregon. Without fertilization an average meadow will yield approximately 1 ton of hay per acre. With proper fertilization yields can often be increased by 2 to 3 tons and hay quality such as protein content is improved. Native meadows fall into three broad classifications: (1) Nevada bluegrass; (2) rush-sedge-grass; and (3) rush.

Nevada bluegrass meadows respond to applications of nitrogen. Rush-sedge-grass meadows respond to a combination of nitrogen, phosphorus, and sulfur. Rush (wire grass) meadows are usually flooded for long periods and do not respond to fertilization.

Fertilized meadows usually reach optimum hay stage earlier than unfertilized meadows. Quality and protein content of early cut hay is greater than later cut hay.

NITROGEN (N)

Nitrogen is the most limiting fertilizer element in meadow hay production. In addition to increasing yield, the application of N improves hay quality such as protein content.

1. An application of 60-80 lb N/A annually has given the greatest economic return. Where a good stand of legume such as white tip clover is present N rates may be reduced by as much as 50%.

2. Rates of N as high as 150 lb/A gave some increases in yield but did not give as high a return for money expended.

3. Nitrogen should be applied annually in late fall or early spring. The residual effect of N the year following application is small.

PHOSPHORUS (P)

Phosphorus applied in combination with N has given increased yields on native meadows that contain a legume such as white tip clover. It is also possible by careful fertilization and management to increase the amount of legume in the stand, resulting in better quality hay. Nitrogen fertilizer increases the growth of grass which competes with the legume. As indicated in the section on N the rate of N application may be reduced when legumes are present. Soil tests have proved fairly accurate for predicting P response on native meadows.

If OSU soil test for P reads (ppm):	Apply this amount of Phosphate (P_2O_5) (lbs/A):
0 - 5	60 - 80
5 - 10	40 - 60
over 10	0

Phosphorus should be applied in the late fall or early spring.

SULFUR (S)

Sulfur applications of 20-30 lb/A have stimulated legume growth in meadows in all areas except Harney County and a portion of Grant County.

Sulfur fertilizers contain S as sulfate or elemental S. As plants absorb S as sulfate this form is immediately available to plants. Elemental S must oxidize to sulfate in order to be available to plants.

Where S is deficient sulfate should be applied annually at 20-30 lbs S/A. Fine ground (less than 40 mesh) elemental S can be applied every second year at 40-50 lbs S/A.

Coarser forms of elemental S such as "popcorn" S oxidize more slowly and should be applied less

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FG 31
Revised March 1985

Fertilizer Guide

BLUEGRASS SEED
(Northeast Oregon)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seedbed preparation, proper seeding methods, adequate irrigation and timely harvest.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, soil sample bags and information sheets.

NITROGEN (N)

Liberal amounts of available N are required for optimum yields of bluegrass seed. Irrigated fields require more N fertilizer than non-irrigated fields.

On new seedings. Apply 20-40 lbs N/A. A band application near the seed is an effective way to apply N. At least 1 inch of soil should separate the seed and fertilizer. For broadcast applications N should be applied at the higher rate.

If the soil test value for available N in the surface foot of soil exceeds 10 ppm N fertilizer is probably not required.

On established stands. Apply 15-20 lb N/A after post harvest burning and before the initial fall irrigation. Apply 100 to 120 lbs N/A in late October or early November.

With older stands apply 20 to 50 lb N/A in March or early April in addition to the fall application.

Soil tests are useful in predicting N fertilizer needs. N fertilizer rates can be reduced where significant amounts of available N are present in the soil.

If the soil test for available N in the surface 2' of soil equals	Apply this amount of N/A in October
ppm	lbs
0 - 5	100 - 120
5 - 10	60 - 100
10 - 15	0 - 60
over 15	0

PHOSPHORUS (P)

Soil testing should be used to evaluate the need for P fertilization.

On new seedings, when the OSU soil test for P is below 15 ppm, place 40 lbs P_2O_5/A near the seed. At least 1 inch of soil should separate the seed and fertilizer. The application rate should be increased by 50% when P is broadcast rather than placed near the seed.

On established stands, P should be applied in the fall following post harvest burn with 15-20 lb N/A and K where applicable.

If the OSU soil test for P reads (ppm):	Apply this amount of phosphate (P_2O_5) (lb/A)
0 - 5	50 - 60
5 - 10	40 - 50
10 - 20	30 - 40
over 20	0

POTASSIUM (K)

Soil testing should be used to evaluate the need for K fertilization.

On new seedings, when the OSU soil test for K is below 100 ppm, place 40 lbs K_2O near the seed. At least 1 inch of soil should separate the seed and fertilizer. The K application rate should be increased by 50% where K is broadcast.

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Fertilizer Guide

FG 37
Revised May 1985

Irrigated Spring-Planted Small Grains

Mineral Soils

(Eastern Oregon—East of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include adequate irrigation, use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest. Recommended soil sampling and testing procedures should be followed to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, sample bags, and information sheets.

Note: For fertilizer suggestions for irrigated spring-planted small grains on peat and muck soils in Klamath County see OSU FG 70.

NITROGEN (N)

Irrigated grain requires a good supply of available N, however, excessive rates of N can reduce grain quality and increase the risk of lodging. An optimum response to N fertilization depends on adequate irrigation. The N applications suggested in this guide are based on the maintenance of good soil moisture throughout the growing season.

Of the suggested N application at least ¼ of the N should be applied before or at planting time. The urea or diammonium phosphate forms of N may cause seedling injury if banded close to the seed at planting. The remainder of the N should be plowed down, injected, or applied through the sprinkler system.

The amount of N fertilizer required depends on the following factors: the preceding crop; the N carry-over from the previous crop; the amount and type of residue to be plowed under; and possible leaching losses due to over-irrigation.

The following fertilizer guides are for mineral soils.

For muck soils in Klamath County see OSU FG 70.

N Fertilizer Guide Based On Soil Test

The amount of residual N in the soil varies considerably.

A soil test for nitrate-N (NO_3-N) helps in evaluating the N carryover from the previous crops in the case of mineral soils with low organic matter content.

Nitrogen soil tests are not recommended following alfalfa (or other legumes).

Soil samples for NO_3-N should be taken following a growing season and prior to the application of N fertilizer.

Soil samples should be taken from the 0-2' and 2-6' soil depths on deep soils. The soil samples should consist of soil cores removed from the entire 0-2 feet and 2-6 feet depth of soil. On soils shallower than 6', soil samples should be taken from 0-2' and from 2' to the rooting depth.

It is important to follow correct soil sampling procedures as outlined in OSU Extension Circular 628. This publication is available from county extension offices.

OSU soil test results for N are reported in ppm. One ppm N in a 1 foot depth of soil equals about 4 lbs N/acre.

As an example:

Soil Depth (ft)	Soil Test ppm	NO_3-N lbs/A
0-2	8	32
2-6	3	48
	Total	80 lbs NO_3-N

The total NO_3-N soil test values are used to estimate the N fertilizer requirement as indicated in the following table:

NO_3-N Soil Test (lbs/A)	N Application (lbs A)[1]	
	Wheat	Oats and Barley
0-40	120-160	80-100
40-80	80-120	40-60
80-120	40-80	0-20
120-160	0-40	0
160-200	0	0

[1]These application rates are suggested for silt loam, loam, and clay loam soils. For sandy soils the application rates should be increased by ¼.

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OREGON STATE UNIVERSITY
Oregon Counties and U.S. Department of Agriculture Cooperating
EXTENSION SERVICE

Oregon State University Fertilizer Recommendation for

Irrigated Pastures
(Central Oregon)

Irrigated pastures are usually composed of a mixture of improved grasses and legumes. Maintaining a proper balance between grasses and legumes is essential to obtain maximum production.

Management is the key to production from irrigated pastures. Proper management of livestock and irrigation water can materially increase pasture production.

Nitrogen

Nitrogen has a tendency to stimulate the grassy portion of the pasture mixture. Continued use of high rates of nitrogen will have a tendency to drive the legume out of the stand.

The following fertilizer recommendations are for pastures containing an optimum balance between grasses and legumes.

1. 120 to 140 pounds of nitrogen should be applied annually.
2. Split applications of nitrogen with 40 to 60 pounds of nitrogen being applied in the fall or early spring and 60 to 80 pounds of nitrogen applied during the late spring or early summer have given better results than single applications.

Phosphorus

Legumes in a pasture mixture will usually respond to phosphorus.

1. Apply 40 to 60 pounds of P_2O_5 in the late fall or early spring when legumes in pasture need stimulation.

Sulfur

Sulfur is utilized dominantly by legumes. In only a few isolated cases has sulfur stimulated grass to any measurable degree.

1. Apply 40 to 60 pounds of sulfur in the fertilizer program.
2. Sulfur applications may be made in conjunction with other materials, but should be applied in the fall or early spring.
3. If a bloat problem develops because of excess legume growth, reduce the amount of sulfur applied.

(OVER)

Test First
TESTING
Then Fertilize

COOPERATIVE EXTENSION SERVICE
OREGON STATE UNIVERSITY

Oregon State University Fertilizer Recommendation for

Potatoes
(Central Oregon)

Irrigated potatoes are one of the important row crops produced in central Oregon. In potato production, growers are interested in both quality and total yield. Potato quality is primarily a function of management, water control, and disease control. Fertilizer applications have been shown to affect quality with regard to specific gravity, size, and smoothness. Fertilizer recommendations for potato production are based on good management and water control.

Nitrogen

Nitrogen fertilizers are applied either by banding or by broadcast methods. It is usually necessary to increase the application rate by at least 50% when nitrogen is applied broadcast.

1. Apply 100 pounds of nitrogen during the growing season when materials are banded.
2. Apply 150 pounds of nitrogen during the growing season when all materials are broadcast.

Phosphorus

On an intensive row crop such as potatoes, annual applications of phosphorus are made regardless of soil test values. 75 pounds of P_2O_5 should be applied annually as a band placement at planting time.

Potassium

Potassium applications on potatoes have shown a significant response in this area.

1. 75 pounds of K_2O should be band placed at planting time.
2. It is recommended that all potassium be applied in the form of potassium sulfate.
3. Potassium chloride is not recommended for potato production in this area because of possible detrimental effects of the chloride.

(OVER)

Test First
SOIL TESTING TELLS
Then Fertilize

Fertilizer Guide

FG 40
Revised July 1983

IRRIGATED WHEAT

(Eastern Oregon - East of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include adequate irrigation, use of recommended varieties, selection of adapted soils, weed control, disease and insect control, proper seeding methods, and timely harvest.

It is important that the soil be sampled and tested as a guide to fertilization. Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions and soil sample bags and information sheets.

NITROGEN (N)

Irrigated grain requires a good supply of available N; however, excessive rates of N can reduce grain quality and increase the risk of lodging. An optimum response to N fertilization depends on adequate irrigation.

Of the suggested N application, 0 to 40% of the N should be applied preplant or at planting time and the remainder during tillering in the spring. The urea or diammonium phosphate forms of N may cause seedling injury if banded close to the seed at planting.

The amount of N fertilizer required depends on the following factors: the preceding crop, the N carryover from the previous crop, the amount and type of residue to be plowed under, and possible leaching losses due to over-irrigation.

The following fertilizer guides are for mineral soils with low organic matter content unless otherwise stated.

N Fertilizer Guide Based on Soil Test

The amount of residual N in the soil varies considerably.

A soil test for nitrate-N (NO_3-N) helps in evaluating the N carryover from the previous crops in the case of mineral soils with low organic matter content.

N soil tests are not recommended following alfalfa (or other legumes) or for muck and peat soils.

Soil samples for NO_3-N should be taken following a growing season and prior to the application of N fertilizer.

Soil samples should be taken from the 0-2 ft and 2-6 ft soil depths on deep soils. The soil samples should consist of soil cores removed from the entire 0-2' and 2-6' depth of soil. On soils shallower than 6', soil samples should be taken from 0-2' and from 2' to the rooting depth.

OSU soil test results for N are reported in ppm. One ppm N in a 1' depth of soil equals about 4 lbs N/A. As an example:

Soil depth (ft)	Soil test NO_3-N ppm	lbs/A
0 - 2	4	32
2 - 6	3	48
		Total = 80

The total NO_3-N soil test values are used to estimate the N fertilizer requirement as indicated in the following table:

NO_3-N soil test lbs/A	N application* lbs/A
0 - 50	250 - 200
50 - 100	200 - 150
100 - 150	150 - 100
150 - 200	100 - 50
200 - 250	50 - 0
Over 250	None

*These application rates are calculated for an estimated yield of 100 bu/A. Add or subtract 3 lbs N/A for each bu/A when estimated yield is above or below 100 bu/A.

Should the soil test value for NO_3-N be less than 2 ppm in the 0-2' soil depth apply a minimum of 30 lbs/A N when well-tillered wheat plants are not present regardless of the soil test value for N below 2'. This application is to insure adequate initial growth of wheat plants.

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FG 52 • Revised June 1990

Fertilizer Guide

Fertilizer and Lime Materials

Chemical fertilizers, when properly used, provide a satisfactory source of plant nutrients and can increase the yield and quality of crops when applied to nutrient deficient soils. Other materials such as manure, sewage sludge, and industrial wastes may supplement the nutrient needs of most crops. In many situations, because of guaranteed analysis, accessibility and transportation costs, chemical fertilizers provide the least expensive and accurate means of supplying plant nutrient requirements.

Soil acidity may be one of the factors that limit yield and growth responses to applied fertilizer. Lime is applied to reduce soil acidity.

Fertilizer grade

The grade of a fertilizer indicates the available nutrient content expressed in terms of percentages of nitrogen (N), phosphorous pentoxide (P_2O_5), and potash (K_2O), in that order. Nitrogen (N) is expressed on the elemental basis, and phosphate and potash are expressed as the oxides rather than elemental phosphorus (P) and potassium (K). A fertilizer grade of 10-20-5, contains:

10% N, 20% P_2O_5, and 5% K_2O.

Fertilizers containing relatively large amounts of nutrients are "high analysis fertilizers." A fertilizer with a grade of 10-20-20 has a high analysis by comparison with a 4-8-8 grade. High analysis fertilizers often provide nutrients at lower relative cost due to lower costs per pound of plant nutrient for transportation, storage, and application. Fertilizers containing the three nutrients N, P, and K are sometimes referred to as "complete."

Other nutrients

Fertilizers often contain other nutrients such as sulfur (S) and magnesium (Mg) or micronutrients such as boron (B), zinc (Zn) or molybdenum (Mo). These nutrients are listed on the fertilizer label on an elemental basis similar to nitrogen and sometimes included in the fertilizer grade. A 15-5-10-8S fertilizer contains an additional 8% S.

Some micronutrient elements such as B and Mo can be toxic to plants if applied in slightly excessive amounts. Apply only recommended amounts of these nutrients.

Application of fertilizers

Recommendations for the method of fertilizer application should be followed for these reasons:

1. Nutrients such as P, K, Mg, and Zn are immobile in the soil and should be "placed" or "banded" in the rooting zone or incorporated by tillage.

2. Fertilizers can cause plant damage if banded close to seed or roots at rates in excess of those suggested. Fertilizers containing B should never be banded but should be applied evenly to the fertilized area.

3. Losses of N into the atmosphere can occur when some N fertilizer materials are applied to the surface of the soil and are not incorporated.

4. N fertilizers applied in excess or before active plant growth can result in N contamination of ground water.

Dilute solutions of fertilizers are sometimes applied as "foliar" sprays. This practice is often used to apply micronutrients. Large amounts of nutrients cannot economically be applied using foliar sprays. Foliar sprays are often used when quick response is needed.

Rates of application of fertilizer materials

Most fertilizer applications suggested in OSU Fertilizer Guides are stated in terms of pounds per acre of N, P_2O_5, K_2O, or S, etc. To convert these recommendations to pounds per acre of an actual fertilizer material, use the following formula:

$$\frac{\text{Pounds of nutrient recommended}}{\text{Percentage of nutrient in fertilizer material}} \times 100$$

Example: To supply 80 lb of N using ammonium sulfate that has a grade of 21-0-0

80/21 x 100 = 380 lb of ammonium sulfate should be applied.

Fertilizer guides dealing with lawns and gardens provide recommendations in lb/100 or lb/1000 sq ft. Vegetable and fruit tree guides do not provide units for smaller acreages. To convert pounds per acre (lb/a) to lb/100 sq ft, divide by 400. A fertilizer application of 400 lb/a would equal 1 lb/100 sq ft. Similarly, to convert lb/a to lb/1000 sq ft, divide lb/a by 40. A fertilizer application rate of 400 lb/a would be 10 lb/1000 sq ft.

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ABLE 2. Calcium Carbonate Equivalents

Common name	Chemical name	Chemical formula	*cce*
Ground limestone	Calcium carbonate	$CaCO_3$	100
Dolomitic limestone	Calcium magnesium carbonate	$CaMg(CO_3)_2$	109
Hydrated lime	Calcium hydroxide	$Ca(OH)_2$	135
Burned lime	Calcium	CaO	179

ineness factor

The fineness factor (*ff*) is related to the particle size a liming material. The particle size affects the rate at ich a liming material goes into solution in the soil. Lime does not neutralize acidity or release its nutrients ntil it has dissolved, fine particles will react rapidly if ficiently mixed with the soil.

One T/a lime with all particles passing a #10 screen vill react with the soil in one year or less if thoroughly ixed with the soil. Increased lime rates, larger particle e and incomplete mixing increase time for reaction of me with the soil.

Lime particles which are less than 7/100 (7 hundredths) of an inch in diameter (particles of this size will ss through a #10 sieve) are considered to be soluble nough to be effective. Liming material particles which l pass a #10 sieve are considered to be relatively n-effective. The degree of solubility increases as the rticle size decreases from #10 to #40 sieve, with lime particles which pass a #40 sieve being given the maximum olubility rating. Solubility ratings for particle sizes shown Table 3 are given in Table 4. A fineness factor value ased on particle size is calculated in Table 4.

ABLE 3. Example Analysis of a Liming Material

Sieve Analysis	
Passing #10	98%
Passing #20	92%
Passing #40	78%

BLE 4. Calculation of Fineness Factor

Particle size group	Percent in Particle size group (A)	Solubility rating (B)	Fineness value (A) x (B)
o. 40 sieve or iller (% passing) sieve)	78	1.00	78
20-40 sieve % passing #20 us % passing) sieve	14	0.60	8.4
10-20 sieve passing #10 passing e)	6	0.30	1.8
10 sieve or er (100% minus assing #10 sieve)	2	0	0
		TOTAL	88.2

The values for "percent in particle size group" are obtained from Table 3. The percent passing a #40 sieve is 78. The percent passing a #20 sieve and caught on a #40 sieve is 92 - 78 = 14. A similar subtraction is made for the last two categories, 98 - 92 = 6 and 100 - 98 = 2.

$$\text{Fineness factor } (ff) = \frac{\text{Total fineness value}}{100} = \frac{88.2}{100} = 0.88$$

Moisture factor

As water does not reduce acidity, the acid neutralizing value of a liming material decreases on a weight basis as the moisture content increases.

$$\text{Moisture factor } (mf) = \frac{100 - \%\text{ water in lime}}{100}$$

A liming material containing 15% water would have a moisture factor,

$$mf = \frac{100-15}{100} = 0.85$$

Lime score

The lime score of a liming material is a numerical expression of the quality of the lime using *ff*, *cce*, and *mf*. A sample calculation of a lime score using a *cce* of 92 and the preceeding values for *ff* and *mf*, follows:

Calcium carbonate equivalent (*cce*) = 92
Fineness factor (*ff*) = 0.88
moisture factor (*mf*) = 0.85

$$\text{Lime score} = cce \times ff \times mf = 92 \times 0.88 \times 0.85 = 69$$

Amount of liming material to apply

Liming recommendations are based on 100-score liming material. Liming equivalent is the amount of liming material needed to equal one ton of 100 score dry lime. In general, this will be greater than 1.0 for limestone and by-product materials and less than 1.0 for burned and hydrated lime. The lime equivalent is calculated

$$\frac{\text{Recommended liming rate}}{\text{Lime score } (ls)} \times 100$$

If a liming material has a lime score of 69 and the recommended liming rate was 3 T/a, then:

$$\text{The lime equivalent} = \frac{3\text{ T/a}}{69} \times 100 = 4.35\text{ T/a}$$

Liming recommendations are based on soil test results and vary with the soil and crop to be grown.

A 1 t/a application of 100-score ground limestone supplies about 2 milliequivalents of calcium/100 grams of soil to the surface 6" of a mineral soil.

Chemical composition of liming materials

Liming materials vary in chemical composition. The chemical makeup of lime affects its neutralizing value and nutrient content. Ground limestone, for instance, consists of calcium carbonate and is a source of calcium. Dolomitic limestone consists of calcium and magnesium carbonates.

OREGON STATE UNIVERSITY EXTENSION SERVICE

Oregon State University Fertilizer Guide for

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FG 62
August 1979

SWEET CORN

(Eastern Oregon- East of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include adequate irrigation, use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest.

Because of the influence of soil type, climatic conditions, and other cultural practices, crop response from fertilizer may not always be accurately predicted. Soil test results, field experience, and knowledge of specific crop requirements help determine the nutrients needed and the rate of application.

The fertilizer application should insure adequate levels of all nutrients--optimum fertilization is essential for top quality and yields.

Plant Population

The fertilizer applications suggested in this guide are based on a population of 20,000 plants/A. Where the plant population exceeds 20,000/A, fertilizer rates should be increased by 10% for each additional 5,000 plants/A. Fertilizer rates should be reduced similarly for populations less than 20,000/A.

An irrigation when corn is 12-18" (30-45 cm) high will insure most efficient utilization of banded fertilizer.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. Your county agent can provide you with soil sampling instructions and soil sample bags and information sheets.

NITROGEN (N)

Sweet corn requires a good supply of available N. An optimum response to N fertilization depends on adequate irrigation.

Part (40-60 lbs/A) of the N should be banded at planting time--the remainder may be applied before planting and/or during the growing season before tasseling.

If the band application of N exceeds 60 lb/A (65 kg/ha), there is danger of seedling injury from the concentration of salt.

Fertilizer salt injury can be reduced by using two rather than one fertilizer band, not banding too close to the seed, immediate irrigation at first sign of crop injury. Salt injury is likely to be greater in sandy soil compared to finer textured soil and in dry soil compared to moist soil.

The urea or diammonium phosphate forms of N may cause seedling injury if banded close to the seed at planting, especially where the soil pH exceeds 7.0.

The amount of N fertilizer required depends on the following factors: the preceding crop; the N carry-over from the previous crop; the amount and type of residue to be plowed under; and possible leaching losses due to over-irrigation.

The following fertilizer guides are for mineral soils with low organic matter content.

N Fertilizer Guide Based On Soil Test

The amount of residual N in the soil varies considerably.

A soil test for nitrate-N (NO_3-N) helps in evaluating the N carry-over from the previous crops in the case of mineral soils with low organic matter content.

Soil samples for NO_3-N should be taken following a growing season and prior to the application of N fertilizer.

Soil samples should be taken from the 0-2' (0-0.6 m) and 2-5' (0.6-1.5 m) soil depths on deep soils. The soil samples should consist of soil cores removed from the entire 0-2' and 2-5' depth of soil. On soils shallower than 5', soil samples should be taken from 0-2' and from 2' to the expected rooting depth.

OSU soil test results for N are reported in ppm. One ppm N in a 1' depth of soil equals about 4 lbs N/acre. As an example:

Soil Depth (ft)	Soil Depth (m)	Soil Test NO_3-N ppm	lbs/A	Kg/ha
0-2	0-0.6	4	32	36
2-5	0.6-1.8	3	36	40
		Total	68 lbs	76 kg

The total NO_3-N soil test values are used to estimate the N fertilizer requirement as indicated in the following table:

NO_3-N Soil Test (lbs/A)	N Application (lbs/A)[1] After non-legume crop[2]	After beans and peas[3]	After productive alfalfa, clover
0	200	160	140
40	160	120	100
80	120	80	60
120	80	40	20
160[4]	40	0	0
200[4]	0	0	0

1/ These application rates are suggested for silt loam, loam, and clay loam soils. For sandy soils the application rates should be increased by 40 lb N/A.

2/ When straw is incorporated after Sept. 1, increase N fertilizer rate by 30-50 lbs/A.

3/ After beans and peas and low producing alfalfa and clover.

4/ For early plantings into cool soil, apply 20-30 lbs N/A in a 2" x 2" band.

Fertilizer Guide

FG 65
Revised April 1983

Onions—Mineral Soils
(Eastern Oregon—East of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include adequate irrigation, use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest.

Because of the influence of soil type, climatic conditions, and other cultural practices, crop response from fertilizer may not always be accurately predicted. Soil test results, field experience, and knowledge of specific crop requirements help determine the nutrients needed and the rate of application.

The fertilizer application should insure adequate levels of all nutrients--optimum fertilization is essential for top quality and yields.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, soil sample bags, and information sheets.

NITROGEN (N)

Onions require a good supply of available N; however, excess N applications can result in late maturity, large necks that are difficult to cure, soft onion bulbs, and poor storage quality.

A higher percentage of fertilizer N is absorbed by the plant if the fertilizer is applied when the onion root system is well developed. Split applications of nitrogen are used more effectively by the plant than a single preplant application.

Sidedressed nitrogen applications or nitrogen applied in irrigation water can be an effective means of providing supplemental nitrogen to the crop during the season. Do not use aqua or anhydrous ammonia in sprinkler irrigation.

Excessive irrigation that causes nitrogen movement beyond the root system can reduce nitrogen available to the plants. Additional nitrogen may be required during the season under these conditions.

Shallow incorporation of high rates of topdressed or broadcast fertilizer N can seriously reduce onion stands. A high rate of fertilizer N applied before planting should be incorporated into the plow layer or banded well away (6") from the seed on the furrow side of rows in two- row onion beds.

Excessive nitrogen available to onions, particularly later in the season (mid-July), can delay onion maturity and make field curing of onions more difficult. Inadequate field curing before storage can result in greater losses because of rot.

Onion varieties which differ markedly in yield potential can be expected to differ somewhat in their requirements for nitrogen. Higher yielding varieties may require slightly more nitrogen.

Onion stands (plant populations) of lower than 4 plants per foot of row require less nitrogen. Onion stands reduced as a result of poor emergence or inclement weather will require less fertilizer N.

The amount of N fertilizer required depends on the nitrogen carry-over from the previous crop and the amount and type of residue to be plowed under.

N Fertilizer Guide Based on Soil Test

The amount of residual N in the soil varies considerably. A soil test for nitrate-N (NO_3-N) helps in evaluating the N carry-over from the previous crops in the case of mineral soils with organic matter content below 2%.

Soil samples for NO_3-N should be taken in the spring prior to the application of N fertilizer.

Soil samples should be taken from the 0-12" soil depth.

OSU soil test results for N are reported in ppm. One ppm N in a 12" depth of soil equals about 4 lb N/acre.

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Fertilizer Guide

FG 69
May 1983

Peppermint and Spearmint
(Eastern Oregon—East of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended varieties, adequate irrigation, selection of adapted soils, weed control, disease and insect control, proper planting methods, and timely harvest.

Because of the influence of soil type, climatic conditions, and other cultural practices, crop response from fertilizer may not always be accurately predicted. Soil tests results, field experience, and knowledge of specific crop requirements help determine the nutrients needed and the rate of application. The fertilizer application for mint should insure adequate levels of all nutrients--optimum fertilization is essential for top quality and yields.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, soil sample bags, and information sheets.

NITROGEN (N)

Mint farmers spend most of their fertilizer dollars for N. A continuous N supply throughout the growing season is important to maintain active vegetative growth and development of new leaves for optimum oil production.

For maximum effectiveness, 1/4 to 1/3 of the the total N required should be applied from mid-May to late June. Excessive N rates applied within 3 weeks of maturity tend to reduce oil quality.

N applied in May or early June can be topdressed with conventional spreaders with little permanent plant damage. A pipe, small pole or chain dragged behind the spreader will reduce the chance of foliage being burned as a result of dry fertilizer particles caught in the leaf axials of the plant. Avoid topdressing dry fertilizers when the leaves are wet with dew or rain.

N applied in irrigation water can also be effective in supplying N to mint during the season where sprinkler irrigation is used. The uniformity of N application is no better than the uniformity of water application. Best results are obtained when the fertilizer application is gauged to enter the system toward the middle of the set and is terminated shortly before the set is completed.

Fertilizer application to furrow irrigated fields presents problems as fertilizer salts tend to migrate and accumulate in tops of beds. Also, even application of fertilizer is difficult if fertilizer is applied in water. Maximum effectiveness results when fertilizer is applied during the first portion of the set and injection stops when water reaches the end of the field.

Fall regrowth can be enhanced with light fertilizer N applications (20-40 lb/A) if available N is low at harvest. Vigorous fall regrowth, in turn, promotes more vigorous growth in the spring.

N rates on mint depend on many factors including previous crop, method of application, past fertilizer use, soil type, irrigation practices and carryover N as measured with a soil analysis.

N needs can be determined using soil samples collected in the early spring. Soil samples for the N soil test should be taken from a 0-12" soil depth.

N rates in the following table are for established stands or new plantings following grain or grass with straw removed, or following row crops.

If the OSU soil test for available N reads (ppm)*	Apply this amount of N (lbs/A): Early spring	May & June
0	80	160
10	40	160
20	40	120
30	0	120
Over 30	0	120

* Available N equals the sum of nitrate N and ammonium N (NO_3-N + NH_4-N).

For new plantings the rate of N application should be reduced by 80 lbs/A following legume crops such as alfalfa, clover, beans, or peas.

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Fertilizer Guide

FG 71
June 1983

FIELD CORN

(Eastern Oregon - East of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely harvest.

Because of the influence of soil type, climatic conditions, and other cultural practices, crop response from fertilizer may not always be accurately predicted. Corn grows best on deep, well drained soils. Soil test results, field experience, and knowledge of specific crop requirements help determine the nutrients needed and the rate of application.

The fertilizer application should insure adequate levels of all nutrients--optimum fertilization is essential for top quality and yields. Corn requires comparatively high rates of fertilizer for optimum production.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions and soil sample bags and information sheets.

Plant Population

The fertilizer applications suggested in this guide are based on a population of 25,000 to 30,000 plants/A and yields of at least 150 bu/A. Fertilizer rates can be adjusted proportionately up or down when plant population and predicted yield deviate from these values.

NITROGEN (N)

Field corn requires a good supply of available N. An optimum response to N fertilization depends on adequate irrigation. An irrigation when corn is 12-18" high will insure most efficient utilization of banded fertilizer.

Part (40-60 lbs/A) of the N should be banded at planting time--the remainder may be applied before planting and/or during the growing season before tasseling, particularly where leaching is likely to be a problem.

If the band application of N exceeds 60 lb/A, there is danger of seedling injury from the concentration of salt.

Fertilizer salt injury can be reduced by using 2 rather than 1 fertilizer band, not banding too close to the seed, and immediate irrigation at first sign of crop injury. Salt injury is likely to be greater in sandy soil compared to finer textured soil and in dry compared to moist soil.

The urea or diammonium phosphate forms of N may cause seedling injury if banded close to the seed at planting, especially where the soil pH exceeds 7.0.

Amount of N fertilizer required depends on the following factors: the preceding crop; the N carryover from the previous crop; the amount and type of residue to be plowed under; and possible leaching losses due to over-irrigation.

The following fertilizer guides are for mineral soils with low organic matter content.

N Fertilizer Guide Based on Soil Test

The amount of residual N in the soil varies considerably. A soil test for nitrate-N (NO_3-N) helps in evaluating the N carryover from the previous crops in the case of mineral soils with low organic matter content. Soil samples for NO_3-N should be taken following a growing season and prior to the application of N fertilizer.

Soil samples should be taken from 0-2' and 2-5' depths on deep soils. The soil samples should consist of soil cores removed from the entire 0-2' and 2-5' depths of soil. On soils shallower than 5', soil samples should be taken from 0-2' and from 2' to the expected rooting depth.

OSU soil test results for N are reported in ppm. One ppm N in a 1' depth of soil equals about 4 lbs N/acre. As an example:

Soil depth (ft)	NO_3-N (ppm)	NO_3-N (lbs/A)
0 - 2	4	32
2 - 5	3	36
	Total	68 lbs/A

The total NO_3-N soil test values are used to estimate the N fertilizer requirement as follows:

NO_3-N Soil Test (lbs/A)	After* non-legume crop	After beans, peas or alfalfa
0	300	250
50	250	200
100	200	150
150	150	100
200	100	50
250	50	0
300	0	0

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Fertilizer Guide

FG 72
July 1983

PEAS

(Eastern Oregon - East of Cascades)

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seed bed preparation, proper seeding methods, and timely planting and harvesting.

Recommended soil sampling procedures should be followed in order to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, soil sample bags, and information sheets.

NITROGEN (N)

Rates of 15 to 20 lbs of N/A banded with P and possibly K at planting time are suggested.

Information on the application of N is given below in the sections on P and K.

INOCULATION

Pea seed should be inoculated, immediately before seeding to insure an adequate supply of nitrogen-fixing bacteria. A fresh, effective, live culture of the correct strain of Rhizobia should be used. The need for inoculation is reduced in fields that have been used for a pea-wheat rotation for several years and where pea yields have been satisfactory.

PHOSPHORUS (P)

P is essential for vigorous early growth of seedlings. Preferably P, N, and, where required, up to 60 lbs K_2O/A should be applied in a band 2" to the side or 2" below the seed at planting time.

When banding equipment is not available, 15-20 lbs N/A and 40-75 lbs P_2O_5 can be drilled with the seed. Do not use urea or diammonium phosphate as N and P sources when fertilizer is drilled with seed. Additional P_2O_5 and K_2O, when required, can be broadcast and plowed down prior to planting.

If the OSU soil test for P reads (ppm):	Apply this amount of phosphate (P_2O_5) (lb/A):
0 - 10	40 - 120
10 - 20	0 - 60
Over 20	None

POTASSIUM (K)

Soil testing should be used to evaluate the need for K fertilizer.

If the OSU soil test for K reads (ppm):	Apply this amount of potash (K_2O) (lb/A)
0 - 75	90 - 120
75 - 150	60 - 90
150 - 200	30 - 60
Over 200	None

K should be applied and plowed down before planting or banded at planting time. K should not be included with N and P when fertilizer is drilled with the seed. In a 2" x 2" band application of N, P, and K, the K rate should not exceed 60 lbs K_2O/A. Additional K, where required, should be broadcast and plowed down prior to planting.

Seedling injury from banded fertilizers tends to be more serious:

- -in drier soils
- -in coarse textured, sandy soils
- -where fertilizer band is close to seed.

Superphosphate fertilizers are less injurious to seedlings than N and K fertilizers. Urea and diammonium phosphate can be particularly injurious if placed too close to the seed.

SULFUR (S)

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S.

Elemental S must convert to sulfate in the soil before the S becomes available to plants. The rapid conversion of elemental S to sulfate is dependent on warm, moist soil conditions. This reduces the effectiveness of elemental S as a sulfur source for early planted annual crops.

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Appendix E
ANALYSIS RESULTS FOR UNFILTERED EFFLUENT

Century Testing
Laboratories, Inc.

Mail: Post Office Box 1174
Bend, Oregon 97709
503-382-6432

LABORATORY ANALYSIS

CITY OF MADRAS
416 6TH ST
MADRAS, OR 97741
475-2622

LAB SAMPLE NO.: 7648-2
SAMPLE DESCRIP.: EFFLUENT
MATRIX: WATER
DATE SUBMITTED: 6/12/91
DATE ANALYZED: 6/12-14/91
DISCARD DATE: 8/12/91
COLLECTED BY: W.G. RAINER

ANALYSIS METHOD NUMBER	CONSTITUENT	SAMPLE CONC.	UNITS
EPA 405.1	BOD	53	mg/l
EPA 160.2	TSS	63	mg/l
SM 909.C	FECAL COLIFORM	0	No. Colonies/100 ml

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Reviewed and approved by:

Bruce H. Bale
Quality Assurance Officer

06/20/91

Century Testing Laboratories, Inc.

Mail: Post Office Box 1174
Bend, Oregon 97709
503-382-6432

LABORATORY ANALYSIS

CITY OF MADRAS
416 6TH ST
MADRAS, OR 97741

LAB SAMPLE NO.: 7773-1
SAMPLE DESCRIP.: EFFLUENT DISCHARGE
MATRIX: WATER
DATE SUBMITTED: 7/8/91
DATE ANALYZED: 7/8-12/91
DISCARD DATE: 9/8/91
COLLECTED BY: W. RAINES

ANALYSIS METHOD NUMBER	CONSTITUENT	SAMPLE CONC.*	METHOD DETECTION LIMIT	UNITS	PERCENT RECOVERY**
EPA 350.1	AMMONIA	21.5	0.05	mg/l	100.0%
ICP 6010	POTASSIUM	7.3	0.05	mg/l	105.0%
EPA 351.3	TKN	23.7	0.12	mg/l	
EPA 365.4	TOTAL PHOSPHORUS	8.3	0.008	mg/l	110.0%
EPA 180.1	TURBIDITY	40	0.50	NTU	

*N.D. means "not detected."

**Percent Recovery values are within established control limits.

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Reviewed and approved by:

Bruce H. Bale
Quality Assurance Officer

07/24/91

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LABORATORY ANALYSIS

EPA INORGANIC ANALYSIS

CITY OF MADRAS
416 6TH ST
MADRAS, OR 97741

LAB SAMPLE NO.: 7773-1
SAMPLE DESCRIP.: EFFLUENT DISCHARGE
MATRIX: WATER
DATE SUBMITTED: 7/8/91
DATE ANALYZED: 7/9-19/91
DISCARD DATE: 9/8/91
COLLECTED BY: W. RAINES

ANALYSIS METHOD NUMBER	CONSTITUENT	SAMPLE CONC.*	METHOD DETECTION LIMIT	UNITS	PERCENT RECOVERY**
EPA 7060	Arsenic	N.D.	0.0015	mg/l	100.0%
ICP 6010	Barium	N.D.	0.005	mg/l	105.0%
EPA 7131	Cadmium	N.D.	0.0006	mg/l	97.0%
EPA 7191	Chromium	N.D.	0.0006	mg/l	106.7%
EPA 340.2	Fluoride	0.19	0.020	mg/l	101.0%
EPA 7421	Lead	N.D.	0.0009	mg/l	98.0%
EPA 7470	Mercury	N.D.	0.0001	mg/l	105.6%
EPA 354.1	Nitrate	0.05	0.01	mg/l	100.0%
EPA 7740	Selenium	N.D.	0.002	mg/l	105.3%
EPA 7761	Silver	N.D.	0.0006	mg/l	94.0%

*N.D. means "not detected."

**Percent Recovery values are within established control limits.

CENTURY TESTING LABORATORIES, INC.

Reviewed and approved by:

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07/24/91

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LABORATORY ANALYSIS

VOLATILE ORGANIC COMPOUND ANALYSIS

CITY OF MADRAS
416 6TH ST
MADRAS, OR 97741

ANALYSIS METHOD: EPA 524.2
LAB SAMPLE NO.: 7773-2
SAMPLE DESCRIP.: TB-6-21
MATRIX: WATER
DATE SUBMITTED: 7/8/91
DATE ANALYZED: 7/22/91
DISCARD DATE: 9/8/91

CONSTITUENT	SAMPLE CONC.*	DETECTION LIMIT**	UNITS
DICHLORODIFLUOROMETHANE	N.D.	0.5	ug/l
CHLOROMETHANE	N.D.	0.5	ug/l
VINYL CHLORIDE	N.D.	0.5	ug/l
BROMOMETHANE	N.D.	0.5	ug/l
CHLOROETHANE	N.D.	0.5	ug/l
TRICHLOROFLUOROMETHANE	N.D.	0.5	ug/l
1,1-DICHLOROETHENE	N.D.	0.5	ug/l
METHYLENE CHLORIDE	N.D.	0.5	ug/l
TRANS-1,2-DICHLOROETHENE	N.D.	0.5	ug/l
1,1-DICHLOROETHANE	N.D.	0.5	ug/l
CIS-1,2-DICHLOROETHENE	N.D.	0.5	ug/l
2,2-DICHLOROPROPANE	N.D.	0.5	ug/l
CHLOROFORM	N.D.	0.5	ug/l
BROMOCHLOROMETHANE	N.D.	0.5	ug/l
1,1,1-TRICHLOROETHANE	N.D.	0.5	ug/l
1,2-DICHLOROETHANE	N.D.	0.5	ug/l
1,1-DICHLOROPROPENE	N.D.	0.5	ug/l
CARBON TETRACHLORIDE	N.D.	0.5	ug/l
BENZENE	N.D.	0.5	ug/l
1,2-DICHLOROPROPANE	N.D.	0.5	ug/l
TRICHLOROETHENE	N.D.	0.5	ug/l
DIBROMOMETHANE	N.D.	0.5	ug/l
BROMODICHLOROMETHANE	N.D.	0.5	ug/l
TOLUENE	N.D.	0.5	ug/l
1,1,2-TRICHLOROETHANE	N.D.	0.5	ug/l
1,3-DICHLOROPROPANE	N.D.	0.5	ug/l
DIBROMOCHLOROMETHANE	N.D.	0.5	ug/l
TETRACHLOROETHENE	N.D.	0.5	ug/l
1,2-DIBROMOETHANE	N.D.	0.5	ug/l

*N.D. means "not detected."

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CITY OF MADRAS
CTL 7773-2

VOLATILE ORGANIC COMPOUND ANALYSIS

CONSTITUENT	SAMPLE CONC.*	DETECTION LIMIT**	UNITS
CHLOROBENZENE	N.D.	0.5	ug/l
1,1,1,2-TETRACHLOROETHANE	N.D.	0.5	ug/l
ETHYLBENZENE	N.D.	0.5	ug/l
P-XYLENE	N.D.	0.5	ug/l
M-XYLENE	N.D.	0.5	ug/l
BROMOFORM	N.D.	0.5	ug/l
O-XYLENE	N.D.	0.5	ug/l
STYRENE	N.D.	0.5	ug/l
1,1,2,2-TETRACHLOROETHANE	N.D.	0.5	ug/l
1,2,3-TRICHLOROPROPANE	N.D.	0.5	ug/l
ISOPROPYLBENZENE	N.D.	0.5	ug/l
BROMOBENZENE	N.D.	0.5	ug/l
O-CHLOROTOLUENE	N.D.	0.5	ug/l
N-PROPYLBENZENE	N.D.	0.5	ug/l
4-CHLOROTOLUENE	N.D.	0.5	ug/l
1,3,5-TRIMETHYLBENZENE	N.D.	0.5	ug/l
TERT-BUTYLBENZENE	N.D.	0.5	ug/l
1,2,4-TRIMETHYLBENZENE	N.D.	0.5	ug/l
SEC-BUTYLBENZENE	N.D.	0.5	ug/l
1,3-DICHLOROBENZENE	N.D.	0.5	ug/l
P-ISOPROPYLTOLUENE	N.D.	0.5	ug/l
1,4-DICHLOROBENZENE	N.D.	0.5	ug/l
1,2-DICHLOROBENZENE	N.D.	0.5	ug/l
N-BUTYLBENZENE	N.D.	0.5	ug/l
1,2-DIBROMO-3-CHLOROPROPANE	N.D.	0.5	ug/l
1,2,4-TRICHLOROBENZENE	N.D.	0.5	ug/l
NAPHTHALENE	N.D.	0.5	ug/l
HEXACHLOROBUTADIENE	N.D.	0.5	ug/l
1,2,3-TRICHLOROBENZENE	N.D.	0.5	ug/l

*N.D. means "not detected."

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VOLATILE ORGANIC COMPOUND ANALYSIS

TENTATIVELY IDENTIFIED COMPOUNDS (T.I.C.'s)

NONE

COMPOUNDS ADDED FOR RECOVERY TESTING	PERCENT RECOVERY**
1,2-DICHLOROETHANE-D4 (SS-2)	91%
TOLUENE-D8 (SS-3)	103%
4-BROMOFLUOROBENZENE (SS-1)	92%

**Percent Recovery values were within established control limits

CENTURY TESTING LABORATORIES, INC.

Reviewed and approved by:

Bruce H. Dale
Quality Assurance Officer

07/24/91

Century Testing Laboratories, Inc.

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503-382-6432

LABORATORY ANALYSIS

CITY OF MADRAS
MADRAS SEWER DEPARTMENT
406 6TH ST
MADRAS, OR 97741

LAB SAMPLE NO.: 7818-2
SAMPLE DESCRIP.: EFFLUENT
MATRIX: WATER
DATE SUBMITTED: 7/16/91
DATE ANALYZED: 7/17/91
DISCARD DATE: 9/16/91
COLLECTED BY: W.G.RAINES

ANALYSIS METHOD NUMBER	CONSTITUENT	SAMPLE CONC.*	METHOD DETECTION LIMIT	UNITS	PERCENT RECOVERY**
EPA 120.1	CONDUCTANCE	637	0.1	umhos/cm	
EPA 375.4	SULFATE	27	0.25	mg/l	103%

*N.D. means "not detected,"
**Percent Recovery values are within established control limits.

CENTURY TESTING LABORATORIES, INC.

Reviewed and approved by:

Bruce H. Bale
Quality Assurance Officer

07/31/91

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Laboratories, Inc.

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LABORATORY ANALYSIS

CITY OF MADRAS
MADRAS SEWER DEPARTMENT
406 6TH ST
MADRAS, OR 97741

LAB SAMPLE NO.: 7818-2
SAMPLE DESCRIP.: EFFLUENT
MATRIX: WATER
DATE SUBMITTED: 7/16/91
DATE ANALYZED: 7/16-18/91
DISCARD DATE: 9/16/91
COLLECTED BY: W.G.RAINES

ANALYSIS METHOD NUMBER	CONSTITUENT	SAMPLE CONC.	UNITS
EPA 405.1	BOD	42	mg/l
EPA 160.2	TSS	62	mg/l
SM 909.C	FECAL COLIFORM	0	No. Colonies/100 ml

CENTURY TESTING LABORATORIES, INC.

Reviewed and approved by:

Bruce H. Bale
Quality Assurance Officer

07/31/91

Century Testing Laboratories, Inc.

Mail: Post Office Box 1174
Bend, Oregon 97709
503-382-6432

LABORATORY ANALYSIS

CITY OF MADRAS
MADRAS SEWER DEPARTMENT
406 6TH ST
MADRAS, OR 97741

LAB SAMPLE NO.: 7818-2
SAMPLE DESCRIP.: EFFLUENT
MATRIX: WATER
DATE SUBMITTED: 7/16/91
DATE ANALYZED: 7/26-31/91
DISCARD DATE: 9/16/91
COLLECTED BY: W.G.RAINES

ANALYSIS METHOD NUMBER	CONSTITUENT	SAMPLE CONC.*	METHOD DETECTION LIMIT	UNITS	PERCENT RECOVERY**
EPA 7140	CALCIUM	28.7	0.010	mg/l	105.9%
EPA 7210	COPPER	N.D.	0.012	mg/l	102.1%
EPA 7380	IRON	0.096	0.20	mg/l	95.0%
EPA 7460	MANGANESE	0.246	0.010	mg/l	90.1%
EPA 7520	NICKEL	N.D.	0.030	mg/l	96.7%
EPA 7770	SODIUM	75.3	0.002	mg/l	101.2%
EPA 7950	ZINC	0.034	0.006	mg/l	91.7%

*N.D. means "not detected."
**Percent Recovery values are within established control limits

CENTURY TESTING LABORATORIES, INC.

Reviewed and approved by:

Bruce H. Bale
Quality Assurance Officer

07/31/91

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX B-2

EFFLUENT REUSE PLAN – SOUTH WWTP
(PREPARED BY ACE CONSULTANTS, 2004)

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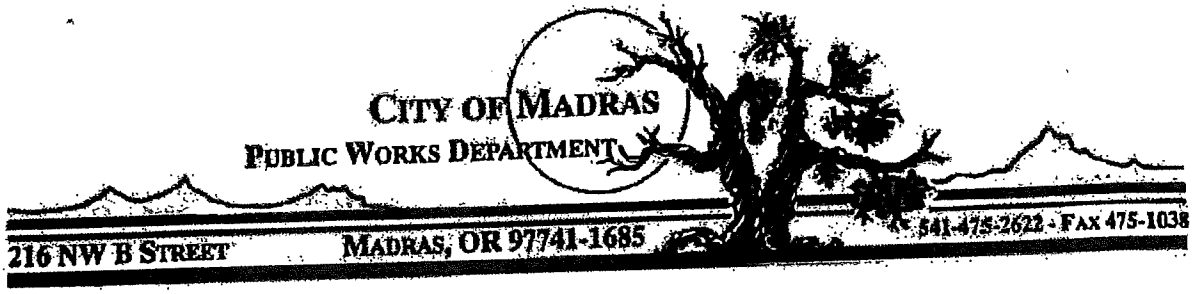
Consultants, Inc.



City of Madras
South Wastewater Treatment Facility
Effluent Reuse Plan

MAY 19, 2004

4755 SW Watson Avenue
Suite 200
Beaverton, Oregon 97005
(503) 626-2320 FAX (503) 626-6463

CIVIL / ENVIRONMENTAL ENGINEERS

EFFLUENT REUSE PLAN

CITY OF MADRAS

TABLE OF CONTENTS

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2	**Land Application**	2-1
3	**Irrigation Site Management Information**	3-1
4	**Wastewater Analysis**	4-1
5	**Wastewater Application Rates**	5-1
6	**Contingency Options**	6-1
7	**Recordkeeping**	7-1

APPENDICES

A	RECLAIMED WATER AGREEMENT
B	RESULTS OF SOILS TESTS
C	FERTILIZER GUIDES

Section 1 – Treatment Process

The facilities at the South Wastewater Treatment Plant (SWWTP) are intended to produce either a Level II, or a Level IV effluent using a Sequencing Batch Reactor (SBR) process. Raw Sewage collected from the southern portion of the City of Madras and pumped up from other portions of the City by the "B" Street Pump Station enters the Influent Pump Station wet well by gravity flow. It is pumped up to the Headworks facility where the treatment process begins. The influent sampler removes a sample of the raw sewage to determine the characteristics of the incoming wastewater and for determining the effectiveness of the treatment process.

The wastewater then passes through a fine screen for removal of non-biological materials. For periods when the fine screen is being maintained, or is not operating, the flow can be bypassed to a coarse screen for removal of some of the non-biological materials. These materials are removed from the flow to a dumpster and disposed of properly.

The flow then goes into a Pista® Grit Removal unit to remove the heavier sand, gravel and grit from the flow. This non-biological material is then dewatered and sent to a dumpster to be disposed of properly.

From the Headworks the flow passes through a valve vault that channels the flow either directly to the SBR Basin or to the Pre-Equalization Basin where it is stored until the next SBR cycle begins.

The SBR process is a plug flow form of activated-sludge treatment consisting of five stages. In the first stage the SBR basin is filled with the incoming sewage. In this installation flow comes directly from the Headworks and is pumped from the Pre-Equalization Basin. Once the SBR Basin is filled the valve to the SBR basin is closed and the valve to the Pre-Equalization Basin is opened. For the remainder of the SBR process the flow from the Headworks is sent to the Pre-Equalization Basin while a "batch" goes through the treatment process. In the second stage the wastewater in the SBR Basin goes through a "react" cycle where it is mixed and aerated. In the third stage the aeration is turned off and the solids are allowed to settle. In the forth stage the liquid from the top of the tank is "decanted" into Post-Equalization Basin. In the fifth stage a portion of the sludge from the bottom of the basin is pumped into the Aerobic Digesters. The process is then repeated.

The Post Equalization Basin is interconnected to an on-site Emergency Storage Pond. These basins store the wastewater to be filtered and disinfected and sent out for irrigation. A motorized valve is used for maintaining the rate of flow through the filter. Polymer and alum can be added either at the Post-Equalization Basin or in the SBR Basin to allow for more solids removal either in the SBR Basin, or during the filtering process. The filter has both a low-pressure and high-pressure backwash for automatically cleaning itself while it is in use. The flow goes to the Effluent Pump Station where sodium hypochlorite is added for disinfection. The effluent pumps then pump the flow to either the Effluent Storage Pond, or for on-site/nearby irrigation during the summer months. The water from the Effluent Storage Pond is applied as needed for irrigation of off-site crop.

Section 2 - Land Application

The effluent wastewater is stored during the winter months (November 1 st to April 1 st), and is applied for irrigation during the summer months (April 1 st to November 1st). Effluent from the treatment facility is pumped through a pipeline dedicated to effluent destined for either the Effluent Storage Pond, or the land application sites. This pipeline is called the Effluent Pump Main. See Figure 2-1 for the locations of the treatment, storage and irrigation facilities.

For the land application of effluent there are two different modes of operation. There is a mode for using only Level IV effluent, and there is a mode for using Level II effluent. The standard mode is for using Level IV effluent, however if the effluent does not meet the requirements for turbidity, and/or chlorine residual for a long period of by-passing to the Emergency Storage Pond then the Level II mode of application will be instituted until Level IV effluent can be consistently produced.

Under the Level IV mode of operation effluent will be applied to a crop grown up to the edge of fencing on the irrigated properties. If the water does not meet turbidity, or Level IV requirements, then it is sent to the Emergency Storage Pond. This is accomplished by a turbidity meter located at the Filtration/Disinfection Building. If the effluent does not meet the Level IV turbidity requirements then the control system shuts a valve to stop discharge to irrigation and the water is routed into the Emergency Storage Pond. The water can then be further treated. Once the water from the Effluent pumps meets Level IV requirements the Irrigation Discharge valve is opened and water is sent to either the Effluent Storage Pond or directly used for irrigation at the on-site/nearby locations.

Under the Level II mode of operation effluent irrigation will be modified so that buffers will be maintained under the Level II DEQ requirements. The surface application of Reclaimed Water shall not be applied closer than 70 feet to any drainage ditch, channel, pond or waterway, or within 200 feet of a domestic water source or well, and 10 feet surface buffer zone to the access roads. A spray buffer of 70 feet shall be maintained from public roads and neighboring property. Irrigation over spray shall be monitored during windy days to ensure the 70 foot buffer is not violated. When wind velocities exceed 15 mph, irrigation shall be stopped or reduced to prevent over spray on public roads and neighboring properties.

The Effluent Pump Main has three discharge locations beyond the valve chamber at the Emergency Storage Pond. 1) Water can discharge through a header to supply water for irrigation to the on-site/nearby locations; 2) Water can discharge for irrigation through a header across an irrigation field on property previously owned by Zemke; and, 3) Water can discharge to the Effluent Storage Pond.

The header for the on-site/nearby irrigation has a pressure reducing valve. It can discharge effluent to Gail Woodworth's property to the south, the City's property to the west, and Doug Kowaleski's property to the northwest. The City also irrigates on site at the treatment facility from this pipe. This provides several irrigation options for the City.

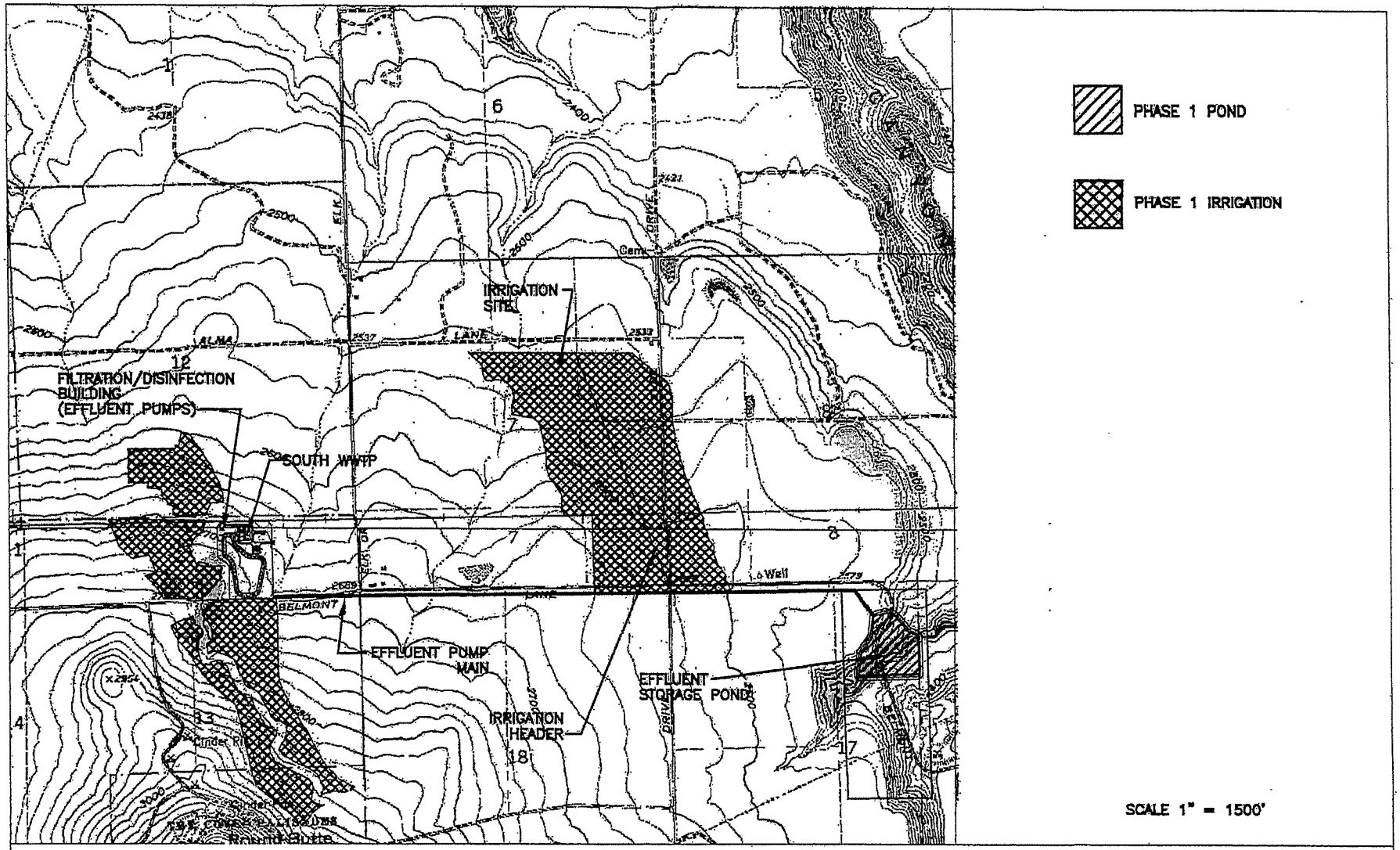
All of the Effluent pipelines and irrigation equipment are installed and operated in accordance

with the *Guidelines for Distribution of Nonpotable Water* published by the California-Nevada section of the AWWA. Above ground elements such as hydrants, valves, and valve boxes are identified with warning labels. All distribution components are constructed to prevent cross-connection with potable water, aquifers, or other water sources.

The effluent irrigation areas are surrounded by barbed-wire fencing. There is signage on the fencing at 500' max spacing saying in English and Spanish "ATTENTION: RECLAIMED WATER USED FOR IRRIGATION -- AVOID CONTACT – DO NOT DRINK. ATENCION: RECLAMADO DESPERDICIO DE AGUA USADO PARA LA IRRIGACION –EVITE EL CONTACTO – NO BEBA EL AGUA."

Copies of the Agreement(s) between the City and the landowner(s) using the water from the SWWTP are included in Appendix A. Similar agreements will be implemented for any other reuse sites not under direct control of the City that may be implemented in the future.

The chlorine residual and turbidity are monitored on a continuous basis. The chlorine residual analyzer is an amperometric type with pH buffering and reagent supply equipment for sample conditioning. The turbidimeter is a flow-through type with 90-degree side-scatter using photocell-sensed, nephelometric measurement. The process control logic associated with the effluent residual□ and turbidity monitoring is described in Section 6, Contingency Options.



ACE Consultants, Inc.

CITY OF MADRAS – WASTEWATER EFFLUENT STORAGE AND SPRAY IRRIGATION

FIGURE 2-1

Section 3 – Irrigation Site Management Information

The City of Madras is providing either Level II or Level IV effluent for the irrigation of farmland located near the SWWTP and on property previously owned by Zemke. Refer to Figure 2-1 for the locations of the storage and irrigation facilities. Refer to Figure 3-1 for the soil classifications in the areas of the storage and irrigation facilities.

The soils to be irrigated in the areas near the SWWTP are classified as an Era sandy loam with a cobbly substratum on 0 to 3% slopes in the Soil Survey of the Upper Deschutes River Area, Oregon by the Natural Resources Conservation Service issued in 1999. These are considered well draining soils suitable for irrigated cropland. Maintaining a cover crop on these soils is considered important since they are subject to wind erosion. Bedrock is typically at a depth of 60 inches, or more. Permeability is classified as moderately rapid. The available water capacity of the soil is about 7 inches.

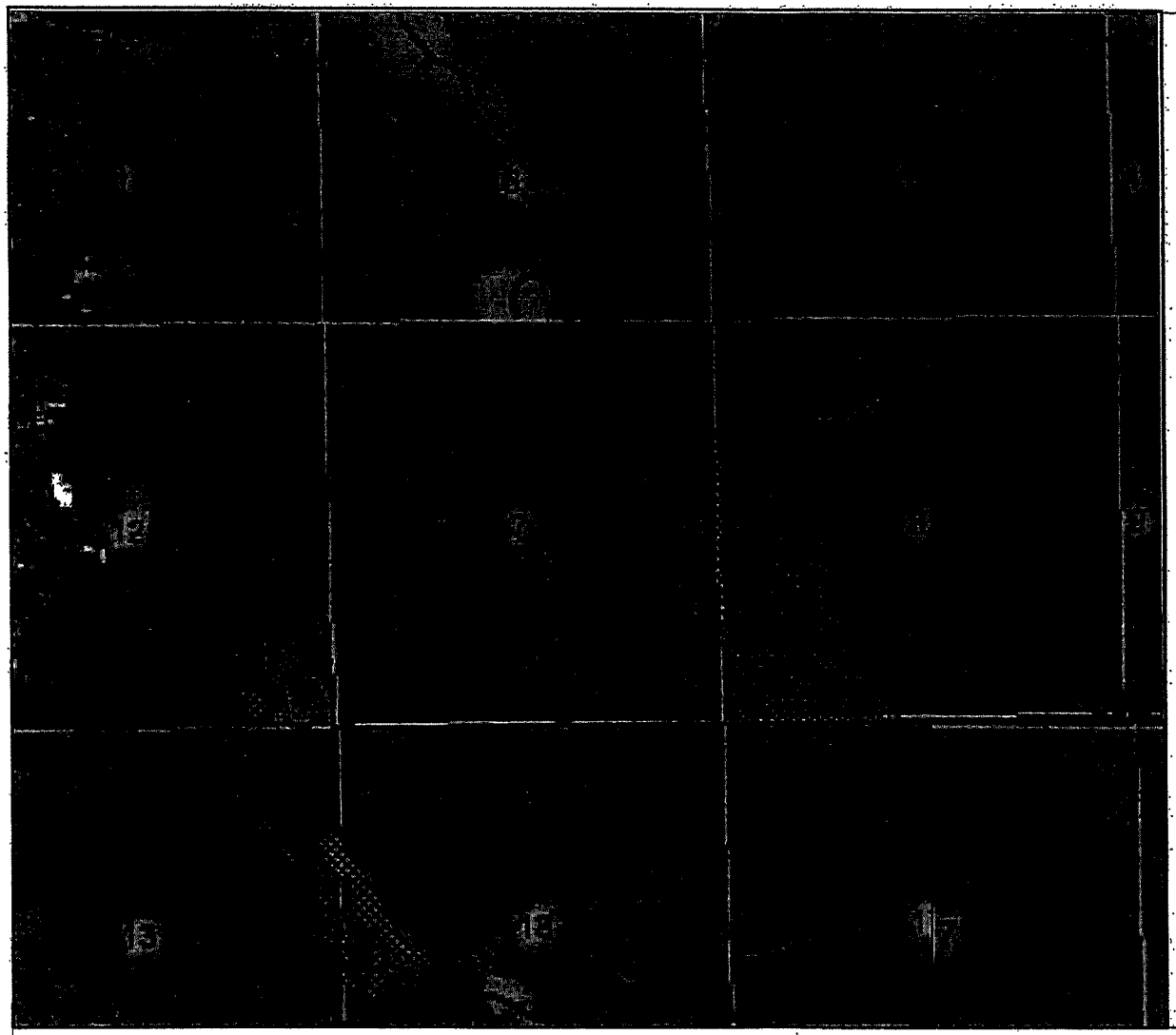
The soils to be irrigated in the area on the property previously owned by Zemke is classified primarily as a Madras sandy loam on 3 to 8% slopes in the Soil Survey of the Upper Deschutes River Area, Oregon by the Natural Resources Conservation Service issued in 1999. These are considered well draining soils suitable for irrigated cropland. Maintaining a cover crop on these soils is considered important since they are subject to wind erosion. Bedrock is typically at a depth of 22 to 40 inches, or more. Permeability is classified as moderately slow. The available water capacity of the soil is about 3.5 inches. Sprinkler irrigation systems are recommended to minimize runoff due to the steepness of slope. To prevent water soluble chemicals from being carried off in the runoff it is recommended that irrigation rates be maintained at rates that prevent overland flow.

The crops that are grown on these properties are turf grass and pasture grass. Other possible crops include alfalfa, oats and irrigated clover-grass pastures. The soils in these locations are well suited for irrigated agriculture and are widely developed with major irrigation projects in the Madras area. These crops will not require ripping for planting. To maintain optimum yields they will require light and frequent irrigation during the drier periods of the year (up to several times per week in July and August). The soil pH is ideal for production of most irrigated crops that are raised in the Madras area, and are well suited for effluent irrigation.

Soil tests were conducted on several of the irrigation sites. The results of the soils test are included in Appendix B. The test results show good pH, organic matter content, soluble salt levels, electrical conductivity and nutrient levels consistent with good agronomic practice. Fertilizer guides for the possible crops to be grown on the areas irrigated with effluent are included in Appendix C. These guides have been developed by the Oregon State University Extension Service. The information they provide is helpful to growers in determining the nutrient requirements for the specific crop being grown. Some nutrients are retained and will accumulate in the soil depending upon the crop that is being grown. The soil will need to be tested to determine fertilizer requirements. The effluent will supply a portion of the nutrients required. Additional nutrients may be required by the crop. Growers are required to keep the total available nitrogen (the primary nutrient) applied equal to that required by the crop. This will prevent leaching of the nutrients into surface or ground water. Flow metering will be used at

the irrigation locations to insure that the correct amount of effluent irrigation water and nutrients are applied to the area for maintaining the crop.

Signs are posted around the effluent disposal sites stating in English and Spanish that reclaimed water is being used for irrigation and is not suitable for drinking. The irrigation sites are controlled to prevent direct public access or contact during irrigation cycles. The storage pond is fenced in using six foot high chain-link fencing. Irrigation is at agronomic rates to prevent ponding and runoff.



PHASE 1 POND

PHASE 1 IRRIGATION

SCALE 1" = 1500'

ACE Consultants, Inc.

CITY OF MADRAS – WASTEWATER EFFLUENT STORAGE AND SPRAY IRRIGATION

FIGURE 3–1

Section 4 – Wastewater Analysis

Table 4-1 lists the amounts of nutrients and growth impacting chemicals in the effluent. This table can be used by farmers to determine the amount of supplemental fertilizer required for their crops. The effluent will be analyzed on an annual basis and provided to those requiring information on the irrigation water constituents. Table 4-1 will be modified to account for changes in the nutrient concentrations.

Upon completion of the wastewater treatment facilities modifications, a sample of the filtered effluent will be analyzed for nutrients. A new table similar to Table 4-1 will be generated for the filtered effluent.

TABLE 4-1

WASTEWATER NUTRIENT LEVELS

Crop Nutrients	Effluent Concentration (mg/l)	Pounds of Nutrients Applied in Irrigation per Acre-Inch of Effluent
TKN	1.72	--
Ammonia Nitrogen	0.063	--
Organic Nitrogen	1.66	--
Nitrate Nitrogen	1.87	--
Available Nitrogen[1]	3.39	0.77
Phosphorus	2.82	0.64
Sulfate	17.9	4.06
Boron	0.288	0.07
Zinc	0.038	0.01
Manganese	0.004	0.0009
Copper	0.084	0.02
Iron	0.024	0.01
Sodium	72.5	16.43
Calcium	13.4	3.04

[1]Available nitrogen is calculated assuming 50% of the ammonia nitrogen is lost to volatilization from sprinkler application. 10% of the organic nitrogen is lost to denitrification/volatilization losses, and there are no nitrate nitrogen application losses.

Section 5 – Wastewater Application Rates

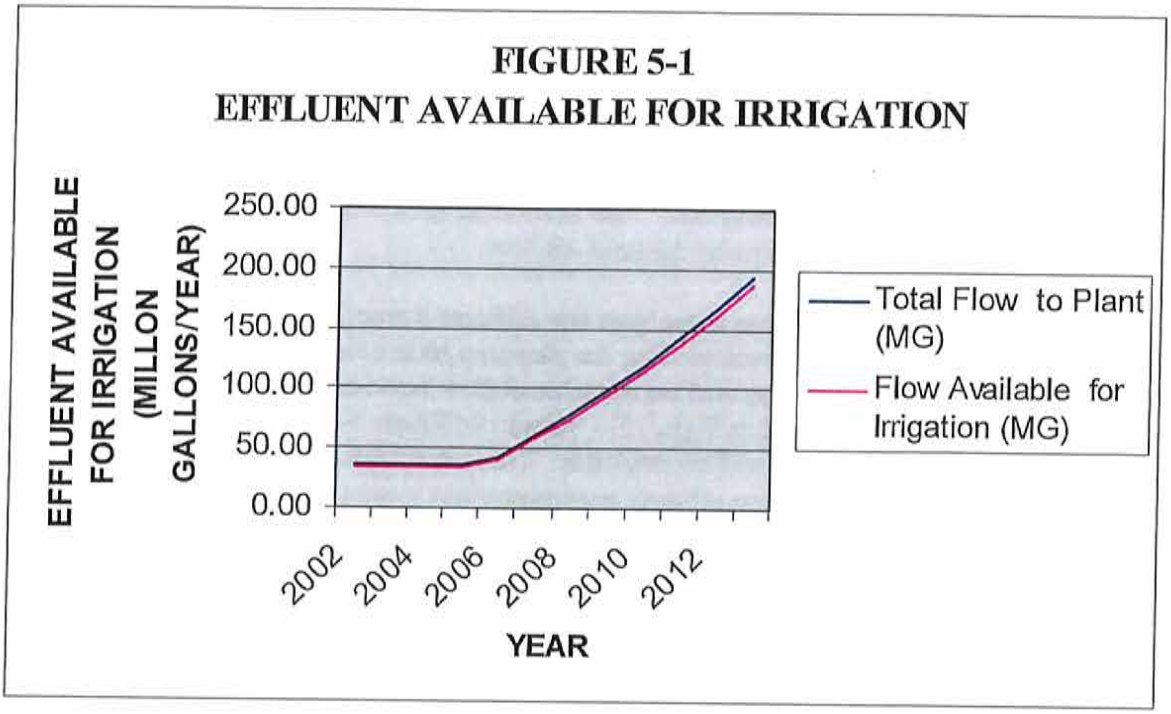
The hydraulic and nutrient loading rates were examined to determine which factor controlled the wastewater application rates. Based on the quality data for the City's wastewater effluent and the soil information acquired for the irrigation sites, the application rates for wastewater reuse are controlled by the hydraulic loading rate. This is because the nitrogen and other nutrient levels in the wastewater and in the receiving soils are low.

Based upon the information available at the time this Effluent Reuse Plan was put together a revised projection of flows were developed for the planning period through 2022. The flow information for the collection system and the division of flow between the North and South WWTP are shown in Table 5-1 and in Figure 5-1 below. In Figure 5-1 the lower curve shows the amount of irrigation water that will be available. This curve takes into account the impact yearly rainfall and evaporation on the effluent wastewater that is stored.

TABLE 5-1 WASTEWATER INFLUENT FLOW PROJECTION (GPD)

Year	Total Flow in System	Flow to North WWTP	Flow to South WWTP
2002	460,000	360,000	100,000
2003	495,000	395,000	100,000
2004	533,000	432,825	100,000
2005	573,000	473,454	100,000
2006	617,000	500,000	117,000
2007	664,000	500,000	164,000
2008	715,000	500,000	215,000
2009	769,000	500,000	269,000
2010	828,000	500,000	328,000
2011	891,000	500,000	391,000
2012	959,000	500,000	459,000
2013	1,030,000	500,000	530,000
2014	1,110,000	500,000	610,000
2015	1,200,000	500,000	700,000
2016	1,290,000	500,000	790,000
2017	1,390,000	500,000	890,000
2018	1,490,000	500,000	990,000
2019	1,600,000	500,000	1,100,000
2020	1,730,000	500,000	1,230,000
2021	1,860,000	500,000	1,360,000
2022	2,000,000	500,000	1,500,000

FIGURE 5-1
EFFLUENT AVAILABLE FOR IRRIGATION



The water balance to determine the sizing of the Effluent Storage Pond is shown in Table 5-2. This table is based upon a scenario that puts together a year with the maximum precipitation and the minimum evaporation. The rainfall information was based upon the maximum rainfall for a full year of data available from 1913 to the 2002 from the Oregon Climate Service's station in Madras. The minimum evaporation data is based upon the evaporation data for a full year of data available from 1987 to the 2002 from the North Unit Irrigation District's station in Madras. Based upon design flows the Phase 1 SWWTP and these criteria the Effluent Storage Pond was sized to hold 84 million gallons of the effluent wastewater.

Table 5-3 lists the crop water requirement (ETcorp), net irrigation required and recommended gross irrigation required based on a 5 out of 10-year probability. These values are based upon field testing and formulas developed in Extension Service publication Oregon Crop Water Use and Irrigation Requirements, Reprinted in March 1999 and some irrigation efficiency assumptions to develop the gross irrigation requirements. The probability for the crop water requirements and the net irrigation requirements represent recommended rates based on an averaging of precipitation and temperature for the period. Gross irrigation rates were developed for the crops under consideration to determine the maximum acreage required for growing various crops. An irrigation efficiency of 80 percent for field crops and 85 percent for turf grass was used to develop the gross application rates (irrigation required) for 5 out of 10-year and 19 out of 20-year irrigation requirements (Table 5-4). The 19 out of 20-year requirement is being considered as the design maximum application rate for a dry year period based on a 19 out of 20-year probability.

From these gross irrigation rates for the crops under consideration in Table 5-5 the amount of acreage required to grow these crops at the present flows (100,000 gpd) in 2002 and the design

flow (500,000 gpd) projected to occur in the year 2012 were calculated. Table 5-6 was developed to investigate the nitrogen requirements of the crops under consideration to see how they would compare to the maximum hydraulic loading (and therefore maximum nitrogen loading from the wastewater effluent). In all cases except alfalfa application of commercial fertilizer containing nitrogen is required. The recommendations for the amount of nitrogen required (Lbs-N/Acre) for the crops were obtained from the fertilizer guides published by the Oregon State University Extension Service (see Appendix C). These values are only provided for reference. Actual applications will require on-going soil analysis for available nutrients at the individual irrigation/crop sites. The guides also recommend applications during certain periods of the year or growing season to provide for optimal growth and yields. Fertilizers containing other important nutrients may be required based on soil analysis.

The areas available for irrigation during Phase 1 are listed below in Table 5-7. The total acreage available is more than enough for this period (compare with acreage requirements in Table 5-5). The water users also have water rights to water from the North Unit Irrigation Unit so that a back-up supply of water is obtainable for crops when effluent is not available. The acreage will need to be managed in a way that allows for the expansion of the growing area from the present requirements out to the design flow for the facilities.

TABLE 5-7
PHASE 1B PROPERTIES AVAILABLE FOR IRRIGATION

PROPERTY DESCRIPTION	ACRES AVAILABLE FOR IRRIGATION
Gail Woodworth	76
Doug Kowaleski/City	22
City Lease Property	28
Property Previously owned by Zemke	196
TOTAL	**322**

Section 6 – Contingency Options

In the event of an irrigation system breakdown or a treatment facility upset there are several contingency options that can be implemented. As mentioned in Section 2 there are two modes of operation for the application of effluent. The standard mode is based upon supplying Level IV effluent. In this mode the effluent is monitored for turbidity and sent to the Emergency Storage Pond if it does not meet the Level IV turbidity requirement. The on-site Emergency Storage Pond is capable of holding one-quarter of the Phase 1 winter design flow. There is a valve chamber located on the Effluent Pump Main. The system logic is designed so that if either the monitored turbidity goes too high, or the chlorine residual goes too low that the flow will be sent to the Emergency Storage Pond. From here the effluent can be sent back through the treatment process. The effluent water can be routed to the Emergency Storage Pond until the process or equipment failure has been properly addressed. If the problem requiring by-passing proves persistent (filling up most of the Emergency Storage Pond) the back-up contingency mode is to irrigate to Level II effluent requirements until the condition and the effluent produced has been disposed. The irrigation sites are fenced, signed and controlled as if for Level II Reclaimed Water application. To convert to Level II requirements means not using effluent for irrigation within the required buffer limitations. These buffer areas can either be irrigated with water from the North Unit Irrigation Water Rights, or shall not receive water at all.

In the case of an irrigation distribution system failure, there is valving that can be used to manually route the flow to the either the Effluent Storage Pond or to the Emergency Storage Pond. The location will be dependent upon the nature of the equipment problem. The effluent water can be routed to the storage location used until the failure has been repaired.
Any overpressure problems in the Effluent Pump Main will also cause the Effluent wastewater to be discharged to the Emergency Storage Pond. There is a pressure relief valve on the Effluent Pump Main. Once the pressure in the line reaches the setpoint of this valve (i.e. if a valve is suddenly closed) the flow will be directed to the Emergency Storage Pond.

The Emergency Storage Pond is connected by valving to the Post-Equalization Basin prior to the Filtration/disinfection Building. In case of any type of process upset the flow can be diverted to it until the problem has been resolved. Then the stored water can be bled back into the system using the valving to direct it to either chemical coagulation and filtering, or through the Plant Drain back to the head of the SBR process for treatment.

The SWWTP is provided with a SCADA system that is monitored around the clock. Any system related alarms are relayed to an on-call operator who can take the appropriate steps for routing the flows within the system as described above.

Section 7 – Recordkeeping

In accordance with DEQ requirements the City will provide wastewater quality analyses on a monthly basis, maintain a log of wastewater applications, monitor total coliform on a daily basis and monitor turbidity on an hourly basis. The City shall submit an annual report describing the system's effectiveness in complying with the reuse plan, DEQ rules, permit limits and conditions.

A wastewater application record will be kept as a permanent running record of wastewater volume, application rates, dates of application and accumulated application for each irrigation area. Figure 7-1 shows a sample Wastewater Application Record Form. Daily records shall also be kept on a daily field grid map (log) or other easily readable system to keep track of where the effluent is applied.

These records shall be kept current in order to provide an accurate record of application rates and to determine when the total limit on accumulated wastewater application is reached for each irrigation area. A totalizing flowmeter is installed on both the Effluent Pumps and the irrigation pump discharge to accurately measure effluent discharges for irrigation.

A wastewater monitoring record is maintained for the irrigation system. Figure 7-2 shows a sample of a Wastewater Monitoring Record Form. The total coliform count is recorded on a daily basis. The turbidity is monitored on a continuous basis (hourly requirement) with a turbidimeter. The data is recorded on the plant computer as part of the SCADA system. The 24-hour mean turbidity is recorded on the wastewater monitoring record on a daily basis.

CITY OF MADRAS
WASTEWATER APPLICATION RECORD

Location of Irrigation: _____

Crop Type: _____ Irrigation Required: _____

Date	Volume (gallons)	Area Covered (acres)	Irrigation Amount (inches)	Cumulative Irrigation Amount (inches)

FIGURE 7-1

CITY OF MADRAS
WASTEWATER MONITORING RECORD

Date	Total Coliform (organisms per 100 ml)	Turbidity 24-Hour Mean (NTU)

FIGURE 7-2

APPENDIX A

RECLAIMED WATER AGREEMENT

EFFLUENT DELIVERY AGREEMENT

COPY

Parties:

"City" **CITY OF MADRAS,** an Oregon municipality

"Irrigator" **GAIL WOODWORTH**

RECITALS

WHEREAS, Irrigator desires to receive such amounts of effluent from City as may be available from City's South Wastewater Treatment Facility and City desires to provide such effluent from said south plant as may be available to Irrigator.

NOW, THEREFORE, the parties hereby agree as follows:

1. **Supply of Effluent.**

City agrees to supply such amounts of effluent to Irrigator, as City, in its sole and absolute discretion, decides to deliver to a pipe hook-up point on Irrigator's property as described on Exhibit "A" (the "Delivery Point"). Irrigator agrees to immediately use all effluent delivered to the Delivery Point as provided in article 3.

2. **No Guarantee.**

City makes no guarantee as to the quantity or grade of effluent delivered. In addition, City makes no guarantee or representation as to the pressure of the effluent arriving at the Delivery Point. Such pressure may vary from time to time and Irrigator shall make use of the effluent provided under this Agreement notwithstanding quantity, quality or pressure. IRRIGATOR ACCEPTS THE EFFLUENT "AS IS" WITHOUT WARRANTY, EITHER EXPRESSED OR IMPLIED, AND THE CITY MAKES NO WARRANTY OR REPRESENTATION WHATSOEVER AS TO THE MERCHANTABILITY, FITNESS FOR ANY PARTICULAR PURPOSE, QUALITY, CONDITION OR SUITABILITY OF THE EFFLUENT IN ANY RESPECT.

3. **Use; Compliance With Law.**

Irrigator shall use all effluent delivered by City for irrigation purposes only. Irrigator shall comply with all applicable state and federal laws, rules and regulations regarding the use of the effluent, including but not limited to the observance of all laws, rules and regulations designed for the protection of Willow Creek. The foregoing shall apply to all laws, rules and regulations in existence at the commencement of this Agreement and as may be amended or created during the term hereof.

4. **No Assignment.**

Neither Irrigators rights under this Agreement nor the effluent provided under this Agreement may be transferred, assigned, or otherwise conveyed to any third party without City's written consent, which consent may be withheld or denied in City's sole and absolute discretion.

5. **Term.**

The term of this Agreement shall commence upon its execution and terminate on October 15, 2002, unless sooner terminated as provided hereafter.

6. **Default.**

If Irrigator fails to observe or perform any obligation or covenant under this Agreement then City may terminate this Agreement and pursue any other remedy at law or equity available to the City.

7. **No Investment Representation.**

Irrigator has agreed to accept the effluent on the basis of Irrigator's evaluation of its value and acknowledges that City has made no warranty or representation as to any profit or other return which may be made from the effluent's use.

8. **Waiver**

The failure by either party at any time to require strict performance of any provision of this Agreement shall not be a waiver of or prejudice the right to subsequently enforce that provision or any other provision of this Agreement.

9. **Attorney Fees.**

If any dispute arises in connection with (a) the interpretation or enforcement of this Agreement or (b) any issues related to the U.S. Bankruptcy Code (whether or not such issues relate to the terms of this Agreement), the prevailing party in any dispute will be entitled to recover all of its attorney fees, paralegal fees, costs, disbursements, and other expenses from the nonprevailing party, including without limitation those arising before and at any trial, arbitration, bankruptcy, or other proceeding, and in any appeal.

10. **Integration of Documents.**

This Agreement is the final and complete agreement of the parties. There are no promises, terms, conditions or obligations other than those contained in this Agreement. All prior and contemporaneous negotiations and agreements between parties, verbal and written, are replaced by this agreement and are of no further force or effect.

11. Indemnity and Insurance.

Irrigator shall defend, indemnify and hold City harmless from and against any and all claims, costs, expenses, damages and liabilities, including reasonable attorney fees, rising out of or related to Irrigator's use of the effluent. Irrigator shall procure and thereafter during the term of this agreement shall continue to carry the following insurance at Irrigator's cost: A commercial general liability policy (occurrence version) in a responsible company with coverage for bodily injury and property damage liability, personal and advertising injury liability, and medical payment with a general aggregate limit of not less than $1,000,000 and a per occurrence limit of not less than $1,000,000. Such insurance shall cover all risks arising directly or indirectly out of Irrigator's activities under this Agreement. Such insurance shall protect Irrigator against the claims of City on account of the obligations assumed by Irrigator under this Section 11, and shall name City as an additional insured. Certificates evidencing such insurance and bearing endorsements requiring ten days' written notice to City prior to any change or cancellation shall be furnished to City prior to commencement of this Agreement.

12. Entry for Inspection.

City shall be allowed to inspect Irrigator's plumbing, storage or such other facilities and/or equipment as may be relevant to the use of the effluent to assure compliance with any law or rule, regulation and/or this Agreement.

13. Modifications.

This Agreement may not be modified except in a writing signed and dated by the parties.

"City"

By _____
Richard L. Allen
Its Mayor

Dated: April 12, 2002

"Irrigator" Gold Workers

Dated: 13 Mar 02

APPENDIX B

RESULTS OF SOILS TESTS

soiltest farm consultants, inc.

2925 WAPATO DRIVE (Exit 176, I-90) MOSES LAKE, WASHINGTON 98837
(509) 765-1622 1-800-764-1622 FAX (509) 765-0314

CITY OF MADRAS
800 SE GRIZZLY DR
MADRAS, OR 97741

INVOICE # 9705-01
DATE RECEIVED - 07/05/02
GROWER - DK
FIELD -

SOIL TEST RESULTS

NITRATE NITROGEN	ppm	16	pH		7.6
	lbs/acre	52	ORGANIC MATTER	%	2.2
AMMONIUM NITROGEN	ppm	2.0	SOLUBLE SALTS	m.mhos/cm	1.0
	lbs/acre	7			
PHOSPHORUS	ppm	21			
POTASSIUM	ppm	385			
BORON	ppm	0.7			
ZINC	ppm	1.0			
SODIUM	meq/100g	0.4			
CEC	meq/100g	21.0			
SUM OF TESTED NITROGEN	lbs/acre	59			

list price 43.25

soiltest farm consultants, inc.

2925 WAPATO DRIVE (Exit 176, I-90) MOSES LAKE, WASHINGTON 98837
(509) 765-1622 1-800-764-1622 FAX (509) 765-0314

CITY OF MADRAS
800 SE GRIZZLY DR
MADRAS, OR 97741

INVOICE # 9704-01
DATE RECEIVED - 07/05/02
GROWER - COM
FIELD -

SOIL TEST RESULTS

NITRATE NITROGEN	ppm	32	pH		7.7
	lbs/acre	105	ORGANIC MATTER	%	2.0
AMMONIUM NITROGEN	ppm	3.0	SOLUBLE SALTS	m.mhos/cm	1.5
	lbs/acre	10			
PHOSPHORUS	ppm	56			
POTASSIUM	ppm	668			
BORON	ppm	0.8			
ZINC	ppm	1.7			
SODIUM	meq/100g	1.3			
CEC	meq/100g	19.7			

SUM OF TESTED NITROGEN lbs/acre 115

list price 43.25

soiltest farm consultants, inc.

2925 WAPATO DRIVE (Exit 178, I-90) MOSES LAKE, WASHINGTON 98837
(509) 765-1622 1-800-764-1622 FAX (509) 765-0314

CITY OF MADRAS
800 SE GRIZZLY DR
MADRAS, OR 97741

INVOICE # 9703-01
DATE RECEIVED - 07/06/02
GROWER - GW
FIELD -

SOIL TEST RESULTS

NITRATE NITROGEN	ppm	17	pH		7.4
	lbs/acre	28	ORGANIC MATTER	%	1.5
AMMONIUM NITROGEN	ppm	5.0	SOLUBLE SALTS	m.mhos/cm	1.0
	lbs/acre	8			
PHOSPHORUS	ppm	21			
POTASSIUM	ppm	332			
BORON	ppm	0.5			
ZINC	ppm	1.4			
SODIUM	meq/100g	0.4			
CEC	meq/100g	16.2			
SUM OF TESTED NITROGEN	lbs/acre	36			

list price 43.25

Oregon
John A. Kitzhaber, M.D., Governor

Department of Environmental Quality
2146 NE 4th Street, Suite 104
Bend, OR 97701
(541) 388-6146
Eastern Region
Bend Office

October 18, 2002

Craig Johns, Public Works Director
City of Madras
216 NW B Street
Madras, OR 97741

Re: City of Madras Proposed Reuse Site

Dear Mr. Johns:

On September 25, 2002, Tom Hall and I conducted a site evaluation for the new proposed reuse site for the City of Madras. Four soil test pits were dug and the soils were characterized. Based upon this preliminary inspection, the Department feels that the proposed location for the application of treated effluent is satisfactory. As discussed, the Department will comment on your draft Reclaimed Water Use Plan submitted on July 17, 2002, as soon as possible. The City will then need to finalize the plan including information on the new reuse site for final Department approval before irrigation can begin. Please find enclosed a copy of the soils evaluation.

If you have any questions please contact me at 541-388-6146, extension 244.

Sincerely,

Jayne West
Water Quality Section
Eastern Region Bend

Encl: Soils Evaluation

July 9, 2001

to: file

from: Tom Hall

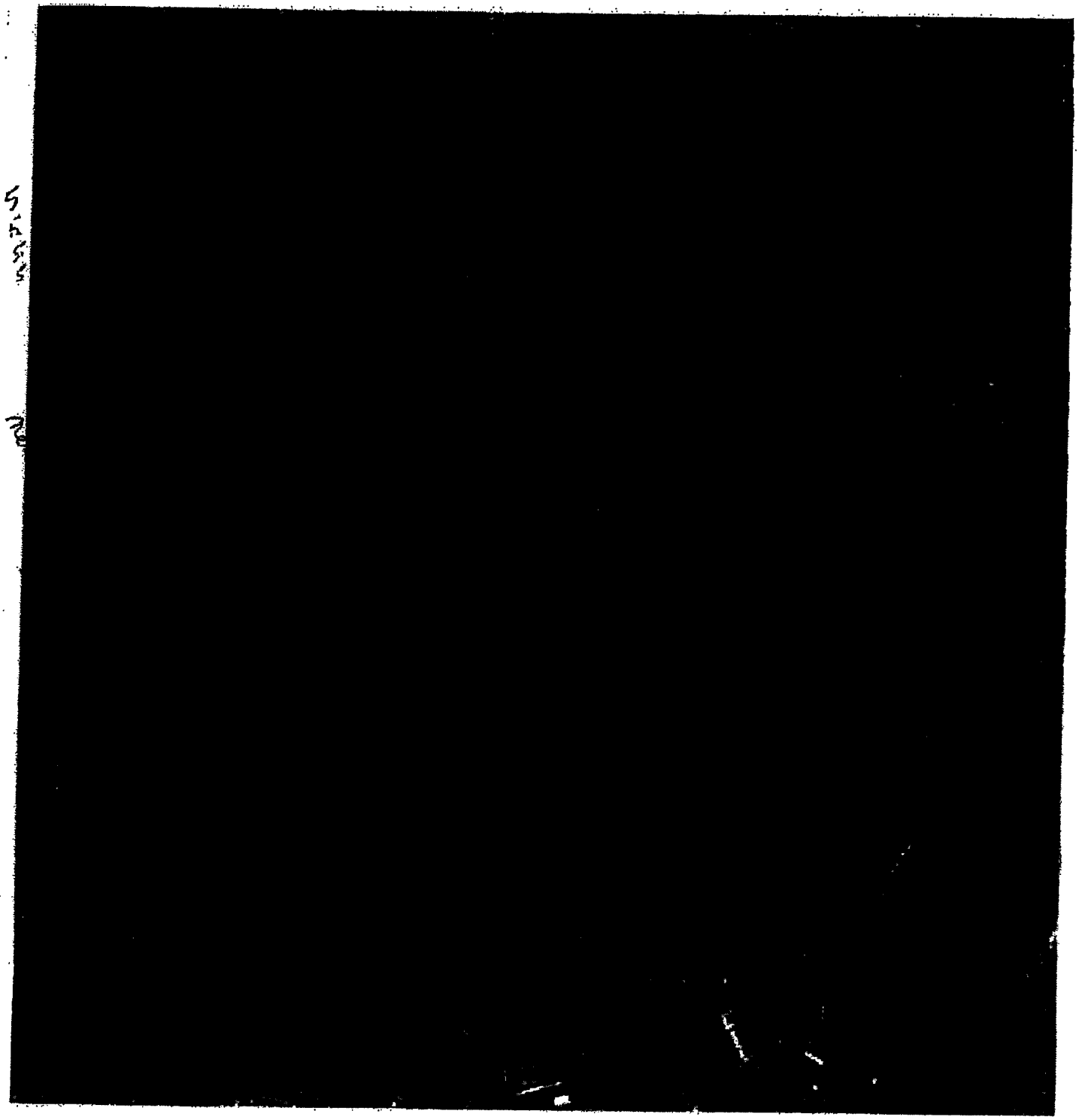
subject: Soil evaluation - Madras Irrigation sites

On June 19, 2001, we examined a test pit in each of the proposed effluent irrigation sites for the new Madras sewage treatment facility.

The pit in the Woodworth field revealed a sandy loam surface soil to a depth of about 19 inches. The subsoil has a loam texture to the bottom of the pit at about 44 inches. The upper 6 inches of the subsoil was weakly cemented. There was root penetration to the bottom of the pit.

The pit on the City property west of the new treatment facility revealed a soil with a loam texture to about 36 inches. The layer below that was gravelly sand to the bottom of the pit at 42 inches.

Both sites are essentially flat and are suitable for effluent irrigation.



@ 10th Piece
6" bonded wood
[illegible] Valve
between [illegible]
20 + [illegible]

APPENDIX C

FERTILIZER GUIDES

FERTILIZERguide
FG 21
Reprinted January 2000

Irrigated clover–grass pastures

Eastern Oregon—east of Cascades

E.H. Gardner, D.B. Hannaway, and W.S. McGuire

This guide to fertilization is intended for pastures consisting of white clover in combination with orchardgrass or tall fescue. The optimum response of irrigated pasture to fertilization depends on good management.

The following management factors are important:

1. Maintenance of a good stand of adapted, improved clovers and grass with estimated 30 to 50 percent clover. Fifty percent or more clover might cause a bloat problem and require extra care in grazing.
2. Adequate irrigation without over-irrigation.
3. Harvesting at 5–8 inches using rotation grazing or green chop. Green chop management results in more rapid depletion of soil fertility than grazing.
4. Close grazing to 2 inches favors white clover, and light grazing to 4 inches or higher favors the grass.
5. Well-fertilized grass will outgrow clover in the fall. Excessive grass growth could result in smothering the clover. Either grazing or clipping will reduce the problem.
6. Avoid soil compaction by eliminating grazing when the surface soil is saturated with water.
7. Inoculate clover seed with the correct strain of fresh inoculum immediately prior to seeding.
8. Retest the soil and adjust fertilizer applications at least every 2 years.

Follow recommended soil sampling procedures in order to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, soil sample bags, and information sheets.

Nitrogen (N)

N fertilizer favors the growth of grass over that of clover. Excessive fertilization with N can result in a decrease in the clover stand.

Clover-grass pastures

For new seedings, an application of 40 lb N/a is suggested where adequate available N is not present in the soil. Where the presence of residual available N in the soil is suspected because of heavy N fertilization the previous year or from a previous legume crop, a soil test for N is useful in determining the N fertilizer requirement.

If the nitrate-N level in the soil exceeds 7 ppm in the surface foot, N fertilization should not be necessary. N fertilization of new seedings usually is not practiced in northeast Oregon.

For established stands, an application of 30–40 lb N/a in the spring will stimulate the grass and provide early feed. Single applications of N should not exceed 40 lb/a.

If the clover stand is adequate, summer N applications seldom pay. In some lower altitude areas, an application of 30–40 lb N/a in late August will stimulate grass growth and may provide additional fall grazing.

Pure grass

Productive irrigated pure grass pastures require 125–300 lb N/a each year. N should be applied in two or three equal applications in early spring and about June 1 and August 1. The higher rates of application are suggested for lower altitude, longer growing-season areas such as Ontario and Hermiston.

Phosphorus (P)

The need for P fertilizer can be estimated using a soil test (Table 1). Adequate fertilization with P is particularly important to the maintenance of a good stand of clover.

Table 1.—P fertilization rates for irrigated clover.

If the soil test for P is (ppm)	Apply this amount of phosphate (P_2O_5) (lb/a)
0–5	60–80
6–10	40–60
over 10	0

Broadcast P in fall or early spring on established pasture.

If possible, band phosphate 1/2–1 inch to the side or below seed when seeding. Some soil should separate the seed from the fertilizer.

OREGON STATE UNIVERSITY
EXTENSION SERVICE

E. Hugh Gardner, Extension soil scientist emeritus; David B. Hannaway, Extension agronomist; and W.S. McGuire, professor emeritus of agronomy; Oregon State University.

Potassium (K)

An adequate level of available K is essential to the optimum growth of clover–grass pastures. K is particularly important to the growth of clover. Grass competes vigorously with clover in the uptake of K.

Most of the soils in eastern Oregon contain adequate amounts of K for pasture production. The need for K fertilization can be determined by a soil test (Table 2).

High-producing pasture can cause rapid depletion of soil K, particularly when pastures are not grazed. Test soils frequently to determine available K levels.

K can be supplied most effectively by working it into the seedbed prior to planting. On established stands, apply K in the fall or early spring.

Table 2.—K fertilization rates for irrigated clover.

If the soil test for K is (ppm)	Apply this amount of potash (K_2O) (lb/a)
0–100	100–120
75–150	50–100
over 150	0

In central Oregon, a response to K fertilizer may be obtained when the soil test value exceeds 150 ppm.

Sulfur (S)

S requirements vary with soil texture, leaching losses, and the soil parent material. Soils developed on pumice in central Oregon have a particularly high S requirement. In some cases, irrigation water contains appreciable amounts of S.

1. In central Oregon, when sulfate is used, 60–80 lb S/a should be applied annually on the coarse sandy loam and loamy sand soils; 30–50 lb S/a should be applied annually on the silt loam and finer textured soils. When elemental S is used, the rate of application can be reduced to 20 lb/a on central Oregon soils.
2. In north-central, south-central, and northeast Oregon, 15–25 lb S/a should be applied on an annual basis. Two years' needs for S can be provided by applying double the recommended annual rate.
3. S response has not been measured on some soils, such as the river-bottom soils in Crook County, and in Malheur and Harney Counties when irrigation water contains S.
4. Apply S in the fall or early spring.
5. When elemental S is used as the S fertilizer, applying 30–40 lb S/a every second year is sufficient. Elemental S used as S fertilizer should be finely ground so that all will pass through a 32-mesh sieve and most will pass through a 60-mesh sieve.
6. As elemental S gives a slow response, it is not recommended for application to pastures where S deficiency symptoms are apparent. In this case, use the more rapidly available sulfate form of S.
7. S frequently is applied as a component of fertilizer materials such as single super phosphate, ammonium sulfate, and 16-20-0.
8. Much of the irrigation water contains appreciable amounts of S, which can be utilized by plants. Water containing 1 ppm S would supply 2.70 lb S/a for each foot of water applied. Growers should have their irrigation water analyzed for S content.

A soil test will provide information about the need for S fertilizer. It is recommended that soil samples for sulfate (SO_4) analysis be taken to a depth of 24 inches. Based on a 0- to 24-inch soil sample, the soil test value (ppm) is multiplied by a factor of 8 to convert to lb of SO_4-S/a. Thus a soil test value of 6 ppm SO_4-S for a 0- to 24-inch soil sample would equal 48 lb of SO_4-S/a.

S fertilizer probably is not required if the soil test for SO_4-S exceeds 3 ppm.

Boron (B)

Boron deficiencies are not common in irrigated pastures in eastern Oregon. If the soil test value for B is below 0.4 ppm, an application of 2–4 lb B/a could be applied on a trial basis.

As B can be toxic to plants, the recommended application rate should not be exceeded, and B should be uniformly applied and not banded.

Magnesium (Mg)

Yield responses of pastures to applications of Mg have not been observed in eastern Oregon. Mg is important in animal nutrition. Low levels of Mg in forage have been related to grass tetany.

Other Micronutrients

Economic responses of pastures from the application of micronutrients, except possibly B, have not been observed in eastern Oregon.

Lime

Responses to lime have not been measured in experiments with irrigated pasture in eastern Oregon. In some fields, surface soil values below pH 6.0 cause some concern about the need for lime, particularly in central Oregon.

Before liming, test soil samples, including subsoil samples (8- to 20-inch depth). In many cases, the subsoil is more basic, and the acid reaction in the surface soil can be corrected by deep plowing.

For the satisfactory growth of white clover, the pH of the soil should exceed 5.6. Where the soil pH is below 5.6 and this condition cannot be corrected by deep plowing, the following liming rates are suggested (Table 3).

Table 3.—Lime application rates for irrigated clover.

	Apply this amount of lime (t/a)	
If the soil pH is	**Sandy soils**	**Silt/clay loam soils**
under 5.0	1–1½	2–3
5.0–5.6	1	1–2
over 5.6	0	0

For More Information

How to Take a Soil Sample ... and Why, EC 628, by E.H. Gardner (revised 1997). No charge.

A List of Analytical Laboratories Serving Oregon, EM 8677, by J. Hart (revised 1997). No charge.

To order copies of the above publications, send the complete title and series number, along with a check or money order for the amount listed (payable to Oregon State University), to:

Publication Orders
Extension & Station Communications
Oregon State University
422 Kerr Administration
Corvallis, OR 97331-2119
Fax: 541-737-0817

You may order up to six no-charge publications without charge. If you request seven or more no-charge publications, include 25 cents for each publication beyond six.

World Wide Web

Fertilizer and Lime Materials, FG 52, by J. Hart (reprinted 1997). No charge.

You can access the above publications, as well as FG 21, *Irrigated Clover–Grass Pastures: Eastern Oregon—East of Cascades*, our Publications and Videos catalog, and many other publications via our Web site at **eesc.orst.edu**

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Revised May 1983. Reprinted January 2000.

FERTILIZERguide
FG 22
Reprinted January 2000

Native meadows

Eastern Oregon—east of Cascades

E.H. Gardner

Native meadows produce a significant portion of the hay used for winter feed in eastern Oregon. Without fertilization, an average meadow will yield approximately 1 ton of hay per acre. With proper fertilization, yields often can be increased by 2 to 3 tons, and hay quality such as protein content is improved. Native meadows fall into three broad classifications: (1) Nevada bluegrass, (2) rush-sedge-grass, and (3) rush.

Nevada bluegrass meadows respond to applications of nitrogen. Rush-sedge-grass meadows respond to a combination of nitrogen, phosphorus, and sulfur. Rush (wire grass) meadows usually are flooded for long periods and do not respond to fertilization.

Fertilized meadows usually reach optimum hay stage earlier than unfertilized meadows. Quality and protein content of early cut hay is greater than later cut hay.

Nitrogen (N)

Nitrogen is the most limiting fertilizer element in meadow hay production. In addition to increasing yield, the application of N improves hay quality such as protein content.

1. An annual application of 60–80 lb N/a has given the greatest economic return. Where a good stand of legume such as white tip clover is present, N rates may be reduced by as much as 50 percent.
2. Rates of N as high as 150 lb/a gave some increases in yield but did not give as high a return for money expended.
3. Apply nitrogen annually in late fall or early spring. The residual effect of N the year following application is small.

Phosphorus (P)

Phosphorus applied in combination with N has given increased yields on native meadows that contain a legume such as white tip clover. It also is possible, by careful fertilization and management, to increase the amount of legume in the stand, resulting in better quality hay. Nitrogen fertilizer increases the growth of grass, which competes with the legume. As indicated in the section on N, the rate of N application may be reduced when legumes are present. Soil tests have proved fairly accurate for predicting P response on native meadows. See Table 1.

Table 1.—P fertilization rates for native meadows.

If the soil test for P is (ppm)	Apply this amount of phosphate (P_2O_5) (lb/a)
0–5	60–80
5–10	40–60
over 10	0

Apply phosphorus in the late fall or early spring.

Sulfur (S)

Sulfur applications of 20–30 lb/a have stimulated legume growth in meadows in all areas except Harney County and a portion of Grant County.

Sulfur fertilizers contain S as sulfate or elemental S. Since plants absorb S as sulfate, this form is immediately available to plants. Elemental S must oxidize to sulfate in order to be available to plants.

Where S is deficient, apply sulfate annually at 20–30 lb S/a. Fine-ground (less than 40-mesh) elemental S can be applied every second year at 40–50 lb S/a.

Coarser forms of elemental S such as "popcorn" S oxidize more slowly and should be applied less frequently but at higher rates such as 100 lb S/a every 5 or 6 years.

Sulfur often is provided by other fertilizer materials used to supply N and/or P such as ammonium sulfate or ammonium phosphate sulfate (16-20-0-15). Gypsum is another source of sulfate.

Other Nutrients and Amendments

Applications of other nutrients such as potassium and magnesium and amendments such as lime have not increased yields or quality of hay on native meadows. Likewise, micronutrients such as boron and zinc have not improved hay crops.

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Hugh Gardner, Extension soil scientist emeritus, Oregon State University.

For More Information

How to Take a Soil Sample ... and Why, EC 628, by E.H. Gardner (revised 1997). No charge.

A List of Analytical Laboratories Serving Oregon, EM 8677, by J. Hart (revised 1997). No charge.

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You can access the above publications, as well as FG 22, *Native Meadows: Eastern Oregon—East of Cascades*, our Publications and Videos catalog, and many other publications via our Web site at **eesc.orst.edu**

This fertilizer guide is based on experiments and field trials conducted by C.B. Rumburg and C.S. Cooper, U.S. Dept. of Agriculture, and R.O. Peterson, Oregon State University.

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Irrigated spring-planted small grains—mineral soils

Eastern Oregon—east of Cascades

E.H. Gardner, T.L. Jackson, B.G. Wilcox, R. Todd, L. Fitch, M. Johnson, and V. Pumphrey

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include adequate irrigation, use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seedbed preparation, proper seeding methods, and timely harvest. Follow recommended soil sampling and testing procedures to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, sampler bags, and information sheets.

Note: For fertilizer suggestions for irrigated spring-planted small grains on peat and muck soils in Klamath County, see OSU Extension publication FG 70, *Irrigated Spring-Planted Small Grains—Peat and Muck Soils (Klamath and Lake Counties).*

Nitrogen (N)

Irrigated grain requires a good supply of available N; however, excessive rates of N can reduce grain quality and increase the risk of lodging. An optimum response to N fertilization depends on adequate irrigation. The N applications suggested in this guide are based on the maintenance of good soil moisture throughout the growing season.

Of the suggested N application, at least one-fourth of the N should be applied before or at planting time. The urea or diammonium phosphate forms of N may cause seedling injury if banded close to the seed at planting. The remainder of the N should be plowed down, injected, or applied through the sprinkler system.

The amount of N fertilizer required depends on the following factors: the preceding crop, the N carryover from the previous crop, the amount and type of residue to be plowed under, and possible leaching losses due to overirrigation.

The following recommendations are for mineral soils. For muck soils in Klamath County, see OSU Extension publication FG 70, *Irrigated Spring-Planted Small Grains—Peat and Muck Soils (Klamath and Lake Counties).*

N fertilizer rates based on soil test

The amount of residual N in the soil varies considerably.

A soil test for nitrate-N (NO_3-N) helps in evaluating the N carryover from the previous crops in the case of mineral soils with low organic matter content.

Nitrogen soil tests are not recommended following alfalfa (or other legumes).

Soil samples for NO_3-N should be taken following a growing season and prior to the application of N fertilizer.

Soil samples should be taken from the 0- to 2-foot and 2- to 6-foot soil depths on deep soils. The soil samples should consist of soil cores removed from the entire 0- to 2-foot and 2- to 6-foot depth of soil. On soils shallower than 6 feet, take soil samples from 0–2 feet and from 2 feet to the rooting depth.

It is important to follow correct soil sampling procedures as outlined in OSU Extension publication EC 628, *How to Take a Soil Sample. . . and Why.* This publication is available from county Extension offices.

Soil test results for N are reported in ppm. One ppm N in a 1-foot depth of soil equals about 4 lb N/a (Table 1).

As an example:

Table 1.—N fertilization rates for spring-planted small grains.

Soil depth (ft)	If the soil test for NO_3-N is (ppm)	Apply this amount of NO_3-N (lb/a)
0–2	4	32
2–6	3	48
		Total 80

The total NO_3-N soil test values are used to estimate the N fertilizer requirement as indicated in the following table.

E. Hugh Gardner, Extension soil scientist emeritus; T.L. Jackson, Extension soil scientist emeritus; Rodney Todd, Extension agent, Klamath County; Bert G. Wilcox; Luther Fitch; Malcolm Johnson; and Vance Pumphrey; Oregon State University.

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Table 2.—N fertilization rates for spring-planted small grains based on total NO_3-N test values.

If the soil test for NO_3-N is (lb/a)	Apply this amount of N	
	Wheat (lb/a)*	Oats and barley (lb/a)*
0–40	120–160	60–100
40–80	80–120	20–60
80–120	40–80	0–20
120–160	0–40	0
160–200	0	0

*These application rates are suggested for silt loam, loam, and clay loam soils. For sandy soils, increase the application rates by one-fourth.

If the soil test value for NO_3-N is less than 2 ppm in the 0- to 2-foot soil depth, apply a minimum of 30 lb N/a when well-tillered wheat plants are not present regardless of the soil test value for N below 2 feet. This application will ensure adequate initial growth of wheat plants.

N fertilizer rates based on previous crop

Where a soil test is not used, N fertilization is based on the preceding crops.

As the amount of residual N in the soil varies considerably, a soil test usually is the most accurate method of estimating N fertilizer needs except following a legume crop (Table 3).

Table 3.—N fertilization rates for spring-planted small grains based on previous crop.

If the previous crop was	Apply this amount of N	
	Wheat (lb/a)[1]	Oats and barley (lb/a)*
Grass sod or grain	140–160	80–100
Potatoes and peppermint	80–100	40–60
Productive alfalfa	60–80	20–40

*It may be necessary to increase these rates by about one-fourth to optimize yields on sandy soils.

Phosphorus (P)

Best results are obtained when P is banded at planting time. Plowing P down before planting is preferable to broadcast applications. (See Table 4).

Table 4.—P fertilization rates for spring-planted small grains.

If the soil test for P is (ppm)	Apply this amount of phosphate (P_2O_5) (lb/a)*	
	Central Ore. and Klamath County	Remainder of eastern Ore.
0–10	80	60
10–20	40	0
over 20	0	0

*Increase the application rate by 50 percent if P is not banded. Increased responses to banded P occur in cold, wet soils. For muck soils in the Klamath area, see OSU Extension publication FG 70, *Irrigated Spring-Planted Small Grains—Peat and Muck Soils (Klamath and Lake Counties).*

Potassium (K)

K fertilizers usually are not required for production of irrigated spring-planted small grain in eastern Oregon, but potassium responses may be obtained when soil test values for mineral soils for K are less than 100 ppm. In this case, 30 to 50 lb K_2O/a should be banded at planting time or plowed down prior to planting.

For muck soils in Klamath County, see OSU Extension publication FG 70, *Irrigated Spring-Planted Small Grains—Peat and Muck Soils (Klamath and Lake Counties).*

Sulfur (S)

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S. Elemental S must be converted to sulfate in the soil before the S becomes available to the plant.

S fertilizer requirements vary with soil texture, leaching losses, S content of irrigation water, and the soil parent material.

The S requirements of spring cereals can be provided by:

1. Applying sulfate (SO_4) sulfur at 40–60 lb S/a at seeding on sandy soils and at 15–20 lb S/a on silt loam and finer-textured soils.
2. Applying fine-ground (less than 40-mesh) elemental S at 30–40 lb S/a the preceding year. Such an S application will suffice for 2 years.
3. Applying coarser-ground elemental S at higher rates and less frequently.

As elemental S gives a slow response, it is not recommended for application to grain fields where S deficiency symptoms are apparent. In this case, use a more rapidly available form of S such as gypsum.

S frequently is applied as a component of fertilizer materials such as ammonium sulfate and single super phosphate.

Some irrigation water contains appreciable amounts of S, which can be utilized by plants. Water containing 1 ppm S would supply 2.72 lb S/a for each foot of water applied. Growers should have their irrigation water analyzed to determine its S content.

Some S fertilizers such as elemental S increase soil acidity. Gypsum can be used as a source of S without affecting soil acidity.

Magnesium and Lime

Responses of small grains to applications of magnesium and lime have not been observed on mineral soils in eastern Oregon.

Manure

Manure can be used as a source of nutrients for small grains. Information on the use of manure is available from your county Extension agent.

For More Information

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Irrigated wheat

Eastern Oregon—east of Cascades

E.H. Gardner, T.L. Jackson, B.G. Wilcox, L. Fitch, M. Johnson, and V. Pumphrey

Good management practices are essential if optimum fertilizer responses are to be realized. These practices include adequate irrigation, use of recommended varieties, selection of adapted soils, weed control, disease and insect control, proper seeding methods, and timely harvest.

It is important that the soil be sampled and tested as a guide to fertilization. Follow recommended soil sampling procedures to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, soil sample bags, and information sheets.

Nitrogen (N)

Irrigated grain requires a good supply of available N; however, excessive rates of N can reduce grain quality and increase the risk of lodging. An optimum response to N fertilization depends on adequate irrigation.

Of the suggested N application, 0 to 40 percent of the N should be applied preplant or at planting time, and the remainder during tillering in the spring. The urea or diammonium phosphate forms of N may cause seedling injury if banded close to the seed at planting.

The amount of N fertilizer required depends on the following factors: the preceding crop, the N carryover from the previous crop, the amount and type of residue to be plowed under, and possible leaching losses due to over-irrigation.

The following recommendations are for mineral soils with low organic matter content unless otherwise stated.

N fertilizer rates based on soil test

The amount of residual N in the soil varies considerably.

A soil test for nitrate-N (NO_3-N) helps in evaluating the N carryover from the previous crops in the case of mineral soils with low organic matter content.

N soil tests are not recommended following alfalfa (or other legumes) or for muck and peat soils.

Soil samples for NO_3-N should be taken following a growing season and prior to the application of N fertilizer.

Take soil samples from the 0- to 2-foot and 2- to 6-foot soil depths on deep soils. The soil samples should consist of soil cores removed from the entire 0- to 2-foot and 2- to 6-foot depths of soil. On soils shallower than 6 feet, take soil samples from 0–2 feet and from 2 feet to the rooting depth.

Soil test results for N are reported in parts per million (ppm). One ppm N in a 1-foot depth of soil equals about 4 lb N/a (Table 1).

Table 1.—N quantities according to soil depth.

Soil depth	Soil test NO_3-N	
(ft)	(ppm)	(lb/a)
0–2	4	32
2–6	3	48
		Total = 80

The total NO_3-N soil test values are used to estimate the N fertilizer requirement as indicated in Table 2.

Table 2.—N fertilization rates for irrigated wheat according to NO_3-N soil test values.

If the soil test for NO_3-N is (lb/a)	Apply this amount of N* (lb/a)
0–50	250–200
50–100	200–150
100–150	150–100
150–200	100–50
200–250	50–0
over 250	0

*These application rates are calculated for an estimated yield of 100 bu/a. Add or subtract 3 lb N/a for each bu/a when estimated yield is above or below 100 bu/a.

If the soil test value for NO_3-N is less than 2 ppm in the 0- to 2-foot soil depth, apply a minimum of 30 lb/a N when well-tillered wheat plants are not present regardless of the soil test value for N below 2 feet. This application will ensure adequate initial growth of wheat plants.

E. Hugh Gardner and T.L. Jackson, Extension soil scientists emeritus; Bert G. Wilcox and Luther Fitch, county Extension agents emeritus; Malcolm Johnson, former agronomist; and Vance Pumphrey, agronomist emeritus; Oregon State University.

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N fertilizer rates based on previous crop

Where a soil test is not used, N fertilization is based on the preceding crop (Table 3).

As the amount of residual N in the soil varies considerably, a soil test usually is the most accurate method of estimating N fertilizer needs except following a legume crop.

Table 3.—N fertilization rates for irrigated wheat according to previous crop.

If the previous crop was	Apply this amount of N (lb/a)*
Grass sod	200–250
Grain	175–225
Potatoes or peppermint	150–200
Productive alfalfa	125–175

*These application rates are based on an estimated yield of 100 bu/a.

Phosphorus (P)

Best results are obtained when P is banded 2 inches to the side or below the seed at planting time. Plowing P down before planting is preferable to broadcast applications. (See Table 4.)

Table 4.—P fertilization rates for irrigated wheat on mineral soils.

If the soil test for P is (ppm)	Apply this amount of phosphate (P_2O_5) (lb/a)*	
	Central Ore. and Klamath Co.	Remainder of eastern Ore.
0–12	60	30
12–20	30	0
over 20	0	0

*Increase the application rate by 50 percent if P is not banded.

On muck soils in the Klamath area apply 40 lb P_2O_5/a.

Potassium (K)

K fertilizers usually are not required for production of irrigated spring-planted small grain in eastern Oregon, but K responses may be obtained when soil test values for mineral soils for K are less than 100 ppm. In this case, 30 to 50 lb K_2O/a should be banded at least 2 inches from the seed at planting or plowed down before planting.

On the acid muck soils in Klamath County, small grains have responded to the application of K.

Sulfur (S)

S requirements vary with soil texture, leaching losses, and the soil parent material. S frequently is contained in fertilizers used to supply other nutrients such as N, P, and K and may be present in irrigation water, which can be tested for S content.

Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S. Elemental S must be converted to sulfate in the soil before the S becomes available to plants. The conversion of elemental S to sulfate usually is rapid for fine-ground (less than 40-mesh) material in warm, moist soil.

Elemental S is a strong soil acidifier.

S in the sulfate form can be applied at planting time (Table 5).

Table 5.—S application rates for irrigated wheat.

If the soil test for SO_4-S in the 0–2' soil depth is (ppm)	Apply this amount of S (lb/a)*	
	Loamy soil	Sandy soil
0–3	0–20	20–40
3–5	0	0–20
over 5	0	0

*When the irrigation water contains over 2 ppm S, additional S fertilizer probably is not required.

Magnesium (Mg)

Responses of small grains to applications of Mg have not been observed on mineral soils in eastern Oregon.

Lime

Responses of wheat to lime have not been observed in eastern Oregon; however, where the soil test pH value is less than 5.5, a lime application is suggested.

On sandy soils where soil acidity is most prevalent, 1 ton of 100-score lime raises the pH about 1 unit. In most instances, 1 to 1½ tons lime/a is adequate to correct soil acidity.

Mix lime into the seedbed at least several weeks before seeding. A lime application is effective for several years.

Micronutrient Elements

In the Klamath area, a micronutrient mix containing zinc, copper, and manganese has given yield responses with small grains on muck soils.

Manure

Manure can be used as a source of nutrients for small grains. Information on the use of manure is available from your county Extension agent.

For More Information

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Fertilizer and Lime Materials

J. Hart

Chemical fertilizers, when properly used, provide a satisfactory source of plant nutrients and can increase the yield and quality of crops when applied to nutrient-deficient soils. Other materials such as manure, sewage sludge, and industrial wastes may supplement the nutrient needs of most crops. In many situations, because of guaranteed analysis, accessibility, and transportation costs, chemical fertilizers provide the least expensive and accurate means of supplying plant nutrient requirements.

Soil acidity may be one of the factors that limit yield and growth responses to applied fertilizer. Lime is applied to reduce soil acidity.

Fertilizer grade

The grade of a fertilizer indicates the available nutrient content expressed in terms of percentages of nitrogen (N), phosphorus pentoxide (P_2O_5), and potash (K_2O), in that order. Nitrogen (N) is expressed on the elemental basis, and phosphate and potash are expressed as the oxides rather than elemental phosphorus (P) and potassium (K). A fertilizer grade of 10-20-5, contains:

10% N, 20% P_2O_5, and 5% K_2O

Fertilizers containing relatively large amounts of nutrients are "high analysis fertilizers." A fertilizer with a grade of 10-20-20 has a high analysis by comparison with a 4-8-8 grade. High analysis fertilizers often provide nutrients at lower relative cost due to lower costs per pound of plant nutrient for transportation, storage, and application. Fertilizers containing the three nutrients N, P, and K sometimes are referred to as "complete."

Other nutrients

Fertilizers often contain other nutrients such as sulfur (S) and magnesium (Mg), or micronutrients such as boron (B), zinc (Zn), or molybdenum (Mo). These nutrients are listed on the fertilizer label on an elemental basis similar to nitrogen and sometimes are included in the fertilizer grade. A 15-5-10-8S fertilizer contains an additional 8% S.

Some micronutrient elements such as B and Mo can be toxic to plants if applied in slightly excessive amounts. Apply only recommended amounts of these nutrients.

Application of fertilizers

Recommendations for the method of fertilizer application should be followed for these reasons:

1. Nutrients such as P, K, Mg, and Zn are immobile in the soil and should be "placed" or "banded" in the rooting zone or incorporated by tillage.
2. Fertilizers can cause plant damage if banded close to seed or roots at rates in excess of those suggested. Fertilizers containing B never should be banded but should be applied evenly to the fertilized area.
3. Losses of N into the atmosphere can occur when some N fertilizer materials are applied to the surface of the soil and are not incorporated.
4. N fertilizers applied in excess or before active plant growth can result in N contamination of groundwater.

Dilute solutions of fertilizers sometimes are applied as "foliar" sprays. This practice often is used to apply micronutrients. Large amounts of nutrients cannot economically be applied using foliar sprays. Foliar sprays often are used when a rapid response to a micronutrient deficiency is needed.

Rates of application of fertilizer materials

Most fertilizer applications suggested in OSU fertilizer guides are stated in terms of pounds per acre of N, P_2O_5, K_2O, or S, etc. To convert these recommendations to pounds per acre of an actual fertilizer material, use the following formula:

$$\frac{\text{Pounds of nutrient recommended}}{\text{Percentage of nutrient in fertilizer material}} \times 100$$

Example: To supply 80 lb of N using ammonium sulfate that has a grade of 21-0-0:

80/21 x 100 = 380 lb of ammonium sulfate should be applied.

Fertilizer guides dealing with lawns and gardens provide recommendations in lb/100 sq ft or lb/1,000 sq ft. Vegetable and fruit tree guides do not provide units for smaller acreage. To convert pounds per acre (lb/a) to lb/100 sq ft, divide by 400. A fertilizer application of

John Hart, Extension soil scientist, Oregon State University.

400 lb/a would equal 1 lb/100 sq ft. Similarly, to convert lb/a to lb/1,000 sq ft, divide lb/a by 40. A fertilizer application rate of 400 lb/a would be 10 lb/1,000 sq ft.

Solid fertilizers

Solid fertilizer materials are available as pellets or granules. The solubility of solid fertilizer materials varies. Some, such as urea and ammonium nitrate, can be dissolved and applied in irrigation water.

Fluid fertilizers

This term applies to fertilizer solutions and suspensions. Suspensions are fluid mixtures containing dissolved and undissolved plant nutrient materials that may require agitation to ensure homogeneity. Solutions contain only dissolved materials. A common N solution in Oregon is urea-ammonium nitrate, 32-0-0, accounting for over 20% of the N applied. Suspensions usually have a higher P and K grade compared to solutions. The grade of liquid fertilizers is expressed similarly to solid fertilizers.

Nitrogen solutions are classed as pressure or nonpressure. Pressure solutions have appreciable vapor pressure due to ammonia. Such solutions must be injected into the soil to prevent loss of ammonia.

Blended fertilizers

Blending fertilizer materials may be necessary to obtain a desirable grade or ratio of nutrients. Not all materials can be blended. For instance, urea and ammonium nitrate, when blended, give a moist, mushy mixture. Fertilizer materials may be of different sizes, creating segregation and the potential for uneven distribution of the materials. Segregation is most likely to occur during transportation. Segregation can be reduced by using fertilizer material of similar particle size in blended fertilizers. This is especially important for micronutrients or nutrients included in small amounts compared to the major amount of fertilizer being blended. Segregation can be avoided by adding micronutrients as a coating to the particles of bulk fertilizer material.

Blended fertilizers are available in solid and liquid forms. Chemicals that control weeds, insects, and other pests sometimes are blended and applied with fertilizer materials. Before preparing such blends, determine the compatibility of the ingredients.

Slow-release fertilizers

Some fertilizers, such as urea formaldehyde, magnesium ammonium phosphate, and coated fertilizers, release nutrients slowly to supply plant food over a relatively long time period. Uses for these materials include potting mixtures and turf management. Slow-release fertilizers can reduce plant toxicity hazards due to a slower release of nutrients into the soil solution. These materials usually are comparatively expensive. Slow-release N fertilizers offer the potential for reduced N leaching if the N fertilizer release can be matched to crop demand. Other materials that release nutrients at relatively slow rates include organic fertilizers such as blood meal, tankage, sewage sludge, manure, and seafood waste.

Fertilizer salt effect (salt index)

Fertilizer applications increase the concentration of salt in the soil and when incorrectly applied can create toxic salt concentrations. Fertilizer materials differ in their ability to create salt problems in the soil. The salt index is a measure of the tendency of a fertilizer to create a salty condition in the soil.

The salt index of a fertilizer is based on a comparison with sodium nitrate and is used to compare solubility of fertilizers. Fertilizers with high salt index have a high potential to damage young plants compared to fertilizers with a lower salt index. The salt index for selected fertilizers is listed in Table 1. Salt toxicity is likely to be more serious in soils with low moisture content, in sandy soils, or where fertilizer is banded close to seed or plants.

Acidity from fertilizers

Some N fertilizer materials acidify soil. The continuous use of acidifying fertilizers over a period of years can appreciably lower soil pH. The acidifying effect of fertilizers can be neutralized through the application of lime. Fertilizer materials vary in their ability to create soil acidity, and some have no acidifying effect (see Table 1). Some fertilizers, such as urea, initially raise the pH of the soil, but the longer term effect is an increase in soil acidity.

Table 1.—Acidifying potential and salt index for selected fertilizers.

Fertilizer material	Grade	Acidity*	Salt index
Anhydrous ammonia	82-0-0	140	47.1
Sodium nitrate	16-0-0	—	100
Ammonium nitrate	34-0-0	62	105
Ammonium sulfate	21-0-0	110	69
Urea	46-0-0	71	75
Monoammonium phosphate	11-48-0	58	27
Ammonium-phosphate-sulfate	16-20-0	88	
Triple super phosphate	0-45-0	0	10
Potassium chloride	0-0-60	0	116
Potassium sulfate	0-0-50	0	46

*The acidity value indicates the pounds of 100-score lime needed to neutralize the acidity produced by fertilizer application of 100 lb/a.

Soil amendments and lime quality

Materials used to alter the pH or physical properties of soil are referred to as amendments. Examples of soil amendments are: lime used to reduce soil acidity; elemental sulfur and aluminum sulfate used to increase soil acidity; and gypsum and elemental sulfur used to improve the physical condition of alkali soil. Liming materials are used to raise soil pH and supply calcium or magnesium. The quality of liming material is related to its degree of fineness or particle size, the chemical composition or calcium carbonate equivalent, and the moisture content.

Calcium carbonate equivalent

The calcium carbonate equivalent *(cce)* is an expression of the acid neutralizing value of a liming material compared to pure calcium carbonate. Pure calcium carbonate is given a rating of 100. The *cce* of common materials is listed in Table 2.

Table 2.—Calcium carbonate equivalents.

Common name	Chemical name	Chemical formula	cce
Ground limestone	Calcium carbonate	$CaCO_3$	100
Dolomitic limestone	Calcium magnesium carbonate	$CaMg(CO_3)_2$	109
Hydrated lime	Calcium hydroxide	$Ca(OH)_2$	135
Burned lime	Calcium	CaO	179

Fineness factor

The fineness factor (ff) is related to the particle size of a liming material. The particle size affects the rate at which a liming material goes into solution in the soil. Lime does not neutralize acidity or release its nutrients until it has dissolved, so fine particles will react rapidly if sufficiently mixed with the soil.

One T/a lime with all particles passing a #10 screen will react with the soil in 1 year or less if thoroughly mixed with the soil. Increased lime rates, larger particle size, and incomplete mixing increase time for reaction of lime with the soil.

Lime particles that are less than 7/100 (7 hundredths) of an inch in diameter (particles of this size will pass through a #10 sieve) are considered to be soluble enough to be effective. Liming material particles that do not pass a #10 sieve are considered to be relatively noneffective. The degree of solubility increases as the particle size decreases from #10 to #40 sieve, with lime particles that pass a #40 sieve being given the maximum solubility rating. Solubility ratings for particle sizes shown in Table 3 are given in Table 4. A fineness factor value based on particle size is calculated in Table 4.

Table 3.—Example analysis of a liming material.

Sieve analysis	
Passing #10	98%
Passing #20	92%
Passing #40	78%

Table 4.—Calculation of fineness factor.

Particle size group	Percent in particle size group (A)	Solubility rating (B)	Fineness value (A)x(B)
No. 40 sieve or smaller (% passing #40 sieve)	78	1.00	78
#20–40 sieve (% passing #20 minus % passing #40 sieve)	14	0.60	8.4
#10–20 sieve (% passing #10 minus % passing #20 sieve)	6	0.30	1.8
#10 sieve or larger (100% minus % passing #10 sieve)	2	0	0
		TOTAL	88.2

The values for "percent in particle size group" are obtained from Table 3. The percent passing a #40 sieve is 78. The percent passing a #20 sieve and caught on a #40 sieve is 92 – 78 = 14. A similar subtraction is made for the last two categories, 98 – 92 = 6 and 100 – 98 = 2.

$$\text{Fineness factor } (ff) = \frac{\text{Total fineness value}}{100} = \frac{88.2}{100} = 0.88$$

Moisture factor

As water does not reduce acidity, the acid neutralizing value of a liming material decreases on a weight basis as the moisture content increases.

$$\text{Moisture factor } (mf) = \frac{100 - \%\text{ water in lime}}{100}$$

A liming material containing 15% water would have a moisture factor of:

$$mf = \frac{100 - 15}{100} = 0.85$$

Lime score

The lime score of a liming material is a numerical expression of the quality of the lime using *ff*, *cce*, and *mf*. A sample calculation of a lime score using a *cce* of 92 and the preceding values for *ff* and *mf*, follows:

Calcium carbonate equivalent *(cce)* = 92
Fineness factor *(ff)* = 0.88
Moisture factor *(mf)* = 0.85

Lime score = *cce* x *ff* x *mf*
= 92 x 0.88 x 0.85
= 69

Amount of liming material to apply

Liming recommendations are based on 100-score liming material. Liming equivalent is the amount of liming material needed to equal 1 ton of 100-score dry lime. In general, this amount will be greater than 1.0 for limestone and by-product materials and less than 1.0 for burned and hydrated lime. The lime equivalent is calculated as:

$$\frac{\text{Recommended liming rate}}{\text{Lime score } (ls)} \times 100$$

If a liming material has a lime score of 69 and the recommended liming rate is 3 T/a, then:

$$\text{The lime equivalent} = \frac{3 \text{ T/a}}{69} \times 100 = 4.35 \text{ T/a}$$

Liming recommendations are based on soil test results and vary with the soil and crop to be grown.

A 1 T/a application of 100-score ground limestone supplies about 2 milliequivalents of calcium/100 grams of soil to the surface 6" of a mineral soil.

Chemical composition of liming materials

Liming materials vary in chemical composition. The chemical makeup of lime affects its neutralizing value and nutrient content. Ground limestone, for instance, consists of calcium carbonate and is a source of calcium. Dolomitic limestone consists of calcium and magnesium carbonates.

Kinds of liming materials

Several different kinds of liming materials are available in Oregon. They include:

Ground limestone

Consists of calcium carbonate and varying amounts of impurities. This material sometimes contains small amounts of magnesium carbonate. Pure calcium carbonate (calcite) contains 40% Ca.

Dolomitic limestone

Limestone containing from 10 to 49% dolomite, and from 50 to 90% calcite. The magnesium carbonate ($MgCO_3$) content of dolomitic limestone may range from approximately 4.4 to 22.6%. Dolomitic lime commonly is recommended as a liming material for acid soils that are deficient in magnesium.

Dolomite

A mineral containing approximately equal amounts calcium carbonate and magnesium carbonate.

Hydrated lime

Sometimes referred to as slaked, spray, or builder lime. Consists of calcium hydroxide with varying amounts of impurities. It is a white powder that reacts quickly when mixed with moist soil. Often mixed with copper sulfate to make Bordeaux fungicide sprays.

By-product liming materials

Effective liming materials are produced as by-products of industrial processes such as the manufacture of cement, wood pulp, sugar, and calcium carbide. These by-products contain varying amounts of calcium and magnesium compounds and other materials. Some of the names used for these by-product materials are: sugar lime, Cotrell lime or dust, lime sludge, carbide lime, and pulp mill lime.

Soil testing for lime requirement

The SMP lime requirement test is used to estimate the amount of lime required to raise the pH of the surface 6" of soil. The SMP test is performed by mixing a soil sample with a buffer solution and determining the resulting pH of the mixture. The "SMP buffer" value is used to estimate lime requirement. The choice of the pH column in Table 5 depends on the crop to be grown and possibly other factors. These lime rates are adjusted for western Oregon conditions based on the research of Peterson. The practical upper limit for a single application of lime is 4 to 5 T/a.

Some soils may have a fairly high SMP buffer value (>6.2) and a low pH (<5.3). This condition can be caused by the application of fertilizer. In this case, the low pH value is temporary and the pH of the soil will increase as the fertilizer completes its reaction with the soil. It often is encountered after dry periods and is found when soil samples are obtained in late summer.

Sandy soils to which fertilizers have not been recently applied sometimes record low pH and high SMP buffer values. In such cases, a light application of lime (1 to 2 T/a) should suffice to neutralize soil acidity.

Lime requirements for organic soils, very sandy soils, or orchards in the Hood River Valley should be obtained from your county agent of the OSU Extension Service.

Table 5.—SMP lime requirement table.

SMP Buffer	T/a of 100-score lime needed to raise pH of surface 6" of soil to the following pH's			
	5.3	5.6	6.0	6.4
6.7	-	-	-	-
6.6	-	-	-	1.1
6.5	-	-	1.0	1.7
6.4	-	-	1.1	2.2
6.3	-	-	1.5	2.7
6.2	-	1.0	2.0	3.2
6.1	-	1.4	2.4	3.7
6.0	1.0	1.7	2.9	4.2
5.9	1.4	2.1	3.3	4.7
5.8	1.7	2.5	3.7	5.3
5.7	2.0	2.8	4.2	5.8
5.6	2.3	3.2	4.6	6.3
5.5	2.6	3.6	5.1	6.8
5.4	2.9	3.9	5.5	7.3
5.3	3.2	4.3	6.0	7.8
5.2	3.6	4.7	6.4	8.3
5.1	3.9	5.0	6.9	8.9
5.0	4.2	5.4	7.3	9.4
4.9	4.5	5.8	7.7	9.9
4.8	4.8	6.2	8.2	10.4

Example: If the "SMP buffer" value is 5.9, then the estimated lime requirement to raise the pH to 6.0 would be 3.3 tons of 100-score lime/a.

For more information

You can obtain additional copies of this publication, *Fertilizer and Lime Materials*, FG 52, from your county office of the OSU Extension Service or from the Extension and Experiment Station Communications Web site at eesc.ads.orst.edu

Other publications

Peterson, Paul W. 1972. Liming requirements of selected Willamette Valley soils. M.S. thesis, Oregon State University, Corvallis.

Shoemaker, H.E., E.O. McLean, and P.F. Pratt. 1961. Buffer methods for determining lime requirement of soils with appreciable amounts of extractable aluminum. Soil Science Society of America Proceedings, 25:274–277.

Western Fertilizer Handbook. 1995. 8th ed. California Fertilizer Association, Sacramento, CA. The Interstate Printers and Publishers, Inc., Danville, IL.

Doerge, Thomas A. and E.H. Gardner. 1985. Reacidification of two lime amended soils in western Oregon. Soil Science Society of America Journal. 4(3):680–685.

NCSA AGLIME Fact Book. 1981. National Crushed Stone Association, 1415 Elliot Place, Washington, DC.

John Hart, Extension soil scientist, Oregon State University, prepared this revision; it was reviewed by OSU county extension agents and by personnel of the Oregon Agricultural Experiment Station, the Oregon State Department of Agriculture, and the fertilizer industry.

This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties. Oregon State University Extension Service offers educational programs, activities, and materials—*without regard to race, color, religion, sex, sexual orientation, national origin, age, marital status, disability, and disabled veteran or Vietnam-era veteran status*—as required by Title VI of the Civil Rights Act of 1964, Title IX of the Education Amendments of 1972, and Section 504 of the Rehabilitation Act of 1973. Oregon State University Extension Service is an Equal Opportunity Employer.

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FERTILIZERguide
FG 60
Reprinted January 2000

Alfalfa

Southwest Oregon (Coos, Curry, Jackson, Josephine counties)

E.H. Gardner, W.S. McGuire, and T.L. Jackson

Alfalfa is capable of producing high yields of forage when grown on deep, well-drained soils. Good management practices are essential if optimum fertilizer responses are to be realized. These practices include use of recommended varieties, selection of adapted soils, weed control, disease and insect control, good seedbed preparation, proper inoculation and seeding methods, and timely harvest.

Alfalfa removes substantial amounts of mineral nutrients. Field experiments have shown that under different conditions in western Oregon, alfalfa has responded to phosphorus, potassium, sulfur, boron, and lime. The need for nutrients other than sulfur can be determined with a soil test. With borderline test values, retest every year.

Follow recommended soil sampling procedures to estimate fertilizer needs. The Oregon State University Extension Service agent in your county can provide you with soil sampling instructions, soil sample bags, and information sheets.

Inoculation

All alfalfa seed should be inoculated immediately before seeding to ensure an adequate supply of nitrogen-fixing bacteria. Use a fresh, effective, live culture of the correct strain of Rhizobia.

Nitrogen (N)

If alfalfa responds to applied N, the alfalfa has not been nodulated effectively.

Phosphorus (P)

The need for P fertilization can be determined by a soil test (Table 1).

P can be applied to alfalfa fields most effectively by banding ½–1 inch to the side or below the seed when seeding. Some soil should separate the seed from fertilizer.

Do **not** include boron in band applications.

Broadcasting and working P into the surface 2 inches of soil during seedbed preparation is more effective than broadcasting following seeding.

P recommendations assume the soil pH is above 6.0

On established stands, apply P in the fall.

Table 1.—P fertilization rates for alfalfa.

If the soil test for P is (ppm)	Apply this amount of phosphate (P_2O_5) (lb/a)*
0–5	80–100
5–10	60–80
10–20	40–60
over 20	0

*For nonband applications to new seedings, increase the P rate by 50 percent.

Potassium (K)

Alfalfa requires large amounts of K. Available soil K may decline rapidly under established stands. Check soil tests every year on soils with borderline values.

Table 2.—K fertilization rates for alfalfa.

If the soil test for K is (ppm)	Apply this amount of potash (K_2O) (lb/a)
0–75	80–100
75–100	60–80
over 100	0

On new seedings

Broadcast K and work it into the seedbed prior to seeding.

On established stands

On nonirrigated alfalfa, broadcast K in the fall or early spring. On irrigated alfalfa, apply half the K in fall or early spring and the other half after the first cutting.

A K deficiency is indicated by light-colored spots around the margins of the leaves. If K deficiency symptoms become apparent on alfalfa leaves, apply at least 80 lb K_2O to provide the needs of the following crop.

Responses to K fertilizer often are obtained before leaf deficiency symptoms are apparent.

OREGON STATE UNIVERSITY
EXTENSION SERVICE

E. Hugh Gardner, Extension soil scientist emeritus; W.S. McGuire, professor emeritus of agronomy; and T.L. Jackson, Extension soil scientist emeritus; Oregon State University. Reviewed by a committee of southwest Oregon county Extension agents.

Sulfur (S)

Include 20–40 lb S/a in the annual fertilizer program. Apply S in the fall or early spring. An early spring application is suggested for valley floor soils.

One ton of alfalfa hay removes about 5 lb S.

S is contained in several fertilizer materials used to supply other nutrients. Plants absorb S in the form of sulfate. Fertilizer materials supply S in the form of sulfate and elemental S. Elemental S must be converted to sulfate in the soil before the S becomes available to plants. The conversion of elemental S to sulfate usually is rapid for fine-ground (less than 40-mesh) material in warm, moist soil.

The S requirements of alfalfa can be provided by:

1. Annually applying 20–40 lb S/a in the form of sulfate or fine-ground (finer than 40-mesh) elemental S. Elemental S will not be available to plants until the soil warms up.
2. Applying 40–60 lb S/a as sulfate or fine-ground elemental S every second year.
3. Applying coarser ground elemental S at higher rates and less frequently.

Magnesium (Mg)

Responses to Mg applications have not been measured in alfalfa fertility experiments to date. Trial applications are suggested when soil test values are below 0.8 meq Mg/100 g or when the amount of calcium is more than 10 times the amount of Mg.

Mg can be applied in the form of dolomite lime, which is equal to ground limestone in reducing soil acidity.

Boron (B)

On established stands, apply 3 lb B/a if the soil test is 1 ppm B or less. The application of B is not recommended for new seedings.

Apply B uniformly to the soil. B and other materials should be thoroughly mixed when B application is combined with other fertilizers. Apply B in fall or early spring.

B can be toxic to plants if applied at rates higher than recommended.

Response to B is most apparent on the second or third cutting

Lime

Alfalfa is sensitive to soil acidity and is responsive to liming of acid soils. Apply lime if the soil pH is below 6.4 or the soil test for calcium is below 5 meq Ca/100 g of soil.

Table 3.—Lime application rates for alfalfa.

If the SMP buffer test for lime is	Apply this amount of lime (t/a)
under 5.2	5–7
5.2–5.5	4–5
5.5–6.0	3–4
6.0–6.4	2–3
6.4–6.6	1–2
over 6.6	0

These liming rates are based on dry 100-score lime. Check liming materials for moisture content and score.

Apply lime preferably a season ahead, or at least several weeks before seeding, and thoroughly mix it with the surface 5–6 inches of soil. A lime application is effective for several years. Broadcasting lime on established alfalfa fields is not effective.

Dolomite lime, which can be used as a source of Mg, is equal to ground limestone in reducing soil acidity.

For More Information

How to Take a Soil Sample ... and Why, EC 628, by E.H. Gardner (revised 1997). No charge.

A List of Analytical Laboratories Serving Oregon, EM 8677, by J. Hart (revised 1997). No charge.

To order copies of the above publications, send the complete title and series number, along with a check or money order for the amount listed (payable to Oregon State University), to:

Publication Orders
Extension & Station Communications
Oregon State University
422 Kerr Administration
Corvallis, OR 97331-2119
Fax: 541-737-0817

You may order up to six no-charge publications without charge. If you request seven or more no-charge publications, include 25 cents for each publication beyond six.

World Wide Web

Fertilizer and Lime Materials, FG 52, by J. Hart (reprinted 1997). No charge.

You can access the above publications, as well as FG 60, *Alfalfa: Southwest Oregon (Coos, Curry, Jackson, Josephine counties)*, our Publications and Videos catalog, and many other publications via our Web site at **eesc.orst.edu**

Fertilizer recommendations are based on experiments conducted by T.L. Jackson, E.H Gardner, and H. Hickerson, Oregon State University.

This publication was produced and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Extension work is a cooperative program of Oregon State University, the U.S. Department of Agriculture, and Oregon counties. Oregon State University Extension Service offers educational programs, activities, and materials—*without regard to race, color, religion, sex, sexual orientation, national origin, age, marital status, disability, and disabled veteran or Vietnam-era veteran status*—as required by Title VI of the Civil Rights Act of 1964, Title IX of the Education Amendments of 1972, and Section 504 of the Rehabilitation Act of 1973. Oregon State University Extension Service is an Equal Opportunity Employer.

Revised May 1985; Reprinted January 2000.

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX B-3

1996 BIOSOLIDS MANAGEMENT PLAN
W/2005 SUPPLEMENT
(PREPARED BY CITY)

BIO-SOLIDS MANAGEMENT PLAN

for

CITY OF MADRAS

February 1996

approved April 16, 1996

OBJECTIVE

Biosolids and Domestic septage management plan
according to OAR 340 Division 50

5(a): ***A description of the method(s) of solids removal;***

There are no solid's removal methods at the WWTF other than that which is naturally settled in the treatment ponds and removed through the Diffused Air Floatation(DAF) system.

5(b): ***For wastewater and septate treatment facilities, a detailed description of the wastewater processing facility, including unit processes used in wastewater treatment; source design flow (gpd); and wastewater flow origin (e.g., percent domestic, industrial, commercial, and domestic septate);***

The City of Madras owns and operates a .45MGD wastewater treatment facility northwest of the City at the Airport/Industrial area. The plant serves Madras residents, businesses, and industries.

The Lagoon System became operational in approximately 1973 with an upgrade in 1993 consisting of a Diffused Air Floatation (DAF) plant and a 25-acre storage pond.

The facility consists of two 10-acre primary lagoons, two 2.5-acre secondary lagoons, a 2-acre polishing pond, DAF system, chlorine disinfection, sludge storage pond, and a 25-acre effluent storage pond for treated effluent reuse at a privately owned golf course.

Biological treatment of liquid and solid wastes occurs in the primary and secondary lagoons, as well as the polishing pond. Settling of solids occurs mainly in the primary lagoons. The secondary lagoons and polishing pond provide polishing of the wastewater and additional settling of solids. Solids removed are stored in the two primary lagoons and removal is not anticipated within the next 5 years.

The DAF system removes suspended solids, mainly of algae content, from the wastewater prior to disinfection. Solids are removed by two-stage dissolved air flotation with chemical addition followed by filtration. Collected solids then flow to the sludge storage pond which holds 800,000 gallons.

Residential flow is 63%, Commercial is 30%, and Industrial is 7% of flow to WWTF.

5(c): ***An indication of how primary, secondary, and tertiary solids or septages are removed, thickened, digested, and dewatered;***

There is no primary or secondary solids removal. Tertiary solid's removal is through the DAF system. The City is no longer receiving septate to the system.

5(d): ***A description of the quantities of raw and stabilized solids volumes generated annually;***

The tertiary solids generated at the facility are mainly of algal content since they are coming from the lagoon system. Approximately 43.5 dry tons DT is generated each year.

5(e): ***The means used to attain pathogen reduction, and data confirming pathogen reduction has been accomplished;***

The process used for pathogen reduction is to allow the sludge to biologically digest in the sludge storage pond during plant shut down (approximately 5 months). This process is a combination of aerobic, during the time the sludge is first put in the pond, and anaerobic, after the sludge has been sitting in the pond for an extended period. Confirmation of pathogen reduction was accomplished by: 503.32(b)(2) class B-Alternative 1;

Subchapter O, Part 503, page 42;
Using Standard Methods 909-C;
503.32(b)(2)(I) "Seven samples of the sewage sludge will be collected at the time the sewage sludge is used or disposed."

503.32(b)(2)(ii) "The geometric mean of the density of fecal coliform in the samples collected in (2)(I) of this subsection shall be less than either 2,000,000. Most Probable Number per gram of total solids (dry weight basis) or 2,000,000 Colony Forming Units per gram of total solids (dry weight basis)."

See Exhibit "A" page 3 of 3, Analytical Data from Coffey Labs which is attached and made a part of this plan.

5(f): **The method(s) for determining degree of solids stability, and data supporting means of stabilization;**

The method used for determining solids stability was by 503.33(b)(4) using Standard Methods 2710: "The specific oxygen uptake rate (SOUR) for sewage sludge treated in an aerobic process shall be equal to or less than 1.5 milligrams of oxygen per hour per gram of total solids (dry weight basis) at a temperature of 20 degrees Celsius."

See Exhibit "A" page 2 of 3, Analytical Data from Coffey Labs which is attached and made a part of this plan.

5(g): ***The projected use and volume of solids storage basins (if appropriate) and a description of additional treatment which occurs during storage;***

The sludge pond holds 800,000 gal. The use is for storage prior to land application. There is no additional treatment other than the natural facultative process.

5(h): ***A description of the means used to transport and apply biosolids or domestic septate at Department authorized land spreading sites;***

The sludge will by applied by tanker truck equipped with a chopper circulation pump and a rear-exit on the tank with a splash plate on it to uniformly spread the sludge at the prescribed rate.

5(I): ***A description of biosolids monitoring and sampling programs and biosolids analysis, including but not limited to nitrate-nitrogen, ammonia nitrogen, total Kjeldahl nitrogen(TKN), phosphorus, potassium, total solids, arsenic, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, zinc, and pH.***

The monitoring of the biosolids is done prior to land application. Analysis is done for arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, potassium, selenium, zinc, pH, ammonium nitrogen, nitrate nitrogen, TKN, total phosphorus, TS, VS, and SOUR. Prior to land application a composite sample will be tested for TS.

See Exhibit "A" page 2 of 3, Analytical Data from Coffey Labs which is attached and made a part of this plan.

5(j): ***The delineation of land application site selection criteria, crops and crop assimilative capacity (nitrogen), and site management practices, including but not limited to annual and long-term application rates, and testing and sampling;***

The application site was selected because of public isolation and being City property. This area has limited access to authorized personnel only. The area is fenced and has a locking gate. The crop on the site is crested wheat with a nitrogen requirement of 40 lbs/acre/year. Annual application rate will be (depending on N content and TS of sludge) as described in the following table. No other constituents of the sludge are considered limiting.

5(k): ***The identification of all Department authorized biosolids or domestic septate land application sites;***

The City will be applying their bio-solids to fields 14 and field 10 if that area is needed. The City will be applying bio-solids received from USA to fields 6, 7, 8, 15, 16, 17, 18, 19, and 20.

See Exhibit "B" which is attached and made a part of this plan.
See Exhibit "C" which is attached and made a part of this plan.

5(l): ***A description of biosolids or domestic septate land application site monitoring, record keeping, and reporting procedures;***

The application site will be tested for nitrate nitrogen, ammonium nitrogen, phosphorus, potassium, sulfur, boron, zinc, pH, organic matter, and soluble salts with a sum of tested nitrogen lbs/acre along with other requirements by DEQ.

Results of all tests done on the sludge and the application site will be kept on record indefinitely for the inspection of DEQ.

The tests results will be sent to DEQ each year before application of sludge.

5(m): ***A description of remedial procedures that would be implemented in the event of a solids treatment process failure (e.g., digester breakdown or upset), solids spill at the wastewater treatment facility or solids generating source, or biosolids or domestic septate spill between and the generating source and land application site.***

If a spill happens to occur during normal plant operations or sludge removal and application it will be scooped up and returned to the sludge pond. Anything that is too fine to remove or left from the cleanup will have dry lime applied to it and the area posted if appropriate. All areas where sludge will be processed, transported or applied are on City owned property with restricted access. This area is enclosed with a locked entrance.

Section 1. Biosolids generator requirement, 503.17(a)(4):

Biosolids from City of Madras facility meet pollutant concentrations specified in 503.13 and Class B pathogen requirements in 503.32(b). Biosolids for land application are monitored on a minimum frequency of once/60 days to determine pollutant concentrations and to document that vector attraction reduction requirements have been met. Monitoring data is provided in an annual report of the previous year's activities along with an updated biosolids reuse plan each year.

Class B pathogen requirements are met through digestion (503.32(b)(1)). Vector attraction reduction (VAR) is met via a specific oxygen uptake rate (SOUR) (503.33(b)(4).

The following certification is required from the biosolids generator:

"I certify, under a penalty of the law, that the Class B pathogen requirements in 503.32(b) and the vector attraction reduction requirements in 503.33(b)(4) or allowable alternatives have been met. This determination has been made under my direction and supervision in accordance with the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the pathogen requirements and vector attraction reduction requirements have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment."

Signed by: _____

Printed Name: _____

Title: _____

Date: _____

Section 2. Biosolids applicator requirements (City of Madras):

Class B biosolids are subject to management practice restrictions specified in 503.14. Site restrictions (503.32(b)(5) are met by limiting public access and controlling agricultural practices. This certification is applicable to local land application carried out by City personnel in the Jefferson County area.

The following certification is required from the biosolids applicator:

"I certify, under a penalty of the law, that the management practices in 503.14 and the site restrictions in 503.32(b)(5) are met for each site on which bulk sewage sludge (biosolids) is applied. This determination has been made under my direction and supervision in accordance with the system designed to ensure that qualified personnel properly gather and evaluate the information used to determine that the management practices and site restrictions have been met. I am aware that there are significant penalties for false certification including the possibility of fine and imprisonment."

Signed by: _____

Printed Name: _____

Title: _____

Date: _____

GEOMETRIC MEAN
FOR
FECAL COLIFORM CALCULATION

$$GM(\text{of } N_1, N_2, \ldots N_n) = \text{anti-log}\left[\frac{\log_{n1} + \log_{n2} + \ldots \log_{Nn}}{n}\right]$$

Madras seven samples and resulting GM from analysis by Coffee Labs

Sample #1: 300 bacteria/g VSS
Sample #2: 1000 bacteria/g VSS
Sample #3: 100 bacteria/g VSS
Sample #4: <100 bacteria/g VSS
Sample #5: 200 bacteria/g VSS
Sample #6: 300 bacteria/g VSS
Sample #7: <100 bacteria/g VSS

anti-log[log 300+ log 1000+ log 100+ log 100+ log 200+
log 300+ log 100]/7 = a GM of 210

This complies with 503.32(b)(2)(I) and 503.32(b)(2)(ii) of the Part 503--STANDARDS FOR THE USE OR DISPOSAL OF SEWAGE SLUDGE

503.32(b)(2)(I) "Seven samples of the sewage sludge will be collected at the time the sewage sludge is used or disposed."

503.32(b)(2)(ii) "The geometric mean of the density of fecal coliform in the samples collected in (2)(I) of this subsection shall be less than either 2,000,000 Most Probable Number per gram of total solids (dry weight basis) or 2,000,000 Colony Forming Units per gram of total solids (dry weight basis)."

AGRONOMIC LOADING CALCULATION

Definitions:

C= Anticipated commercial Nitrogen (fertilizer) to be applied, in lbs/acre.

N= Crop Nitrogen Requirement, in lbs/acre

G= Gallons of sludge/acre/year (Agronomic Loading Rate)

S= Percent Total Solids Content in sludge, expressed as a whole number. Example: 5%= 5

M= Percent Mineral Nitrogen in sludge, being NH_4-N + NO_3-N values, expressed as percentage dry weight basis

T= Percent Total Kjeldahl Nitrogen in sludge, expressed as percentage dry weight basis

FORMULA FOR CALCULATION:

For surface application with no immediate tillage into soil:

$$\frac{120{,}000 \times (N-C)}{S \times [50M + 20(T-M)]} = \frac{120{,}000 \times (40 - 0)}{3.1 \times [50 \times 0.51 + 20 \times (5.5 - 0.51)]} = 12{,}357 \text{ gal/acre/yr}$$

ANNUAL SLUDGE LOADING CALCULATION (dry weight basis)

Definitions:

L= Annual Sludge Loading, in tons/acre (dry weight basis)

S'= Percent solids, of the sludge to be applied, expressed as a decimal fraction (example: 5% solids = 0.05).

G= Agronomic Loading Rate (from calculations performed above).

FORMULA FOR CALCULATION:

$$L = \frac{S' \times G \times 8.34 \text{ lbs/gal}}{2{,}000 \text{ lbs/ton}} = \frac{0.031 \times 12357 \times 8.34 \text{ lbs/gal}}{2{,}000 \text{ lbs/ton}}$$

L = 1.60 tons/acre/year

Report Date: February 15, 1996
Job Number: 960111AN
PO Number: None Provided
Project No: None Provided
Project Name: None Provided

Gordon Wood
City of Madras WWTP
216 NW 'B' Street
Madras, OR 97741

Analytical Narrative

The sample was received on 01/11/96 by Coffey Laboratories, Inc. (CLI) Sample Reception personnel under strict chain of custody protocol. The following information was provided at the time of sample reception:

Laboratory Sample ID	Field Identification	Matrix	Collection Date	Collection Time
960111AN-1	WW Sludge Pond	Sludge	01/11/96	1500

The recommended holding time for each batch of analyses was in accordance with the data quality objectives as specified in the CLI Quality Assurance Plan unless otherwise noted.

Acceptable precision and accuracy were achieved for all analyses associated with this work order as demonstrated by the recoveries of the quality control samples analyzed concurrently with each batch.

The data submitted in this report is for the sole and exclusive use of the above-named client. All samples associated with the work order will be retained a maximum of 15 days from the report date or until the maximum holding time expires. All results pertain only to samples submitted.

Thank you for allowing Coffey Laboratories to be of service to you. If you have questions or need further assistance, please do not hesitate to call our Customer Services Department.

Sincerely,

Susan M. Coffey
President

RAK/pj

Coffey Laboratories, Inc.
12423 N.E. Whitaker Way • Portland, OR • 97230 • (503) 254-1794 • FAX (503) 254-1452

Analytical Data

City of Madras WWTP

Job Number: 960111AN

Page Number: 2 of 3

Lab Sample ID: 960111AN-1
Field ID: WW Sludge Pond
Date/Time: 01/11/96 1500
Matrix: Sludge

Analysis Performed: Comprehensive Sludge Test

Analysis	Method	As Received	Dry Weight	Units
Arsenic	*	0.43	14	mg/kg
Cadmium	*	0.07	2.2	mg/kg
Chromium	*	0.14	4.4	mg/kg
Copper	*	0.46	15	mg/kg
Lead	*, EPA 7420	0.46	15	mg/kg
Mercury	EPA 7471	<0.008	<0.25	mg/kg
Molybdenum	*	0.06	2.0	mg/kg
Nickel	*	0.27	8.8	mg/kg
Potassium	*	59	1900	mg/kg
Selenium	*	<0.2	<5	mg/kg
Zinc	*	1.1	37	mg/kg
pH	EPA 9045	6.23	----	S.U.
Ammonium Nitrogen	SM 417A&D	0.011	0.35	%
Nitrate Nitrogen	SM 418E	0.0050	0.16	%
Total Kjeldahl Nitrogen	SM 420	0.17	5.5	%
Total Phosphorus	*	0.059	1.9	%
Total Solids	EPA 160.3	3.1	----	%
Volatile Solids**	EPA 160.4	2.1	----	%
Volatile Suspended Solids	EPA 160.4	2.0	----	%
Specific Oxygen Uptake Rate	SM 2710	0.59	----	mg/g/hr

* Sample preparation by EPA SW-846 Method 3050. Analysis by EPA SW-846 Method 6010, ICP, unless otherwise indicated.
** Reported as % of total sample.

SM means Standard Methods for the Examination of Water and Wastewater, 1985, 16th Edition.

The less than "<" symbol means none detected at or above the indicated value and represents the detection limit for the method.

Coffey Laboratories, Inc.
12423 N.E. Whitaker Way • Portland, OR • 97230 • (503) 254-1794 • FAX (503) 254-1452

Analytical Data

City of Madras WWTP

Job Number: 960111AN
Page Number: 3 of 3

Lab Sample ID: 960111AN-1
Field ID: WW Sludge Pond
Date/Time: 01/11/96 1500
Matrix: Sludge

EPA Category: Microbiological

Analysis Performed : Fecal Coliform Bacteria SM 909-C

Result	Units
300	Bacteria/g VSS
1000	Bacteria/g VSS
100	Bacteria/g VSS
<100	Bacteria/g VSS
200	Bacteria/g VSS
300	Bacteria/g VSS
<100	Bacteria/g VSS

$GM = \text{Anti-log}\left(\frac{\text{Log}300 + \log 1000 + \log 100 + \log 100 + \log 200 + \log 300 + \log 100}{7}\right)$

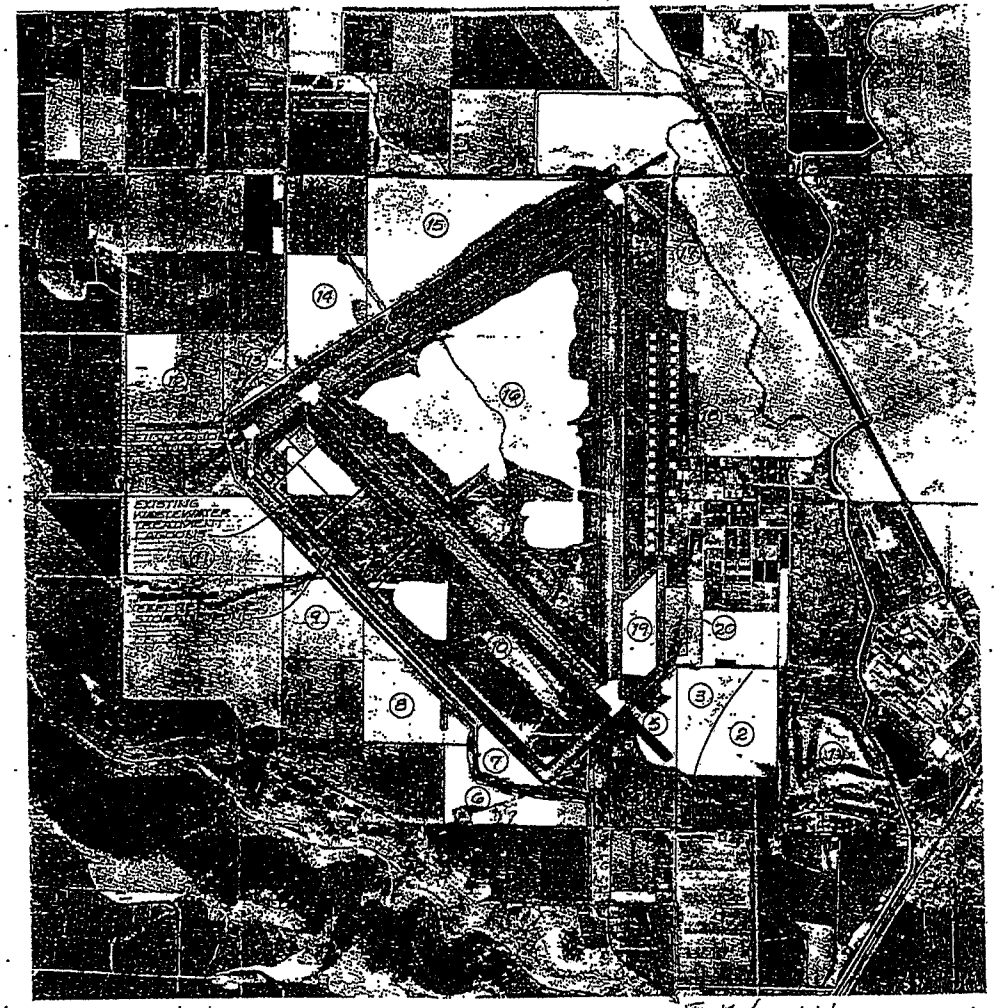
$GM = 210$

Detection Limit : —

VSS means " Volatile Suspended Solids"

The less than "<" symbol means none detected at or above the indicated value and represents the detection limit for the method.

Coffey Laboratories, Inc.
12423 N.E. Whitaker Way • Portland, OR • 97230 • (503) 254-1794 • FAX (503) 254-1452



PARCEL NUMBER	ACRES*	REMARKS
1	84.1	EXISTING [illegible]
2	33.4	EXISTING [illegible]
3	34.5	LOCATION OF EXISTING [illegible] SYSTEM
4	24.0	LOCATION OF EXISTING [illegible]
5	39.2	
6	38.7	
7	7.7	
8	39.0	
9	58.0	
10	143.0	
11	68.3	
12	82.2	
13	21.1	
14	57.3	
15	122.1	
16	593.8	
17	18.6	
18	84.8	
19	20.9	
20	7.3	
	1,257.5	

NOTE:
* INCLUDES ONLY THOSE ACRES TO BE IRRIGATED.

[illegible] for Sludge Disposal

Glass Rd.
Birch Rd.

N

0 1000 2000
SCALE IN FEET

EXHIBIT "B"

CV031439.A1

FIGURE 2.1
MAP OF AVAILABLE IRRIGATION SITES
[illegible] EFFLUENT REUSE PLAN
[illegible]

CH2M HILL

Oregon

DEPARTMENT OF ENVIRONMENTAL QUALITY

NORTHWEST REGION

November 9, 1995

RECEIVED

NOV 14 1995

CITY OF MADRAS
PUBLIC WORKS

DAVE ARGUELLO
PLANT SUPERVISOR BIOSOLIDS REUSE
UNIFIED SEWERAGE AGENCY
3125 SE RIVER ROAD
HILLSBORO OR 97123

Re: WQ-SDS-Washington County
Unified Sewerage Agency (USA)
Rock Creek AWTF
Biosolids Land Application
Authorization
City of Madras Site
TLs100&1000, 100&400, 100&300,
100&300; Ss26, 27, 34, 35; T10S,
R13E WM Jefferson County

Dear Mr. Arguello:

As you are aware, I evaluated the City of Madras site with you on September 22, 1995, to determine if the site would be suitable for the land application of anaerobically digested dewatered cake biosolids from USA's Rock Creek AWTF. On November 2, 1995, USA (Agency) provided the Department of Environmental Quality (Department) with a complete request for authorization to land apply biosolids to a 682.4 acre dryland wheat farm site on the property referenced above.

The site consists of 9 parcels that surround the City of Madras municipal airport and industrial park. The area and location of the parcels are as follows:

Parcel No. 6 - 38.7 acres - Southeast Part of Section 34
Parcel No. 7 - 7.7 acres - Southeast Part of Section 34
Parcel No. 8 - 39.0 acres - Southcentral Part of Section 34
Parcel No. 15 - 122.1 acres - Northeast Part of Section 27
Parcel No. 16 - 393.3 acres - East Part of Section 27
Parcel No. 17 - 18.6 acres - Northwest Part of Section 26
Parcel No. 18 - 34.8 acres - Southwest Part of Section 26
Parcel No. 19 - 20.9 acres - Westcentral Part of Section 35
Parcel No. 20 - 7.3 acres - Westcentral Part of Section 35

The request included information characterizing soils, topography, biosolids, crop, crop management, annual available nitrogen loading (agronomic loading rate), documentation of public notification, and a signed agreement between the Agency and the City of Madras.

John A. Kitzhaber
Governor

2020 SW Fourth Avenue
Suite 400
Portland, OR 97201-4987
(503) 229-5263 Voice
TTY (503) 229-5471

DEQ-1

EXHIBIT "C"

18. The Department shall have the right to (at reasonable times): enter the Agency's place of record keeping to review biosolids management operations and records; obtain copies of any records required under the terms of this authorization and USA's biosolids management plan; inspect any monitoring equipment required under this authorization; inspect any collection, transport, or land application vehicles; and obtain any photographic documentation or evidence deemed appropriate.

19. The Agency shall provide the Department with an annual report of biosolids processing and land application activities as required by Department Rules (Oregon Administrative Rules Chapter 340 Division 50).

20. The Department may impose any additional restrictions or conditions deemed necessary to assure adequate biosolids management. Any variations from the Agency's Department approved biosolids management plan and this authorization letter must receive prior written approval from the Northwest Region Office.

21. This authorization is subject to revocation should health hazards, environmental degradation, or nuisance conditions develop as a result of inadequate biosolids treatment or site management. This authorization is considered to be part of your approved biosolids management plan. Therefore, if operations are not conducted in accordance with terms specified under this authorization, the Department will initiate an enforcement action which may lead to the assessment of a civil penalty.

If you have any questions regarding this authorization, please contact me at 229-5616.

Sincerely,

Bruce W. Henderson

Bruce W. Henderson
Biosolids Specialist
Northwest Region

cc: Bijan Pour, Water Quality Division, Headquarters, DEQ
Craig Costello, Eastern Region, Bend Office, DEQ
Gerald Breazeale, Public Works Director
Public Works Department, City of Madras
216 NW B Street
Madras, OR 97741-1685

State of Oregon
Department of Environmental Quality

Memorandum

Date: November 27, 1995

To: Dave Arguello - Plant Supervisor, Biosolids Reuse
Unified Sewerage Agency of Washington County

From: Bruce W. Henderson - Biosolids Specialist, Northwest Region

Subject: Land Application Site Authorizations - City of Madras, Jefferson County, and near the City of Moro, Sherman County

At your request I have revised the Site Authorization Letter for the City of Madras in Jefferson County. I have removed the condition relating to frozen and snow covered ground. Since the entire site is nearly level (ground slope not exceeding 1%) and annual precipitation is very low, there is no appreciable risk associated with the land application of cake biosolids at this site when the ground is frozen or snow covered.

Also, I have made minor corrections to and reissued the Site Authorization letter for the Pinkerton site near the City of Moro in Sherman County. In this case the site authorization condition items were incorrectly numbered.

Please replace your copies of the Department letters (dated November 9, 1995, and November 6, 1995, with the enclosed letters.

Oregon
John A. Kitzhaber, M.D., Governor

Department of Environmental Quality
Eastern Region Bend Office
2146 NE 4th, Suite 104
Bend, OR 97701
(541) 388-6146
FAX (541) 388-8283

July 22, 1999

City of Madras
Attn: Keith Bedell
71 SE "D" Street
Madras, OR 97058

Re: Biosolids Land Application
Authorization
S - City of Madras
Jefferson County

On March 18, 1999, we reevaluated biosolids application sites on property owned by the City of Madras surrounding the City's municipal airport and industrial park. These sites are located in Township 18 South; Range 12 East; Section 26, 27, 34 and 35, and are identified as follows:

Parcel No. 6 - 38.7 acres - Southeast part of Section 34
Parcel No. 7 - 7.7 acres - Southeast part of Section 34
Parcel No. 8 - 39.0 acres - Southcentral part of Section 34
Parcel No. 15 - 122.1 acres - Northeast part of Section 27
Parcel No. 16 - 393.3 acres - East part of Section 27
Parcel No. 17 - 18.6 acres - Northwest part of Section 26
Parcel No. 18 - 34.8 acres - Southwest part of Section 26
Parcel No. 19 - 20.9 acres - Westcentral part of Section 35
Parcel No. 20 - 7.3 acres - Westcentral part of Section 35

On November 9, 1995, the Department approved the above referenced sites for the application of biosolids from the Unified Sewerage Agency's (USA) Rock Creek Plant. By letters dated October 16, 1998, USA requested the withdrawal of the Department's approval and agreed to a termination of the intergovernmental agreement with the City of Madras for the use of those sites effective April 1, 1999.

Additional designations of property in Sections 27 and 34 that was reevaluated for biosolids application on March 18, 1999 are as follows:

Area G - 30.1 acres - East corner of Section 27
Area L - 64.2 acres - South corner of Section 27
Area M - 76.9 acres - Southeast corner of Section 27 and Northeast corner of Section 34
Area N - 14.7 acres - Northeast corner of Section 34

The above referenced sites are approved for the application of biosolids from the City of Madras in accordance with the following conditions:

DEQ-DC1

1. Biosolids processing, handling and application shall comply with Oregon biosolids rules and guidelines set forth in Oregon Administrative Rule, Chapter 340, Division 50, and the federal biosolids regulations (40 CFR Part 501 & 503).

2. A minimum setback of 50 feet shall be maintained between the nearest point of biosolids application and all roadways, irrigation canals and ditches (except those ditches that dead end on the subject property), drainageways, ponds, wetlands, streams and any other surface water bodies.

3. A minimum setback of 100 feet shall be maintained between the nearest point of biosolids application and all residential structures and irrigation wells.

4. A minimum setback of 200 feet shall be maintained between the nearest point of biosolids application and all drinking water wells and other domestic water sources.

5. Areas where biosolids have been applied shall be clearly marked by flag pins or stakes which note the date when biosolids were last applied, except where there is continuous application by the same operator and the Department is assured of ongoing control of the application rate.

6. Biosolids shall be applied evenly across each site, in a manner that will prevent ponding and runoff.

7. Biosolids shall be applied at rates up to, but not exceeding, the agronomic loading limit for the crop.

8. If other sources of nitrogen will be applied to any of the sites in question, (i.e. commercial fertilizer; animal manure; green manure or wastewater treatment facility effluent), the biosolids application rate must be reduced so that other nitrogen applied plus biosolids applied nitrogen does not exceed the agronomic loading rate of any field within the site.

9. No crops grown for direct human consumption, whose harvested parts may touch the ground or in some other way come in contact with the biosolids, shall be grown on any biosolids amended area for at least 18 months following the date of the last application of biosolids.

10. A 30-day period shall follow the application of biosolids on any field prior to grazing livestock on or harvesting fodder from that field.

11. Biosolids land application shall cease when the potential exists for nuisance conditions or runoff beyond the approved areas.

12. In the event an odor problem is reported to the Department after biosolids application, corrective action must be taken to counteract that condition.

13. The City of Madras shall maintain records which indicate the date; location and amount of biosolids applied; segments of each field that received biosolids; pounds of nutrients applied to each area receiving biosolids; and the type of crop grown. These records must remain available for Department evaluation for at least five years after biosolids land application has been discontinued.

14. The City of Madras shall promptly advise DEQ of any major changes it intends to make to its biosolids processing activities, which could influence biosolids quality or quantity before anticipated modifications are initiated.

15. All biosolids spills shall be immediately cleaned up by the City of Madras or by the transporter under the direction of the City. Spillage, which cannot be completely cleaned up, must be covered with dry lime and posted where appropriate.

16. The Department may impose any additional restrictions or conditions deemed necessary to assure adequate biosolids management. Any variations from the City's approved biosolids management plan and this authorization letter must receive prior written approval from the Department.

This authorization is subject to revocation should health hazards, environmental degradation, or nuisance conditions develop as a result of inadequate biosolids stabilization or site management.

If you have any questions regarding the issues in this letter please call me in Bend at 541-388-6146, ext. 233.

Sincerely,

Thomas D. Hall

Thomas D. Hall
Water Quality Specialist

TDH/mb

cc: Jefferson County Planning Department

DEQ-DCI

Oregon

DEPARTMENT OF
ENVIRONMENTAL
QUALITY

EASTERN REGION

Bend Office

April 16, 1996

RECEIVED

APR 18 1996

CITY OF MADRAS
PUBLIC WORKS

Keith Bedell, Biosolids Coordinator
City of Madras W.W.T.F.
71 SE "D" Street
Madras, OR 97741-1685

RE: City of Madras' Biosolids Management Plan Approval
File No. 52520
WPCF Permit No. 100992

Dear Keith:

The Department has reviewed the City of Madras' draft Biosolids Management Plan, dated February, 1996. Based on a review of the Biosolids Management Plan the Department is pleased to advise the City that its Biosolids Management Plan is approved subject to the following conditions:

- Sufficient hydrated lime (calcium hydroxide) or quick lime (calcium oxide) shall be available at the City's wastewater treatment facility for use as a disinfectant or deodorant in the event of an accidental spill during solids handling;

- The City shall promptly advise DEQ of any significant changes it intends to make in its solids handling activities which could substantially change the quality or quantity of biosolids prior to making these changes. In accordance with Schedule D, Condition 1 of the City's WPCF permit, any substantial changes in sludge management activities which significantly differ from operations specified under the approved plan will require prior written approval by the Department.

- The City shall advise DEQ before any industrial wastewater sources are connected to the City's collection system that could have significant impact on biosolids quality or quantity; and

- The City shall maintain detailed records adequate to characterize its solids stabilization, biosolids handling, and land application activities.

A summary of the City of Madras' biosolids management operation is included as Attachment A.

2146 NE 4th Street
Suite 104
Bend, OR 97701
(541) 388-6146

If you have any questions about this biosolids management plan approval please call me at (541) 388-6146, extension 244.

Sincerely,

Paul A. DeVito
Water Quality Specialist
Eastern Region - Bend

PAD/ns

Attachment

cc: Doug Peters, Biosolids Coordinator, Water Quality Division
File No. 52520

ATTACHMENT A

City of Madras Biosolids Management Plan Elements

The City of Madras operates a wastewater collection and treatment system that receives approximately 0.45 MGD of wastewater. Contributing wastewater flows consist of 63% residential, 30% commercial, and 7% industrial. Septage is no longer received at the facility. The treatment facility consists of two 10-acre primary lagoons, two 2.5-acre secondary lagoons, a 2-acre polishing pond, a dissolved air floatation (DAF) system, chlorine disinfection, sludge storage pond, and a 25-acre effluent storage pond for treated effluent reuse.

Biological treatment of liquid and solid wastes occurs in the primary and secondary lagoons, as well as the polishing pond. Settling of solids occurs mainly in the primary lagoons. The secondary lagoons and polishing pond provide polishing of the wastewater and additional settling of solids. Solids removed from these ponds are stored in the two primary lagoons and removal is not anticipated within the next five years.

The DAF system removes suspended solids, mainly of algae content, from the wastewater prior to disinfection. Solids are removed by two-stage dissolved air floatation with chemical addition followed by filtration. Collected solids then flow to the sludge storage pond which holds 800,000 gallons. Over a period of approximately five months, during which time the DAF system is shut down for the winter, the sludge is allowed to biologically digest in the sludge storage pond. The process is a combination of aerobic, during the time the sludge is first put in the pond, and anaerobic, after the sludge has been sitting in the pond for an extended period of time. Approximately 43.5 dry tons of tertiary solids are generated at the facility annually.

The City is approved to apply biosolids on 200 acres of land located on two City-owned sites adjacent to the treatment facility and City airport (parcels numbered 10 and 14 of Exhibit "B" of the Biosolids Management Plan).

CITY OF MADRAS

71 SE D STREET MADRAS, OR 97741-1685 541-475-2344 - FAX 475-7061

Gave to Jayne West 9-14-05

Supplement B

September 14, 2005

The City of Madras would like to add Field #9 to our Bio-Solids Management Plan. This field is next to field #8 and has the same characteristics, #9 consists of 38 acres. It is currently used as an effluent disposal site with hay grown as the crop and is monitored for the agronomic loading rate. To calculate the agronomic rate for this field we would have to add the bio-solids nitrogen content to the effluent and subtract this from the total allowable nitrogen addition for fertilizer.

We will continue to utilize the same process for Pathogen Reduction which is:

(b) *Sewage sludge—Class B.* (1)(i) The requirements in either §503.32(b)(2), (b)(3), or (b)(4) shall be met for a sewage sludge to be classified Class B with respect to pathogens.

(ii) The site restrictions in §503.32(b)(5) shall be met when sewage sludge that meets the Class B pathogen requirements in §503.32(b)(2), (b)(3), or (b)(4) is applied to the land.

(2) *Class B—Alternative 1.* (i) Seven representative samples of the sewage sludge that is used or disposed shall be collected.

(ii) The geometric mean of the density of fecal coliform in the samples collected in paragraph (b)(2)(i) of this section shall be less than either 2,000,000 Most Probable Number per gram of total solids (dry weight basis) or 2,000,000 Colony Forming Units per gram of total solids (dry weight basis)

and for Vector Attraction Reduction would like to add the process:

Title 40 Code of Federal Regulations Part 503.33(b)(7) The percent solids of sewage sludge that does not contain unstabilized solids generated in a primary wastewater treatment process shall be equal to or greater than 75 percent based on the moisture content and total solids prior to mixing with other materials.

The City would also like to include the use of a sander/fertilizer spreader for the application of the 75% or greater bio-solids. This spreader has a chain drive to put the bio-solids to the rotating disk to spread the bio-solids.

This supplement shall be added to the existing Bio-Solids Management Plan which was submitted in February, 1996 and approved on April 16, 1996.

Oregon
Theodore R. Kulongoski, Governor

Department of Environmental Quality
2146 NE 4th Street, Suite 104
Bend, OR 97701
(541) 388-6146
Eastern Region
Bend Office

September 22, 2005

Keith Bedell, Wastewater Supervisor
City of Madras
800 SE Grizzly Rd.
Madras, OR 97741

RE: Biosolids Management Plan
Supplement Approval
Permit #101739; File #52520
WQ-Jefferson County

Dear Keith:

On September 14, 2005, the Department received the Biosolids Management Plan Supplement from the City of Madras submitted in accordance with 40 CFR Part 503 and Oregon Administrative Rule (OAR) 340-50. The Supplement includes the following:

1. To meet pathogen reduction requirements, Alternative 1 in 40 CFR 503.32 (b)(2) will be applied, which requires the geometric mean of the density of fecal coliform in seven samples to be less than either 2,000,000 Most Probable Number per gram of total solid on a dry weight basis, or 2,000,000 Colony Forming Units per gram of total solid on a dry weight basis.

2. To meet vector attraction reduction requirements, 40 CFR 503.33 (b)(7) will be applied as follows: the percent solids of sewage sludge that does not contain unstabilized solids generated in a primary wastewater treatment process shall be equal to or greater than 75 percent based on the moisture content and total solids prior to mixing with other materials.

3. The addition of Field #9 to the list of approved biosolids application sites.

4. The use of a sander/fertilizer spreader truck to apply the biosolids to the fields.

Based upon the Department's evaluation, information the City has submitted, and DEQ site visit on September 14, 2005, the Supplement is approved provided:

1. Solids processing and handling will comply with Oregon biosolids rules and guidelines (OAR 340-50-005 to OAR 340-50-080) and all other applicable statutes, rules, and federal regulations.
2. Prior to land application, the biosolids must meet one of the three pathogen reduction standards required under 40 CFR 503.32(b).
3. The agronomic rate for each field must be calculated and compared to the actual dry tons/acre applied and submitted with the annual report. Changes in biosolids characteristics or cropping practices will necessitate appropriate adjustments in

the annual application rate to maintain nitrogen loadings consistent with crop demands.

4. If other sources of nitrogen will be applied to the fields, the biosolids application rate must be reduced so that commercial fertilizer nitrogen, animal manure, or green chop nitrogen, plus biosolids nitrogen, do not exceed the agronomic loading rate of any field within the site.
5. The City's truck operator shall immediately clean up any spillage of biosolids. Spillage which cannot be completely cleaned up must be covered with dry lime and posted where appropriate.
6. The DEQ Bend Office (388-6146) shall be notified within one hour of any biosolids spills greater than 50 gallons, or other threats to the environment that may occur. Spills that occur after normal working hours shall be reported to the Emergency Management Division (EMD) within one hour. The telephone number of EMD is 1-800-452-0311.
7. A 50 foot minimum (300 foot minimum if biosolids gun application is used) setback shall be maintained between biosolids application areas and all highways, public roadways, and property lines.
8. A minimum setback of 200 feet shall be maintained between biosolids application areas and all wells and other water sources except irrigation ditches.
9. Biosolids shall be applied evenly and thinly in a manner that will prevent ponding and runoff.
10. No food crops for direct human consumption, whose harvested parts are grown below ground shall be planted on any biosolids amended area for at least 38 months following biosolids land spreading.
11. No food chain crops for direct human consumption, whose harvested parts are grown above ground (e.g., tomatoes) shall be grown on any biosolids amended area for at least 14 months following biosolids land spreading.
12. A 30-day fallow period shall follow the application of biosolids prior to grazing livestock on any biosolids amended field or harvesting animal feed crops from biosolids amended areas.
13. Public access to field sites shall be restricted for at least 12 months after biosolids land spreading has ceased.
14. In the event an odor problem is reported at any land application site, immediate steps, such as, but not limited to, the addition of liming materials, must be taken to counteract that condition.
15. The City shall maintain daily records for the biosolids land application site which indicate (on a field map grid system) where, when, and how many (gallons) biosolids were land applied to the specific fields on the property to verify that annual loading limitations are not being exceeded.
16. Site records shall indicate the date, location and amount of biosolids applied.
17. The Department shall have the right to enter the Madras WWTP's place of record keeping to review biosolids management operations and records; obtain copies of any records required under the terms of this approval and the WWTP's biosolids (sludge) management plan; inspect any monitoring equipment required under this authorization; inspect any collection, transport, or land spreading vehicles; and obtain any photographic documentation or evidence deemed appropriate.

City of Madras
800 SE Grizzly Rd.
Madras, OR 97741

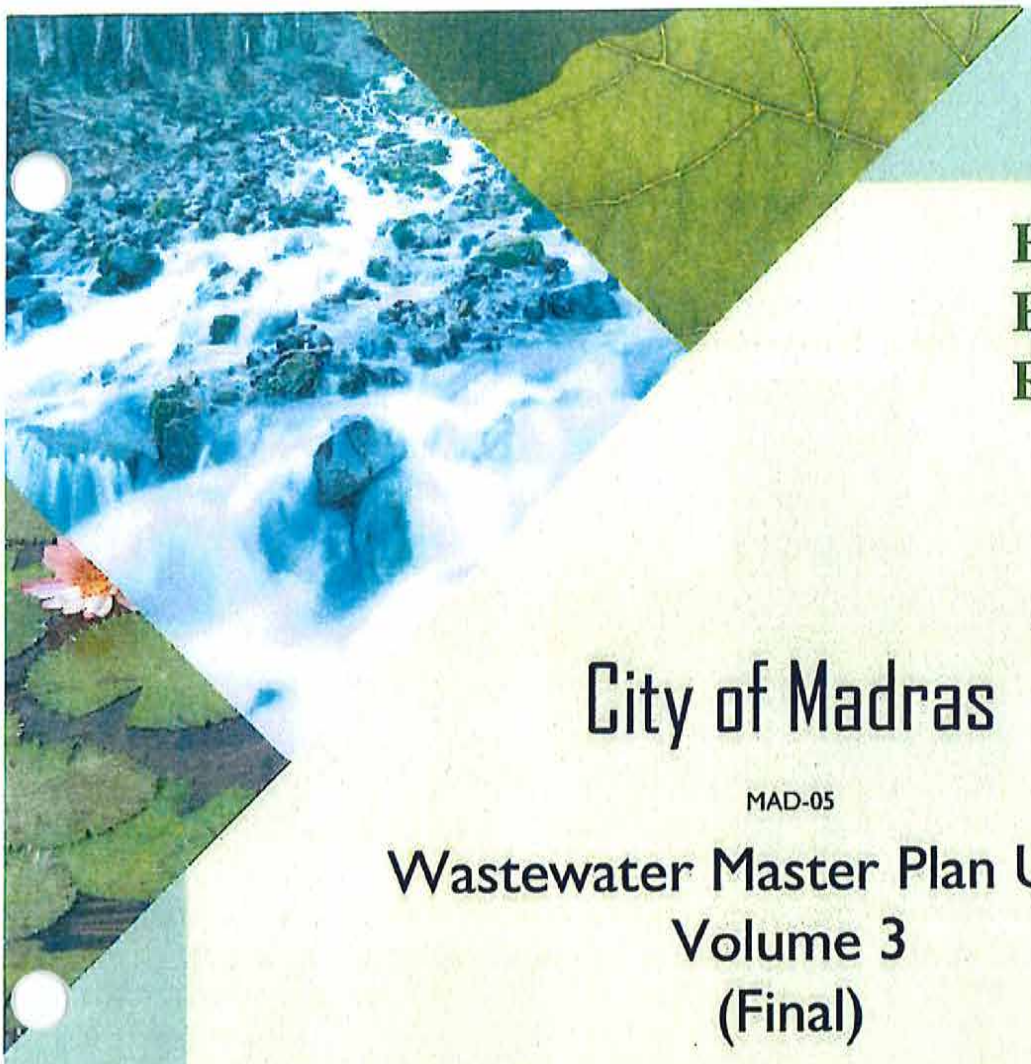
18. The City shall provide DEQ an annual summary of biosolids processing and land application activities. This annual biosolids report shall be submitted to the DEQ on or before February 15th of each year.
19. The Department may impose, at a future date, additional restrictions or conditions deemed necessary to assure adequate biosolids management. Any variations from the City's DEQ approved biosolids management plan and this supplement approval letter must receive prior written approval from the DEQ Bend Office.
20. This approval is subject to revocation should health hazards, environmental degradation, or nuisance conditions develop as a result of inadequate solids treatment or site management. If operations are not conducted in accordance with terms specified under this approval, the department will initiate necessary remedial action.

If you have any questions regarding this approval, please contact me at 388-6146, extension 244.

Sincerely,

Jayne West

Jayne West
Water Quality Permit Specialist
Eastern Region Bend



Harper
Houf Peterson
Righellis Inc.

City of Madras

MAD-05

Wastewater Master Plan Update
Volume 3
(Final)

May 2018

Prepared For:

City of Madras
125 SW "E" Street
Madras, OR 97741
P: 541-475-2344

Enter client number (if applicable)

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ENGINEERS ♦ PLANNERS
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Houf Peterson
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CITY OF MADRAS

WASTEWATER MASTER PLAN UPDATE

VOLUME THREE
APPENDICES C THRU Q
(FINAL)

EXPIRES 12-31-2019

May 2018

205 SE Spokane Street • Suite 200 • Portland, Oregon 97202 • HHPR.COM • P (503) 221-1131 • F (503) 221-1171

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX C

GRAVITY SEWER AND MANHOLE INVENTORY

- C-1 INDUSTRIAL PARK SEWERS
- C-2 CITY SEWERS (MAIN COLLECTION SYSTEM)

APPENDIX C1 INDUSTRIAL PARK SEWERS

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Pipe Length
IA-1	Demers PS Wet Well	2438.00	RCP	18	2423.50	2423.00	0.25252	2.00
IA-2	IA-1	2437.78	RCP	10	2427.15	2425.63	0.34242	447.88
IA-3	IA-2	2337.60	RCP	10	2428.64	2427.17	0.29732	498.41
IA-4	IA-3	2437.61	RCP	10	2430.16	2428.68	0.29820	500.25
IA-5	IA-4	2437.84	RCP	10	2431.72	2430.22	0.30193	500.84
IA-6	IA-5	2438.76	RCP	10	2433.15	2431.74	0.28443	499.66
IA-7	IA-6	2439.83	RCP	10	2434.88	2433.43	0.29859	489.56
IA-8	IA-7	2442.59	RCP	10	2436.38	2434.88	0.30211	500.46
IA-9	IA-8	2444.97	RCP	10	2437.63	2436.38	0.29811	423.28
IA-9-1	IA-9	2444.50	RCP	10	2439.50	2438.00	0.30242	500.00
IA-10	IA-9	2445.14	RCP	10	2438.26	2437.71	0.36891	153.08
IA-10-1	IA-10	2449.66	RCP	8	2443.95	2438.32	1.25713	451.84
IA-11	IA-10	2445.14	RCP	10	2439.02	2438.27	0.23006	329.97
IA-12	IA-11	2446.11	RCP	10	2440.34	2439.11	0.41344	301.48
IA-13	IA-12	2447.30	RCP	8	2442.94	2440.48	0.71363	348.74
IA-13-1	IA-13	2450.44	RCP	8	2444.92	2443.02	0.56410	340.83
IA-14	IA-13	2457.00	RCP	8	2446.90	2444.99	0.60824	318.04
IA-15	IA-14	2458.97	RCP	8	2447.98	2446.94	0.79511	134.78
IA-15-1	IA-15	2459.08	RCP	8	2451.42	2447.99	0.69954	494.30
IA-15-2	IA-15-1	2462.20	RCP	8	2453.62	2451.59	0.40911	500.20
IA-15-3	IA-15-2	2461.31	RCP	8	2455.60	2453.65	0.39398	499.00
IA-16	IA-15	2457.67	RCP	10	2448.45	2447.99	0.33598	140.88
IA-16-1	IA-16	2457.30	RCP	10	2449.63	2448.50	0.31178	366.38
IA-16-1-1	IA-16-1	2457.72	RCP	8	2452.24	2449.71	1.79661	144.78
IA-16-2	IA-16-1	2456.81	RCP	10	2451.25	2449.70	0.31403	497.60
IA-16-3	IA-16-2	2458.19	RCP	8	2452.99	2451.35	0.40242	411.50
IA-16-4	IA-16-3	2462.01	RCP	8	2454.99	2453.04	0.41907	469.30
IA-16-5	IA-16-4	2466.18	RCP	8	2460.19	2455.15	2.99511	172.20
IA-17	IA-16	2457.58	RCP	8	2450.66	2448.52	0.43090	500.64
IA-18	IA-17	2458.25	RCP	8	2452.75	2450.79	0.42654	463.54
IA-19	IA-18	2459.16	RCP	8	2454.15	2452.84	0.33533	394.59
IA-20	IA-19	2464.33	RCP	8	2457.92	2454.18	0.85268	442.58
IA-20-1	IA-20	2464.27	RCP	10	2458.63	2457.97	0.29200	230.00
IA-20-2	IA-20-1	2464.94	RCP	10	2460.47	2458.72	0.36172	487.80
IA-21	IA-20	2466.48	RCP	8	2460.29	2458.22	2.39523	90.43
IA-21-1	IA-21	2473.14	RCP	8	2467.54	2460.39	1.44112	500.10
IA-21-2	IA-21-1	2480.60	RCP	8	2476.89	2467.67	1.86079	499.40
IB-2	IA-1	2436.70	RCP	10	2426.27	2425.71	0.20016	228.77
IB-2A	IB-2	2438.50	RCP	8	2429.61	2426.27	1.60560	212.00
IB-3	IB-2	2439.20	RCP	10	2428.03	2426.29	0.35222	498.00
IB-2-1	IB-2	2442.15	RCP	8	2430.20	2426.70	0.78473	450.00
IB-2-2	IB-2-1	2444.89	RCP	8	2433.23	2430.40	0.59454	480.00
IB-2-3	IB-2-2	2446.90	RCP	8	2435.27	2433.33	0.41451	472.04

APPENDIX C1 INDUSTRIAL PARK SEWERS

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Pipe Length
IB-2-4	IB-2-3	2452.25	RCP	8	2439.93	2436.77	0.06174	262.96
IB-2-5	IB-2-4	2459.98	RCP	8	2444.13	2439.93	1.21377	350.00
IB-2-6	IB-2-5	2459.84	RCP	8	2447.76	2444.13	1.21603	302.49
IB-2-3-1	IB-2-3	2444.29	RCP	8	2437.24	2435.37	0.39382	478.80
IB-2-3-2	IB-2-3-1	2445.58	RCP	8	2438.72	2437.29	0.38636	374.10
IB-2-3-3	IB-2-3-2	2446.88	RCP	8	2439.92	2438.83	0.36856	299.70
IB-2-3-4	IB-2-3-3	2449.56	RCP	8	2441.41	2439.95	0.50976	290.40
IB-2-3-5	IB-2-3-4	2449.56	RCP	8	2442.94	2441.56	0.38652	361.00
IB-3.1	IB-3	2437.04	PVC	12	2428.49	2428.03	0.00206	223.00
IB-3.2	IB-3.1	2438.68	PVC	12	2429.5	2428.69	0.00202	400.00
IB-3.3	IB-3.2	2436.68	PVC	12	2430.31	2429.51	0.00200	400.00
IB-3.4	IB-3.3	2434.8	PVC	12	2431.1	2430.32	0.00195	400.00
IB-2-7	IB-2-6	2465.71	PVC	8	2458.53	2456	0.00647	390.95
IB-2-8	IB-2-7	2466.75	PVC	8	2459.87	2458.63	0.00398	311.50
IB-2.3-1	IB-2-3	2444.7	PVC	8	2437.34	2435.65	0.00399	423.15
IB-2.3-2	IB-2.3-1	2444.1	PVC	8	2439.18	2437.44	0.00400	435.18
IB-2.3-3	IB-2.3-2	2444.7	PVC	8	2440.41	2439.28	0.00400	282.57
IB-2.3-4	IB-2.3-3	2451.5	PVC	8	2442.11	2440.51	0.00400	400.00
IB-2.3-5	IB-2.3-4	2456.9	PVC	8	2448.8	2444	0.01600	300.00
IB-2.6-1	IB-2-6	2460.6	PVC	8	2449.08	2448.07	0.00526	192.02
IB-2.6-2	IB-2.6-1	2464.64	PVC	8	2450.52	2449.18	0.00398	337.02
IB-2.6-3	IB-2.6-2	2460.04	PVC	8	2451.94	2450.62	0.00402	328.68
IB-2.6-4	IB-2.6-3	2458.94	PVC	8	2453.04	2452.04	0.00400	250.00
IB-2.6.2-1	IB-2.6-2	2463.29	PVC	8	2457.93	2456.96	0.01271	76.32
IB-2-9	IB-2-8	2466.24	PVC	8	2459.94	2459.25	0.00374	184.50
IB-2-10	IB-2-9	2468.69	PVC	8	2460.85	2459.94	0.00897	101.45
IB-2-11	IB-2-10	2470.14	PVC	8	2462.34	2460.85	0.00447	333.16
IB-2-12	IB-2-11	2470.99	PVC	8	2462.57	2462.34	0.00102	224.87

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
I-A	B ST PS DIV STRUCTURE	2235.00	DIP	18	2220.00	2219.70	0.0315	9.52
I-0	I-A	2234.54	RCP	18	2220.27	2220.00	0.0039	69.49
I-1	I-0	2234.00	ACP	18	2220.62	2220.46	0.0009	174.74
I-2	I-1	2234.70	ACP	18	2220.95	2220.62	0.0012	275.00
I-3	I-2	2236.00	ACP	15	2221.58	2221.15	0.0016	270.00
I-4	I-3	2236.00	ACP	15	2221.94	2221.58	0.0020	182.00
I-5	I-4	2237.00	ACP	15	2222.89	2221.94	0.0023	420.00
I-6	I-5	2239.00	ACP	12	2224.16	2223.19	0.0024	405.00
I-7	I-6	2240.50	ACP	12	2224.96	2224.16	0.0024	330.00
I-8	I-7	2241.20	ACP	12	2225.59	2224.96	0.0024	265.00
I-9	I-8	2241.60	ACP	10	2226.57	2225.59	0.0037	268.00
I-10	I-9	2241.60	ACP	10	2227.85	2226.67	0.0028	420.00
I-11	I-10	2244.00	ACP	10	2229.54	2227.95	0.0060	265.00
I-12	I-11	2245.00	ACP	10	2230.22	2229.54	0.0028	242.00
A-1	I-12	2245.10	ACP	8	2231.28	2230.45	0.0157	53.00
A-2	A-1	2246.80	ACP	8	2232.99	2231.28	0.0037	468.00
A-3	A-2	2247.20	ACP	8	2235.58	2233.09	0.0096	260.00
A-4	A-3	2247.80	ACP	8	2237.32	2235.58	0.0044	396.00
A-5	A-4	2247.20	ACP	8	2237.62	2237.37	0.0040	63.00
A-6	A-5	2247.50	ACP	8	2238.01	2237.67	0.0039	88.00
A-7	A-6	2248.20	ACP	8	2239.76	2238.06	0.0680	25.00
A-8	A-7	2250.10	ACP	8	2242.82	2239.90	0.0082	356.00
A-9	A-8	2251.90	ACP	8	2244.34	2242.92	0.0040	356.00
A-11	A-9	2267.10	ACP	8	2257.58	2244.44	0.0424	310.00
A-12	A-11	2266.90	ACP	8	2258.20	2257.68	0.0040	129.00
A-13	A-12	2275.70	ACP	8	2267.07	2258.30	0.0516	170.00
A-14	A-13	2275.00	ACP	8	2268.37	2267.17	0.0040	301.00
A-15	A-14	2296.30	ACP	8	2289.06	2268.47	0.0520	396.00
A.1-1	I-2	2239.00	ACP	8	2232.21	2228.09	0.0088	468.00
A.1-3	A.1-1	2241.50	ACP	8	2234.34	2232.31	0.0048	422.00
A.1-4	A.1-3	2246.10	ACP	8	2240.99	2234.44	0.0252	260.00
A.1-5	A.1-4	2257.40	ACP	8	2251.73	2241.09	0.0304	350.00
A.1-6	A.1-5	2261.40	ACP	8	2254.18	2251.73	0.0096	255.00
A.1-7	A.1-6	2264.80	ACP	8	2255.26	2254.18	0.0043	251.00
A.1-8	A.1-7	2268.10	ACP	8	2256.22	2255.26	0.0037	259.00
A.1-9	A.1-8	2273.40	ACP	8	2257.25	2256.22	0.0040	258.00
A.1-10	A.1-9	2266.10	ACP	8	2258.44	2257.25	0.0044	273.00
A.1-11	A.1-10	2274.60	ACP	8	2265.41	2260.18	0.0136	385.00
A.1-12	A.1-11	2280.60	ACP	8	2274.00	2268.42	0.0187	299.00
A.1-13	A.1-12	2286.50	ACP	8	2279.91	2274.00	0.0280	211.00
A.1-14	A.1-13	2301.00	ACP	8	2293.98	2279.91	0.0300	469.00
A.1-15	A.1-14	2310.00	ACP	8	2299.16	2293.98	0.0140	370.00
A.1.1-1	A.1-7	2275.20	ACP	8	2267.64	2255.36	0.0460	267.00

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
A.1.1-2	A.1.1-1	2283.80	ACP	8	2272.43	2267.74	0.0112	419.00
A.1.1-3	A.1.1-2	2289.60	ACP	8	2278.37	2272.43	0.0184	323.00
A.1.1-4	A.1.1-3	2294.90	ACP	8	2288.30	2282.11	0.0200	310.00
A.1.2-1	A.1-9	2284.30	ACP	8	2274.48	2267.23	0.0148	489.00
A.1.2-2	A.1.2-1	2282.40	ACP	8	2276.52	2274.58	0.0040	490.00
A.1.2-3	A.1.2-2	2285.80	ACP	8	2279.68	2276.62	0.0220	139.00
A.1.2-4	A.1.2-3	2294.00	ACP	8	2286.99	2279.78	0.0568	127.00
A.1.2-5	A.1.2-4	2294.90	ACP	8	2288.81	2287.07	0.0109	159.00
A.1.2-6	A.1.2-5	2299.90	ACP	8	2294.54	2289.90	0.0232	200.00
A.1.2.1-1	A.1.2-3	2286.40	ACP	6	2281.33	2279.88	0.0132	110.00
A.1.2.2-1	A.1.2-4	2295.90	ACP	8	2290.75	2287.09	0.0120	305.00
A.1.3-1	A.1-10	2269.10	ACP	8	2263.36	2259.40	0.0132	300.00
A.1.3-2	A.1.3-1	2276.50	ACP	8	2269.91	2263.36	0.0305	215.00
A.1.3-3	A.1.3-2	2297.10	ACP	8	2290.43	2270.01	0.0444	460.00
A.1.3-4	A.1.3-3	2302.00	ACP	8	2295.29	2290.53	0.0136	350.00
A.1.3.1-1	A.1.3-2	2281.60	ACP	8	2276.90	2270.70	0.0496	125.00
A.1.4-1	A.1-11	2275.10	ACP	8	2266.01	2265.51	0.0040	125.00
A.2-1	I-3	2237.80	ACP	8	2226.88	2226.00	0.0040	220.00
A.2-2	A.2-1	2239.20	ACP	8	2230.36	2228.36	0.0080	250.00
A.2-3	A.2-2	2239.80	ACP	8	2231.21	2230.46	0.0040	188.00
A.2-4	A.2-3	2243.30	ACP	8	2236.48	2232.76	0.0100	372.00
A.2-5	A.2-4	2248.50	ACP	8	2242.56	2236.48	0.0152	400.00
A.2-6	A.2-5	2253.50	ACP	8	2247.08	2242.56	0.0175	259.00
A.2-7	A.2-6	2255.80	ACP	8	2249.68	2247.08	0.0129	201.00
A.2-8	A.2-7	2264.30	ACP	8	2258.89	2249.68	0.0340	271.00
A.2-9	A.2-8	2274.80	ACP	8	2268.57	2258.99	0.0240	399.00
A.2-10	A.2-9	2279.40	ACP	8	2272.77	2268.57	0.0100	420.00
A.2-11	A.2-10	2281.00	ACP	8	2275.40	2273.00	0.0141	170.00
A.2-12	A.2-11	2289.70	ACP	8	2283.06	2276.00	0.0840	84.00
A.2-13	A.2-12	2294.70	ACP	8	2289.05	2283.06	0.0183	327.00
A.2-14	A.2-13	2303.50	ACP	8	2297.79	2289.15	0.0320	270.00
A.2.1-1	A.2-2	2244.50	ACP	8	2237.74	2231.96	0.0140	413.00
A.2.1-2	A.2.1-1	2247.30	ACP	8	2241.07	2237.74	0.0116	287.00
A.2.1-3	A.2.1-2	2250.50	ACP	8	2244.83	2241.07	0.0148	254.00
A.2.1A-1	A.2-3	2240.50	ACP	8	2234.50	2231.21	0.0108	305.00
A.2.1A-2	A.2.1A-1	2242.30	ACP	8	2236.28	2234.60	0.0040	420.00
A.2.1A-3	A.2.1A-2	2243.00	ACP	8	2236.77	2236.38	0.0040	98.00
A.2.1A-4	A.2.1A-3	2243.80	ACP	8	2237.49	2236.87	0.0040	155.24
A.2.1A-5	A.2.1A-4	2244.60	ACP	8	2238.03	2237.59	0.0040	110.00
A.2.1A-6	A.2.1A-5	2245.90	ACP	6	2240.84	2238.03	0.0739	38.00
A.2.1A.2-1	A.2.1A-5	2245.00	ACP	8	2238.56	2238.26	0.0060	50.00
A.2.1A.1-1	A.2.1A-4	2250.90	ACP	8	2244.64	2237.49	0.0260	275.00
A.2.2-1	A.2-7	2260.10	ACP	8	2254.40	2249.90	0.0225	200.00

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
A.2.2-2	A.2.2-1	2265.10	ACP	8	2257.52	2254.40	0.0101	310.00
A.2.2-3	A.2.2-2	2268.00	ACP	8	2260.24	2257.52	0.0160	170.00
A.2.2-4	A.2.2-3	2271.00	ACP	8	2262.88	2260.24	0.0160	165.00
A.2.2-5	A.2.2-4	2269.80	ACP	6	2263.77	2263.11	0.0060	110.00
A.2.2.1-1	A.2.2-2	2266.90	ACP	6	2260.75	2257.75	0.0300	100.00
A.2.2.2-1	A.2.2-3	2267.10	ACP	6	2261.13	2260.47	0.0060	110.00
A.3A-1	I-4	2238.70	ACP	8	2233.41	2232.02	0.0040	350.00
A.3.1-1	I-4	2239.10	ACP	8	2231.20	2229.88	0.0089	148.00
A.4-1	I-5	2236.50	ACP	8	2226.65	2226.39	0.0041	64.00
A.4-2	A.4-1	2237.50	ACP	8	2227.83	2226.65	0.0040	296.00
A.4-3	A.4-2	2240.80	ACP	8	2228.68	2227.93	0.0040	187.00
A.4-4	A.4-3	2239.49	ACP	8	2229.39	2228.78	0.0040	153.00
A.4-5	LS-7	2249.50	ACP	8	2236.49	2233.90	0.0087	298.88
A.4-6	A.4-5	2246.80	ACP	8	2237.67	2236.59	0.0041	266.00
A.4-7	A.4-6	2248.30	ACP	8	2239.92	2237.75	0.0120	181.00
A.4-8	A.4-7	2252.21	ACP	8	2240.96	2239.97	0.0036	275.52
1.2.3-2	F	2287.10	RCP	8	2279.10	2278.56	0.0012	460.00
1.2.3-3	1.2.3-2	2300.91	RCP	8	2296.06	2279.22	0.0366	460.00
A.10.1.10-1	A.10.1-10	2359.00	ACP	8	2354.50	2319.28	0.0870	405.00
A.10.1.1-1	A.10.1-1	2271.80	ACP	8	2266.92	2265.33	0.0040	397.00
A.10.1.1-2	A.10.1.1-1	2276.50	ACP	6	2270.03	2267.15	0.0200	144.00
A.10.1.8-1	A.10.1-8	2355.75	PVC	8	2350.00	2317.66	0.0809	400.00
A.10.1-1	A.10-3	2278.50	PVC	8	2265.23	2258.71	0.0172	379.00
A.10.1-10	A.10.1-9	2325.84	PVC	8	2319.28	2318.60	0.0044	154.81
A.10.1-11	A.10.1-10	2333.12	PVC	8	2328.39	2321.00	0.0296	249.33
A.10.1-12	A.10.1-11	2342.89	PVC	8	2332.75	2328.49	0.0268	158.75
A.10.1-13	A.10.1-12	2347.80	PVC	8	2341.04	2332.75	0.0650	127.50
A.10.1-14	A.10.1-13	2357.01	PVC	8	2350.13	2341.14	0.0946	95.04
A.10.1-15	A.10.1-14	2360.72	PVC	8	2352.00	2350.23	0.0314	56.45
A.10.1-16	A.10.1-15	2360.36	PVC	8	2353.70	2352.10	0.0064	249.86
A.10.1-17	A.10.1-16	2360.84	PVC	8	2354.40	2353.80	0.0125	48.11
A.10.1-18	A.10.1-17	2364.25	PVC	8	2358.15	2354.50	0.0355	102.93
A.10.1-2	A.10.1-1	2285.80	ACP	8	2272.60	2271.52	0.0040	270.00
A.10.1-3	A.10.1-2	2284.30	ACP	8	2274.36	2272.70	0.0040	416.00
A.10.1-4	A.10.1-3	2290.20	ACP	8	2282.67	2274.36	0.0361	230.00
A.10.1-5	A.10.1-4	2297.25	RCP	8	2289.21	2282.67	0.0451	145.00
A.10.1-6	A.10.1-5	2304.75	RCP	8	2297.45	2289.90	0.0285	265.00
A.10.1-7	A.10.1-6	2317.25	RCP	8	2311.33	2298.95	0.0550	225.00
A.10.1-8	A.10.1-7	2326.80	RCP	8	2317.66	2311.33	0.0178	356.50
A.10.1-9	A.10.1-8	2325.84	RCP	8	2318.60	2317.76	0.0054	155.19
A.10.2-1	A.10-7	2279.20	ACP	8	2268.90	2266.00	0.0116	250.00
A.10.2-2	A.10.2-1	2280.20	ACP	8	2270.40	2268.90	0.0040	374.00
A.10.2-3	A.10.2-2	2277.50	ACP	8	2270.88	2270.50	0.0040	95.00

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
A.10.2-4	A.10.2-3	2289.00	PVC	8	2279.19	2270.88	0.0277	300.00
A.10.2-5	A.10.2-4	2316.80	PVC	6	2308.45	2279.19	0.1180	248.00
A.10-1	I-12	2246.90	ACP	8	2233.20	2232.00	0.0040	300.00
A.10-10	A.10-9	2279.90	ACP	8	2272.16	2269.10	0.0092	332.00
A.10-11	A.10-10	2283.60	ACP	8	2277.50	2274.00	0.0212	165.00
A.10-12	A.10-11	2289.20	ACP	8	2283.12	2277.60	0.0472	117.00
A.10-13	A.10-12	2294.30	ACP	6	2287.13	2283.22	0.0240	163.00
A.10-2	A.10-1	2258.50	ACP	8	2252.40	2240.00	0.2480	50.00
A.10-3	A.10-2	2263.50	ACP	8	2253.14	2252.40	0.0040	186.00
A.10-4	A.10-3	2261.70	ACP	8	2255.57	2255.07	0.0040	125.00
A.10-5	A.10-4	2269.10	ACP	8	2263.08	2255.67	0.0360	206.00
A.10-6	A.10-5	2268.41	ACP	8	2264.40	2263.18	0.0483	25.23
A.10-7	A.10-6	2272.00	ACP	8	2265.90	2264.39	0.0140	107.69
A.10-8	A.10-7	2272.40	ACP	8	2266.40	2266.01	0.0093	42.00
A.10-9	A.10-8	2276.30	ACP	8	2269.00	2266.50	0.0208	120.00
A.11.1.4-1	A.11.1-4	2256.61	PVC	8	2247.60	2245.25	0.0056	423.06
A.11.1.4-2	A.11.1.4-1	2257.92	PVC	8	2249.34	2247.80	0.0050	309.80
A.11.1.4-3	A.11.1.4-2	2256.00	PVC	8	2250.62	2249.63	0.0042	236.76
A.11.1.4-4	A.11.1.4-3	2259.38	PVC	8	2252.42	2250.82	0.0041	390.40
A.11.1-1	A.11-3	2250.00	ACP	8	2240.29	2238.49	0.0040	450.00
A.11.1-2	A.11.1-1	2252.00	ACP	8	2241.91	2240.29	0.0040	406.00
A.11.1-3	A.11.1-2	2253.50	ACP	8	2243.61	2242.01	0.0040	400.00
A.11.1-4	A.11.1-3	2255.20	ACP	8	2245.25	2243.61	0.0040	408.00
A.11-1	A-2	2246.80	ACP	8	2234.68	2233.00	0.0040	420.00
A.11-2	A.11-1	2247.10	ACP	8	2236.71	2234.68	0.0040	508.00
A.11-3	A.11-2	2248.70	ACP	8	2238.39	2236.71	0.0040	420.00
A.11-4	A.11-3	2255.20	ACP	8	2248.70	2242.04	0.0184	362.00
A.11-5	A.11-4	2273.00	PVC	8	2268.02	2248.70	0.0420	460.00
A.12-1	A-3	2248.80	ACP	8	2237.40	2235.72	0.0040	420.00
A.12-2	A.12-1	2249.00	RCP	8	2238.40	2237.50	0.0045	200.00
A.13-1	A-3	2245.70	ACP	8	2240.03	2239.49	0.0040	135.00
A.14.1-1	A.14.1-1A	2269.20	ACP	8	2264.00	2248.50	0.1292	120.00
A.14.1-1A	A-7	2253.00	ACP	8	2243.53	2239.90	0.0454	80.00
A.14.1-2	A.14.1-1	2287.20	ACP	8	2281.52	2264.10	0.0708	246.00
A.14.1-3	A.14.1-2	2292.00	RCP	6	2286.49	2281.62	0.0616	79.00
A.14.2-1	A.14-2	2286.50	ACP	8	2282.20	2274.40	0.0332	235.00
A.14.3-1	A.14-4	2284.20	RCP	8	2280.02	2279.22	0.0047	168.72
A.14.4-1	A.14-4	2300.40	ACP	8	2295.62	2284.70	0.0265	412.04
A.14.7-1	A.14.7-A	2317.85	PVC	8	2312.87	2290.61	0.0634	351.31
A.14.7-2	A.14.7-1	2327.97	PVC	8	2322.65	2312.87	0.0219	446.26
A.14.7-A	A.14-7	2296.20	PVC	8	2290.61	2288.70	0.0193	98.87
A.14-1	A-7	2265.31	ACP	8	2260.06	2240.20	0.0496	400.00
A.14-1.1	A.14-1	2263.35	RCP	8	2260.70	2260.16	0.0017	322.40

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
A.14-1.2	A.14-1.1	2268.18	RCP	8	2261.40	2260.90	0.0037	136.90
A.14-1.3	A.14-1.2	2272.53	RCP	8	2265.89	2261.50	0.0261	168.40
A.14-1.4	A.14-1.3	2278.85	RCP	8	2273.90	2266.00	0.0279	283.50
A.14-1.5	A.14-1.4	2285.00	RCP	8	2281.38	2274.00	0.0315	234.00
A.14-1.6	A.14-1.5	2289.96	RCP	8	2285.00	2281.38	0.0315	115.00
A.14-1.7	A.14-1.3	2282.77	RCP	6	2277.50	2265.89	0.1116	104.00
A.14-1.8	A.14-1.4	2282.36	RCP	8	2278.00	2273.90	0.0197	208.00
A.14-2	A.14-1	2280.30	ACP	8	2274.30	2260.16	0.0496	285.00
A.14-3	A.14-2	2281.30	ACP	8	2276.00	2274.40	0.0951	16.82
A.14-4	A.14-3	2290.90	ACP	8	2279.12	2276.10	0.0091	333.46
A.14-5	A.14-4	2296.45	PVC	8	2286.76	2285.00	0.0124	142.16
A.14-6	A.14-5	2293.00	ACP	8	2288.70	2286.53	0.0052	417.54
A.14-7	A.14-6	2293.10	PVC	8	2289.19	2288.77	0.0031	134.41
A.14-8	A.14-7	2307.41	PVC	8	2302.73	2289.19	0.0273	496.38
A.15.5-1	A.15-5	2311.70	PVC	8	2304.22	2301.87	0.0149	157.89
A.15-1	A-9	2254.80	ACP	8	2245.88	2244.44	0.0040	360.00
A.15-2	A.15-1	2258.00	ACP	8	2247.40	2245.98	0.0037	380.00
A.15-3	A.15-2	2281.69	RCP	8	2269.60	2247.40	0.0436	509.00
A.15-4	A.15-3	2300.09	RCP	8	2289.12	2269.60	0.0962	203.00
A.15-5	A.15-4	2310.17	PVC	8	2301.77	2289.22	0.0968	129.62
A.15-6	A.15-5	2316.05	PVC	8	2308.45	2301.87	0.0412	159.59
A.15-8	A.A5-7	2320.24	PVC	8	2312.81	2310.36	0.0128	192.03
A.16-1	A-11	2295.60	RCP	8	2286.53	2262.00	0.0876	280.00
A.17.1-1	A.17-1	2287.50	RCP	8	2276.54	2275.00	0.0148	104.00
A.17-1	A-13	2281.50	ACP	8	2275.00	2270.17	0.0604	80.00
A.17-2	A.17-1	2280.90	ACP	8	2275.66	2275.10	0.0040	140.00
A.17-3	A.17-2	2281.50	ACP	8	2276.36	2275.76	0.0040	150.00
A.17-4	A.17-3	2286.21	RCP	8	2278.79	2276.36	0.0104	233.20
A.17-4.1	A.17-4	2288.41	RCP	8	2282.08	2278.92	0.0157	201.50
A.17-5	A.17-4	2303.16	RCP	8	2297.63	2278.79	0.0416	452.80
A.17-6	A.17-5	2316.94	RCP	8	2307.92	2297.63	0.0316	325.60
A.17-7	A.17-6	2345.77	RCP	8	2339.43	2307.92	0.0667	472.70
A.17-8	A.17-7	2366.98	RCP	8	2359.58	2339.64	0.0784	254.30
A.17-9	A.17-8	2387.70	RCP	8	2380.00	2359.81	0.1123	179.80
A.4.10.6-1	A.4.10-6	2302.95	PVC	10	2294.80	2292.00	0.0333	84.03
A.4.10.6-2	A.4.10.6-1	2313.57	PVC	10	2300.76	2295.08	0.0435	130.52
A.4.10.6-3	A.4.10.6-2	2344.00	PVC	10	2334.60	2300.86	0.0785	430.00
A.4.10-1	A.4.10-1A	2265.89	PVC	10	2257.35	2252.48	0.0226	215.20
A.4.10-1A	A.4-10	2260.23	PVC	8	2252.48	2247.84	0.0486	95.49
A.4.10-2	A.4.10-1	2269.26	PVC	10	2261.80	2257.35	0.0688	64.70
A.4.10-3	A.4.10-2	2272.00	PVC	10	2264.00	2262.00	0.0243	82.37
A.4.10-4	A.4.10-3	2291.53	PVC	10	2283.53	2264.20	0.0616	314.01
A.4.10-5	A.4.10-4	2292.09	PVC	10	2284.82	2283.78	0.0102	101.85

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
A.4.10-6	A.4.10-5	2300.68	PVC	10	2291.79	2285.02	0.0695	97.38
A.4.10-7	A.4.10-6	2309.28	PVC	10	2302.03	2291.89	0.1181	85.85
A.4.10-8	A.4.10-7	2333.71	PVC	10	2327.71	2302.03	0.1051	244.30
A.4.1-1	A.4-6	2258.90	ACP	8	2248.04	2237.67	0.0296	350.00
A.4.1-1A	A.4.1-1	2260.14	ACP	8	2248.48	2248.04	0.2179	2.02
A.4.1-2	A.4.1-1A	2267.50	ACP	8	2253.51	2248.48	0.0435	115.60
A.4.16-1	A.4-16	2281.35	PVC	8	2278.29	2267.65	0.0197	539.78
A.4.2-1	A.4-8	2256.00	ACP	8	2246.97	2241.50	0.0376	145.52
A.4.2-2	A.4.2-1	2261.20	ACP	6	2256.29	2251.00	0.0460	115.00
A.4.5-1	A.4-5	2254.57	PVC	8	2249.52	2247.94	0.0419	37.68
A.4.5-2	A.4.5-1	2263.75	PVC	8	2251.03	2249.62	0.0040	354.19
A.4.5-3	A.4.5-2	2255.55	PVC	8	2251.73	2251.13	0.0033	182.68
A.4.8-1	A.4-8	2256.71	ACP	8	2245.62	2241.43	0.0274	152.72
A.4-10	A.4-9	2257.40	ACP	8	2248.04	2242.94	0.0226	225.84
A.4-11	A.4-10	2262.10	ACP	8	2253.81	2248.98	0.0160	302.00
A.4-12	A.4-11	2266.00	ACP	8	2255.00	2253.81	0.0036	326.55
A.4-13	A.4-12	2265.35	PVC	8	2257.50	2255.00	0.0665	37.60
A.4-14	A.4-13	2266.35	PVC	8	2264.01	2261.57	0.0073	334.98
A.4-15	A.4-14	2271.00	PVC	8	2265.45	2264.11	0.0040	334.85
A.4-16	A.4-15	2273.00	PVC	8	2266.17	2265.65	0.0040	396.73
A.4-17	A.4-16	2279.00	PVC	8	2272.42	2266.17	0.0263	178.50
A.4-18	A.4-17	2290.00	PVC	8	2282.42	2272.42	0.0231	463.28
A.4-19	A.4-18	2299.00	PVC	8	2292.32	2282.42	0.0527	188.00
A.4-20	A.4-19	2310.00	PVC	8	2303.24	2292.32	0.0433	252.00
A.4-21	A.4-20	2313.00	PVC	8	2307.00	2303.24	0.0330	114.00
A.4-9	A.4-8	2253.90	ACP	8	2242.94	2240.96	0.0090	220.19
A.5.1-1	A.5-1	2240.50	ACP	8	2233.42	2232.85	0.0040	142.00
A.5.1-2	A.5.1-1	2240.90	ACP	8	2235.22	2233.52	0.0040	426.00
A.5.1-3	A.5.1-2	2241.30	ACP	8	2235.55	2235.22	0.0041	81.00
A.5.1-4	A.5.1-3	2241.70	ACP	8	2236.72	2235.55	0.0040	293.00
A.5.2.1-1	A.5.2-2	2242.20	ACP	6	2236.50	2236.27	0.0115	19.95
A.5.2-1	A.5-3	2242.20	ACP	8	2235.58	2235.00	0.0040	145.00
A.5.2-2	A.5.2-1	2246.10	ACP	6	2236.27	2235.68	0.0031	191.00
A.5.2-3	A.5.2-2	2246.10	ACP	6	2239.20	2236.50	0.0554	48.76
A.5.3.1-1	A.5.3-1	2242.60	ACP	8	2238.49	2237.39	0.0040	275.00
A.5.3-1	A.5-6	2244.50	ACP	8	2237.29	2236.75	0.0040	134.00
A.5.3-2	A.5.3-1	2250.30	ACP	8	2244.62	2237.39	0.0300	241.00
A.5-1	I-7	2241.00	ACP	8	2226.90	2225.22	0.0040	420.00
A.5-2	A.5-1	2241.00	ACP	8	2228.78	2226.90	0.0040	470.00
A.5-3	A.5-2	2241.80	ACP	8	2230.45	2228.78	0.0040	418.00
A.5-4	A.5-3	2242.90	ACP	8	2231.69	2230.55	0.0044	260.00
A.5-5	A.5-4	2242.80	ACP	8	2232.22	2231.69	0.0040	132.00
A.5-6	A.5-5	2243.90	ACP	8	2236.65	2235.50	0.0040	288.00

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
A.5-7	A.5-6	2250.40	ACP	8	2243.01	2236.65	0.0300	212.00
A.5-8	A.5-7	2277.40	ACP	8	2268.81	2243.01	0.0860	300.00
A.5-9	A.5-8	2303.10	ACP	8	2296.81	2268.81	0.0560	500.00
A.6.1-1	A.6-1	2241.00	ACP	8	2232.20	2231.33	0.0060	145.00
A.6.2-1	A.6-3	2272.30	ACP	8	2262.95	2245.26	0.0650	272.00
A.6.2-2	A.6.2-1	2275.00	ACP	8	2263.63	2263.05	0.0040	146.00
A.6.2-3	A.6.2-2	2285.10	ACP	8	2276.06	2264.00	0.0300	402.00
A.6.2-4	A.6.2-3	2296.20	ACP	8	2292.18	2281.10	0.0468	237.00
A.6.3-1	A.6-7	2285.00	ACP	8	2279.75	2277.11	0.0112	235.00
A.6.4.1-1	A.6.4-1	2301.40	PVC	8	2293.84	2284.05	0.0334	293.00
A.6.4-1	A.6-8	2287.70	PVC	8	2282.61	2279.96	0.0074	360.00
A.6.4-2	A.6.4-1	2289.50	PVC	8	2284.05	2282.71	0.0079	170.00
A.6-1	I-7	2240.20	ACP	8	2230.80	2229.79	0.0028	362.00
A.6-2	A.6-1	2249.50	ACP	8	2231.54	2230.90	0.0028	228.00
A.6-3	A.6-2	2250.80	ACP	8	2244.84	2240.74	0.1640	25.00
A.6-4	A.6-3	2262.90	ACP	8	2255.10	2244.74	0.0364	285.00
A.6-5	A.6-4	2268.00	ACP	8	2262.20	2257.10	0.0300	170.00
A.6-6	A.6-5	2279.00	ACP	8	2273.79	2262.20	0.0276	420.00
A.6-7	A.6-6	2282.50	ACP	8	2276.88	2273.84	0.0160	190.00
A.6-8	A.6-7	2286.20	PVC	8	2279.73	2276.88	0.0160	178.00
A.6-9	A.6-8	2291.40	PVC	6	2285.92	2279.96	0.0420	142.00
A.7-1	I-8	2241.80	ACP	8	2234.28	2232.60	0.0040	420.00
A.7-2	A.7-1	2242.90	ACP	8	2236.16	2234.28	0.0040	470.00
A.7-3	A.7-2	2242.90	ACP	8	2236.92	2236.16	0.0040	190.00
A.8.1-1	A.8-7	2287.90	ACP	6	2278.77	2277.96	0.0060	135.00
A.8-1	I-10	2244.00	ACP	8	2229.58	2227.98	0.0040	400.00
A.8-2	A.8-1	2244.20	ACP	8	2230.98	2229.58	0.0040	350.00
A.8-3	A.8-2	2244.20	ACP	8	2236.20	2235.00	0.0040	300.00
A.8-4	A.8-3	2244.60	ACP	8	2237.44	2236.20	0.0040	310.00
A.8-5	A.8-4	2252.30	ACP	8	2243.92	2238.00	0.0160	370.00
A.8-6	A.8-5	2267.60	ACP	8	2258.92	2243.92	0.0600	250.00
A.8-7	A.8-6	2282.70	ACP	8	2276.56	2260.92	0.0920	170.00
A.8-8	A.8-7	2312.00	ACP	8	2305.42	2276.56	0.0740	390.00
A.9-1	I-11	2245.70	ACP	8	2236.21	2234.33	0.0040	470.00
A.9-2	A.9-1	2246.10	ACP	8	2237.89	2236.21	0.0040	420.00
A.9-3	A.9-2	2245.20	ACP	8	2239.57	2237.89	0.0040	420.00
A.9-4	A.9-3	2248.60	ACP	8	2242.60	2239.57	0.0072	420.00
A.9-5	A.9-4	2258.50	ACP	8	2248.93	2242.60	0.0204	310.00
A.9-6	A.9-5	2285.40	ACP	8	2280.00	2250.57	0.1132	260.00
A.9-7	A.9-6	2294.50	ACP	8	2289.02	2280.00	0.0376	240.00
A.9A.2-1	A.9A-2	2261.79	PVC	8	2249.62	2248.20	0.0112	127.05
A.9A-1	I-11	2249.50	RCP	8	2231.54	2229.64	0.0040	475.00
A.9A-2	A.9A-1	2259.00	PVC	8	2248.20	2241.40	0.0215	315.59

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
A.9A-3	A.9A-2	2282.50	PVC	8	2270.90	2248.20	0.0468	485.53
A.9A-4	A.9A-3	2298.50	PVC	8	2291.26	2270.90	0.0468	435.00
A.A5-7	A.15-6	2317.64	PVC	8	2310.26	2308.55	0.0130	131.25
A1	A.11-5	2304.91	ACP	8	2299.90	2268.19	0.1009	314.40
A2	A1	2319.56	ACP	8	2306.37	2300.03	0.0144	439.80
A3	A2	2311.95	ACP	8	2307.82	2306.42	0.0042	333.70
B.1-1	B-1	2238.30	ACP	8	2232.43	2231.23	0.0040	300.00
B.2-1	B-2	2241.50	ACP	8	2236.35	2235.54	0.0060	135.00
B.3-1	B-3	2261.90	ACP	8	2256.24	2239.14	0.0868	197.00
B.3-2	B.3-1	2273.50	ACP	8	2265.48	2256.24	0.0268	345.00
B.4-1	B-4	2254.20	ACP	8	2245.84	2243.07	0.0146	190.00
B.4-2	B.4-1	2278.30	ACP	8	2272.33	2246.33	0.1000	260.00
B.4-3	B.4-2	2283.30	ACP	8	2277.63	2272.33	0.0212	250.00
B.4-4	B.4-3	2286.60	ACP	8	2278.67	2277.63	0.0040	260.00
B.4-5	B.4-4	2291.70	ACP	8	2284.12	2278.67	0.0188	290.00
B.4-6	B.4-5	2292.90	ACP	8	2285.02	2284.12	0.0040	225.00
B.4-7	B.4-6	2300.10	ACP	8	2293.85	2285.02	0.0192	460.00
B.4-8	B.4-7	2308.00	ACP	8	2300.94	2293.85	0.0188	377.00
B.6.A-1	B-8	2260.40	ACP	8	2252.66	2252.21	0.0040	112.00
B.6-1	B-7	2257.10	ACP	8	2250.85	2250.25	0.0040	150.00
B.6-2	B.6-1	2268.70	ACP	8	2263.00	2250.85	0.0664	183.00
B.6-3	B.6-2	2275.00	ACP	6	2269.62	2264.15	0.0456	120.00
B.7.1-1	B.7-1	2277.70	ACP	6	2271.99	2267.07	0.0328	150.00
B.7.2-1	B.7-1	2280.30	RCP	6	2274.95	2268.00	0.0632	110.00
B.7-1	B-8	2273.60	ACP	8	2266.91	2251.81	0.0484	312.00
B.7-2	B.7-1	2281.30	ACP	8	2271.52	2268.42	0.0124	250.00
B.7-3	B.7-2	2282.40	ACP	8	2272.00	2271.52	0.0040	120.00
B1	A.11-5	2281.16	ACP	8	2271.92	2268.24	0.0298	123.40
B-1	I-1	2238.70	ACP	8	2231.13	2225.81	0.0112	475.00
B-10	B-8	2269.00	RCP	8	2260.37	2251.81	0.0344	248.60
B-11	B-10	2267.30	RCP	8	2262.22	2260.47	0.0040	437.00
B2	B1	2281.87	PVC	8	2275.96	2272.17	0.0270	140.50
B-2	B-1	2241.20	ACP	8	2235.44	2232.57	0.0072	399.00
B3	B2	2301.53	PVC	8	2294.57	2275.96	0.0411	453.10
B-3	B-2	2247.30	ACP	8	2238.02	2235.44	0.0060	429.60
B4	B3	2304.62	PVC	8	2296.71	2296.04	0.0075	89.00
B-4	B-3	2248.90	ACP	8	2239.73	2238.07	0.0040	416.20
B5	B4	2329.36	PVC	8	2323.54	2296.82	0.0773	345.70
B-5	B-4	2251.90	RCP	8	2245.13	2242.73	0.0060	400.20
B-6	B-5	2257.80	RCP	8	2249.88	2245.13	0.0116	409.50
B-7	B-6	2254.90	RCP	8	2250.15	2249.93	0.0040	55.54
B-8	B-7	2260.60	ACP	8	2251.71	2250.15	0.0040	389.16
C1	A.8-8	2314.19	PVC	8	2308.38	2305.82	0.0053	485.80

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Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
C2	C1	2316.00	PVC	8	2311.55	2308.38	0.0071	446.80
C3	C2	2320.23	PVC	8	2315.56	2311.62	0.0702	56.10
C4	C3	2328.27	PVC	8	2322.79	2315.56	0.0300	241.30
CV.10.4-1	CV.10-4	2377.21	PVC	8	2368.47	2364.22	0.0340	124.90
CV.10-1	CV-10	2336.28	PVC	8	2328.16	2328.00	0.0039	41.08
CV.10-2	CV.10-1	2356.58	PVC	8	2345.70	2328.26	0.0775	225.03
CV.10-3	CV.10-2	2366.12	PVC	8	2356.94	2345.80	0.0995	112.00
CV.10-4	CV.10-3	2373.78	PVC	8	2364.02	2357.04	0.0624	111.80
CV.10-5	CV.10-4	2372.87	PVC	8	2366.02	2365.59	0.0051	84.10
CV.10-6	CV.10-5	2373.85	PVC	8	2366.75	2366.12	0.0097	64.87
CV.12.5-1	CV.12-5	2385.03	PVC	8	2376.70	2374.46	0.0144	155.27
CV.12.5-2	CV.12.5-1	2388.41	PVC	8	2379.79	2376.80	0.0302	99.16
CV.12.5-3	CV.12.5-2	2386.42	PVC	8	2380.42	2379.89	0.0040	132.62
CV.12.6-1	CV.12-6	2398.35	PVC	8	2390.40	2384.77	0.0384	146.76
CV.12.6-2	CV.12.6-1	2404.94	PVC	8	2393.96	2390.50	0.0232	149.13
CV.12.6-3	CV.12.6-2	2402.44	PVC	8	2395.64	2394.06	0.0080	197.75
CV.12.7-1	CV.12-7	2408.58	PVC	8	2401.16	2396.09	0.0499	101.60
CV.12.7-2	CV.12.7-1	2421.45	PVC	8	2415.79	2401.26	0.1044	139.22
CV.12.7-3	CV.12.7-2	2431.75	PVC	8	2425.20	2415.89	0.0761	122.35
CV.12.7-4	CV.12.7-3	2435.76	PVC	8	2430.50	2425.30	0.0775	67.13
CV.12.8-1	CV.12-8	2407.88	PVC	8	2400.48	2399.98	0.0080	62.42
CV.12.8-2	CV.12.8-1	2414.77	PVC	8	2408.53	2400.68	0.0515	152.35
CV.12.8-3	CV.12.8-2	2423.59	PVC	8	2415.49	2408.68	0.0787	86.51
CV.12.8-4	CV.12.8-3	2431.13	PVC	8	2419.74	2415.59	0.0536	77.38
CV.12.8-5	CV.12.8-4	2434.38	PVC	8	2423.48	2419.84	0.0364	100.01
CV.12.8-6	CV.12.8-5	2431.63	PVC	8	2425.43	2423.68	0.0120	145.54
CV.12.8-7	CV.12.8-6	2434.97	PVC	8	2428.77	2425.63	0.0760	41.30
CV.12.8-8	CV.12.8-7	2438.40	PVC	8	2432.40	2428.87	0.0623	56.70
CV.12-1	CV-12	2436.05	PVC	8	2331.91	2331.80	0.0027	40.16
CV.12-10	CV.12-9	2432.00	PVC	8	2421.23	2410.39	0.0988	109.74
CV.12-11	CV.12-10	2439.28	PVC	8	2429.90	2421.33	0.0797	107.51
CV.12-2	CV.12-1	2355.26	PVC	8	2343.90	2337.24	0.0626	106.38
CV.12-3	CV.12-2	2366.26	PVC	8	2352.40	2344.00	0.0750	111.96
CV.12-4	CV.12-3	2374.46	PVC	8	2365.19	2352.50	0.0744	170.49
CV.12-5	CV.12-4	2382.43	PVC	8	2374.16	2365.29	0.0614	144.49
CV.12-6	CV.12-5	2393.91	PVC	8	2384.47	2374.26	0.0748	136.46
CV.12-7	CV.12-6	2403.97	PVC	8	2395.99	2384.57	0.0744	153.42
CV.12-8	CV.12-7	2412.33	PVC	8	2399.78	2396.09	0.0248	148.78
CV.12-9	CV.12-8	2421.31	PVC	8	2410.29	2401.98	0.0766	108.46
CV.14.3.2-1	CV.14.3-2	2377.53	PVC	8	2370.87	2356.30	0.1020	142.88
CV.14.3-1	CV.14-3	2362.08	PVC	8	2351.40	2349.78	0.0345	47.01
CV.14.3-2	CV.14.3-1	2365.08	PVC	8	2355.86	2351.50	0.0589	73.99
CV.14.3-3	CV.14.3-2	2370.44	PVC	8	2363.60	2355.96	0.0584	130.74

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Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
CV.14.5.2-1	CV.14.5-2	2391.60	PVC	8	2385.00	2374.59	0.0551	189.03
CV.14.5-1	CV.14-5	2380.34	PVC	8	2370.21	2369.53	0.0180	37.68
CV.14.5-2	CV.14.5-1	2382.17	PVC	8	2374.39	2370.31	0.0508	80.32
CV.14.5-3	CV.14.5-2	2390.97	PVC	8	2384.87	2374.59	0.0836	122.95
CV.14.5-4	CV.14.5-3	2394.66	PVC	8	2388.56	2384.97	0.1057	33.97
CV.14.5-5	CV.14.5-4	2402.83	PVC	8	2396.72	2388.66	0.0675	119.33
CV.14-1	CV-14	2345.37	PVC	10	2333.46	2332.61	0.0053	158.95
CV.14-10	CV.14-9	2439.46	PVC	10	2430.74	2420.56	0.0788	129.19
CV.14-2	CV.14-1	2349.11	PVC	10	2339.17	2333.56	0.0583	96.28
CV.14-3	CV.14-2	2359.71	PVC	10	2349.58	2339.27	0.0527	195.68
CV.14-4	CV.14-3	2369.63	PVC	10	2359.69	2349.68	0.0555	180.27
CV.14-5	CV.14-4	2379.38	PVC	10	2369.33	2359.79	0.0566	168.53
CV.14-6	CV.14-5	2388.14	PVC	10	2379.90	2369.43	0.0620	168.79
CV.14-7	CV.14-6	2396.00	PVC	10	2387.90	2380.00	0.0512	154.21
CV.14-8	CV.14-7	2420.05	PVC	10	2411.33	2388.00	0.0648	359.99
CV.14-9	CV.14-8	2429.23	PVC	10	2420.46	2411.43	0.0780	115.81
CV.16-1	CV-16	2343.00	PVC	8	2336.96	2336.80	0.0040	40.06
CV.16-2	CV.16-1	2347.26	PVC	8	2339.59	2337.06	0.0213	119.05
CV.16-3	CV.16-2	2348.96	PVC	8	2341.55	2339.69	0.0262	71.08
CV.16-4	CV.16-3	2361.31	PVC	8	2351.75	2341.65	0.0485	208.42
CV.16-5	CV.16-4	2367.99	PVC	8	2360.91	2351.95	0.0770	116.41
CV.16-6	CV.16-5	2375.09	PVC	8	2368.00	2361.01	0.0874	79.99
CV.18-1	CV-18	2360.51	PVC	8	2349.63	2349.50	0.0040	32.15
CV.18-2	CV.18-1	2367.56	PVC	8	2360.36	2349.73	0.1052	101.08
CV.18-3	CV.18-2	2374.53	PVC	8	2362.81	2360.46	0.0367	63.99
CV.18-4	CV.18-3	2382.30	PVC	8	2375.35	2362.91	0.1028	121.00
CV.18-5	CV.18-4	2385.76	PVC	8	2377.90	2375.55	0.0191	123.31
CV.18-6	CV.18-5	2389.09	PVC	8	2382.32	2378.00	0.0699	61.78
CV.19.2-1	CV.19-2	2387.62	PVC	8	2377.56	2374.87	0.0396	67.86
CV.19.2-2	CV.19.2-1	2393.40	PVC	8	2383.52	2377.66	0.0851	68.86
CV.19.2-3	CV.19.2-2	2401.84	PVC	8	2392.35	2383.72	0.1040	83.01
CV.19-1	CV-19	2379.47	PVC	8	2374.16	2374.00	0.0051	31.28
CV.19-2	CV.19-1	2385.78	PVC	8	2374.67	2374.23	0.0044	101.01
CV.19-3	CV.19-2	2393.27	PVC	8	2387.31	2374.77	0.0853	147.00
CV.19-4	CV.19-3	2400.98	PVC	8	2394.21	2387.51	0.0717	93.45
CV.19-5	CV.19-4	2406.55	PVC	8	2399.78	2394.31	0.0548	99.90
CV.21-1	CV-21	2407.40	PVC	8	2398.01	2386.39	0.0254	456.79
CV.21-10	CV.21-9	2440.60	PVC	8	2434.47	2433.88	0.0099	59.46
CV.21-11	CV.21-10	2443.20	PVC	8	2436.29	2434.57	0.0172	100.19
CV.21-2	CV.21-1	2414.20	PVC	8	2402.46	2398.11	0.0090	481.56
CV.21-3	CV.21-2	2417.91	PVC	8	2410.94	2402.46	0.0401	211.42
CV.21-4	CV.21-3	2422.54	PVC	8	2416.11	2411.24	0.0488	99.73
CV.21-5	CV.21-4	2429.04	PVC	8	2422.27	2416.21	0.0531	114.08

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Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
CV.21-6	CV.21-5	2434.90	PVC	8	2428.76	2422.37	0.0400	159.83
CV.21-7	CV.21-6	2440.62	PVC	8	2431.37	2428.86	0.0201	125.12
CV.21-8	CV.21-7	2442.41	PVC	8	2432.85	2431.47	0.0100	138.63
CV.21-9	CV.21-8	2440.71	PVC	8	2433.78	2432.95	0.0100	82.66
CV.26.3-1	CV.26-3	2464.50	PVC	8	2456.43	2451.93	0.0604	74.56
CV.26-1	CV-26	2406.09	PVC	8	2401.31	2398.06	0.0333	97.70
CV.26-2	CV.26-1	2431.16	PVC	8	2424.20	2401.51	0.0806	281.37
CV.26-3	CV.26-2	2456.75	PVC	8	2451.73	2425.70	0.1232	211.27
CV.26-4	CV.26-3	2464.50	PVC	8	2452.87	2451.93	0.0100	94.36
CV.8-1	CV-08	2331.55	PVC	8	2323.56	2323.40	0.0041	38.93
CV.8-2	CV.8-1	2341.71	PVC	8	2329.45	2326.50	0.0165	179.30
CV.8-3	CV.8-2	2362.86	PVC	8	2350.22	2329.55	0.0942	219.34
CV.8-4	CV.8-3	2379.28	PVC	8	2369.87	2350.32	0.1045	187.14
CV.8-5	CV.8-4	2391.56	PVC	8	2383.04	2369.97	0.0897	145.65
CV-01	OF-HW	2294.00	PVC	15	2290.70	2290.50	0.0090	22.22
CV-02	CV-01	2305.00	PVC	15	2296.00	2290.70	0.0217	243.98
CV-03	CV-02	2310.00	PVC	15	2303.00	2296.10	0.0307	224.83
CV-04	CV-03	2328.00	PVC	15	2319.50	2303.00	0.0469	351.98
CV-05	CV-04	2330.00	PVC	15	2320.20	2319.50	0.0031	229.09
CV-06	CV-05	2328.00	PVC	15	2320.67	2320.20	0.0030	155.43
CV-07	CV-06	2327.50	PVC	15	2321.00	2320.67	0.0030	110.50
CV-08	CV-07	2330.53	PVC	15	2323.22	2321.00	0.0135	164.74
CV-09	CV-08	2334.00	PVC	15	2325.00	2323.22	0.0132	135.27
CV-10	CV-09	2335.93	PVC	15	2327.80	2325.00	0.0170	164.36
CV-11	CV-10	2340.00	PVC	15	2331.26	2327.80	0.0160	215.64
CV-12	CV-11	2340.68	PVC	15	2331.60	2331.26	0.0043	79.49
CV-13	CV-12	2340.00	PVC	15	2332.43	2331.60	0.0034	245.51
CV-14	CV-13	2342.10	PVC	15	2332.61	2332.43	0.0035	51.77
CV14-11	CV.14-10	2442.17	PVC	8	2433.39	2430.84	0.0132	193.19
CV-15	CV-14	2340.00	PVC	15	2333.37	2332.61	0.0036	213.23
CV-16	CV-15	2341.94	PVC	15	2336.60	2333.37	0.0436	74.00
CV-17	CV-16	2357.00	PVC	15	2347.00	2336.60	0.0431	241.08
CV-18	CV-17	2358.67	PVC	15	2349.30	2347.50	0.0397	45.36
CV-19	CV-18	2380.02	PVC	15	2373.80	2349.30	0.0777	315.33
CV-20	CV-19	2384.00	PVC	15	2377.78	2373.80	0.0843	47.22
CV-21	CV-20	2398.00	PVC	15	2379.41	2378.63	0.0030	261.99
CV-22	CV-21	2395.00	PVC	15	2380.82	2379.51	0.0030	438.37
CV-23	CV-22	2387.50	PVC	15	2381.46	2380.82	0.0030	210.75
CV-24	CV-23	2391.71	PVC	12	2385.22	2381.46	0.0099	379.72
CV-25	CV-24	2395.10	PVC	12	2387.98	2385.32	0.0106	249.96
CV-26	CV-25	2409.71	PVC	12	2397.50	2388.08	0.0329	286.24
CV-27	CV-26	2422.82	PVC	12	2415.69	2402.20	0.0785	171.83
CV-28	CV-27	2438.70	PVC	12	2431.27	2416.00	0.0804	189.99

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
CV-29	CV-28	2477.86	PVC	12	2470.87	2431.37	0.0790	500.14
CV-30	CV-29	2495.35	PVC	12	2487.58	2470.97	0.0664	249.97
CV-31	CV-30	2504.01	PVC	12	2497.06	2487.68	0.0268	350.31
CV-32	CV-31	2499.33	HDPE	10	2497.16	2493.70	-0.0069	500.00
CV-33	CV-32	2494.93	HDPE	10	2493.70	2489.30	-0.0098	450.00
CV-34	CV-33	2488.80	HDPE	10	2489.30	2483.00	-0.0126	500.00
CV-35	CV-34	2482.88	HDPE	10	2483.00	2477.00	-0.0120	500.00
CV-36	CV-35	2485.23	HDPE	10	2477.00	2479.50	0.0050	500.00
CV-37	CV-36	2499.25	HDPE	10	2479.50	2493.50	0.0280	500.00
CV-38	CV-37	2518.38	HDPE	10	2493.50	2512.38	0.0334	566.00
CV-39	CV-38	2524.83	PVC	10	2512.48	2518.33	0.0286	204.82
CV-40	CV-39	2533.12	PVC	10	2518.43	2526.61	0.0311	263.18
CV-41	CV-40	2541.26	PVC	10	2526.71	2534.75	0.0312	258.00
CV-42	CV-41	2552.12	PVC	10	2534.85	2545.53	0.0414	258.00
CV-43	CV-42	2567.44	PVC	10	2545.63	2560.73	0.0592	255.00
CV-44	CV-43	2586.20	PVC	10	2560.83	2579.45	0.0725	257.00
CV-45	CV-44	2604.59	PVC	10	2579.55	2597.84	0.0732	250.00
CV-46	CV-45	2633.13	PVC	10	2597.94	2626.39	0.0733	388.00
CV-47	CV-46	2662.56	PVC	10	2626.49	2655.81	0.0733	400.00
CV-48	CV-47	2680.14	PVC	10	2655.91	2673.40	0.0732	239.00
CV-49	CV-48	2693.58	PVC	10	2673.50	2687.05	0.0555	244.00
CV-50	CV-49	2697.93	PVC	10	2687.15	2691.53	0.0185	237.00
CV-51	CV-50	2462.62	PVC	8	2691.63	2462.62	-0.0410	5579.00
D1	A.2-14	2313.31	PVC	8	2308.51	2298.37	0.0271	374.50
D2	D1	2316.63	PVC	8	2311.70	2308.60	0.0088	351.20
E1	A.2-10	2286.11	PVC	8	2279.03	2272.89	0.0115	533.50
E10	E9	2340.40	RCP	8	2334.06	2320.58	0.0626	215.40
E11	E10	2361.58	RCP	8	2353.90	2334.38	0.0612	319.00
E11-1	E11	2364.58	PVC	8	2359.40	2354.89	0.0300	150.50
E12	E11	2372.23	RCP	8	2365.82	2354.60	0.0466	240.90
E3	E1	2290.55	PVC	8	2279.84	2279.08	0.0049	156.30
E4	E3	2287.59	PVC	8	2280.61	2279.88	0.0039	187.20
E4-1	E4	2296.10	PVC	8	2291.69	2280.62	0.0837	132.20
E4-2	E4-1	2297.29	PVC	8	2292.94	2291.84	0.0048	229.70
E5	E4	2292.61	PVC	8	2282.34	2280.62	0.0038	449.30
E5-1	E5	2301.59	RCP	8	2293.36	2282.74	0.0499	212.90
E5-2	E5-1	2303.46	RCP	8	2295.55	2293.46	0.0043	485.00
E5-3	E5-2	2309.64	RCP	8	2301.86	2295.69	0.0475	130.00
E5-3.1	E5-3	2311.15	RCP	8	2304.82	2301.86	0.0108	275.00
E5-3.1.1	E5-3.1	2327.76	RCP	8	2320.24	2304.82	0.0350	440.00
E5-3.1.2	E5-3.1.1	2329.08	RCP	8	2321.71	2320.64	0.0051	211.00
E5-3.1.3	E5-3.1.2	2328.70	RCP	8	2322.44	2321.91	0.0045	118.50
E5-3.2	E5-3.1	2317.83	RCP	8	2310.11	2306.02	0.0128	320.00

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
E5-3.2.1	E5-3.2	2320.67	RCP	8	2314.12	2310.11	0.0112	356.50
E5-3.2.2	E5-3.2	2324.51	RCP	8	2317.71	2314.15	0.0071	500.00
E5-3.2.3	E5-3.2.2	2328.21	RCP	8	2322.51	2318.11	0.0185	237.70
E5-3.3	E5-3.2	2320.75	RCP	8	2312.50	2310.58	0.0115	167.37
E5-3.3.1	E5-3.3	2320.12	PVC	8	2313.93	2312.50	0.0089	160.03
E5-3.3.2	E5-3.3.1	2332.83	PVC	8	2318.51	2313.93	0.0127	359.35
E5-3.3.3	E5-3.3.2	2337.80	PVC	8	2329.77	2318.51	0.0280	401.68
E5-3.4	E5-3.3	2323.16	PVC	8	2315.19	2312.50	0.0261	102.93
E5-3.5	E5-3.4	2329.07	PVC	8	2319.72	2315.19	0.0126	358.26
E5-3.6	E5-3.5	2334.63	PVC	8	2327.45	2319.72	0.0344	224.57
E5-3-1	E5-3	2315.43	RCP	8	2310.66	2302.08	0.0250	343.50
E5-4	E5-3	2337.39	RCP	8	2330.90	2301.96	0.0579	499.50
E5-5	E5-4	2338.08	RCP	8	2332.09	2331.12	0.0066	145.90
E5A	E5	2295.47	PVC	8	2287.84	2282.97	0.0762	63.90
E6	E5A	2305.69	PVC	8	2299.86	2287.97	0.0278	427.50
E7	E6	2310.73	PVC	8	2303.63	2299.96	0.0225	163.30
E8	E7	2320.94	PVC	8	2311.97	2303.83	0.0177	460.00
E9	E8	2329.75	PVC	8	2320.38	2312.16	0.0288	285.00
F	A.1.2-2	2285.73	PVC	8	2278.23	2276.62	0.0034	470.00
F1	F	2292.67	PVC	8	2285.89	2278.62	0.0300	242.20
F1-1	F1	2303.86	PVC	8	2296.09	2286.05	0.0486	206.70
F1-2	F1-1	2308.67	PVC	8	2298.05	2296.20	0.0043	428.60
F2	F1	2308.86	RCP	8	2296.84	2286.05	0.0251	430.70
F3	F2	2313.00	PVC	8	2305.78	2297.51	0.0178	463.40
F4	F3	2316.35	PVC	8	2310.18	2305.99	0.0451	93.00
G	1.2.3-3	2309.91	PVC	8	2301.43	2296.36	0.0145	350.00
G1	G	2312.44	PVC	8	2306.26	2301.58	0.0257	182.00
G10	G9	2338.47	PVC	8	2331.09	2327.88	0.0080	400.90
G11	G10	2338.78	PVC	8	2331.94	2331.27	0.0039	170.50
G1-1	G1	2313.75	PVC	8	2308.15	2306.41	0.0041	421.10
G11-1	G11	2351.06	PVC	8	2345.42	2332.22	0.0464	284.70
G12	G11	2349.20	PVC	8	2342.30	2332.22	0.0356	283.00
G1-2	G1-1	2318.04	PVC	8	2312.78	2308.24	0.0409	111.10
G13	G12	2360.62	PVC	8	2354.67	2342.47	0.0322	379.40
G1-3	G1-2	2326.81	PVC	8	2314.96	2312.96	0.0042	473.10
G13-1	G13	2369.80	PVC	8	2365.06	2354.67	0.1309	79.40
G13-2	G13-1	2372.50	PVC	8	2368.10	2365.16	0.0110	266.89
G13-3	G13-2	2376.60	PVC	8	2371.10	2368.20	0.0090	322.24
G13-4	G13-3	2377.50	PVC	8	2371.68	2371.20	0.0068	70.23
G1-4	G1-3	2337.37	PVC	8	2330.71	2316.70	0.0304	461.40
G15	G13-4	2384.26	PVC	8	2375.88	2371.68	0.0269	156.19
G1-5	G1-4	2353.14	PVC	8	2347.78	2330.71	0.0342	499.50
G-15	G13-4	2384.26	PVC	8	2375.74	2371.68	0.0238	170.81

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
G16	G15	2389.41	PVC	8	2378.18	2376.09	0.0047	446.70
G1-6	G1-5	2373.14	PVC	8	2366.37	2347.78	0.0408	455.20
G16-1	G16	2385.80	PVC	8	2379.04	2378.50	0.0054	100.30
G16-2	G16-1	2391.15	PVC	8	2380.97	2379.24	0.0035	491.90
G17	G16	2386.02	PVC	8	2380.26	2378.50	0.0036	491.80
G1-7	G1-6	2382.22	PVC	8	2375.10	2366.51	0.0252	340.90
G18	OF-S97TH PS	2375.82	PVC	8	2368.88	2362.48	0.0165	388.70
G2	G1	2321.98	PVC	8	2313.03	2306.57	0.0299	215.70
G3	G2	2323.83	PVC	8	2315.00	2313.14	0.0039	471.40
G4	G3	2324.44	PVC	8	2316.91	2315.21	0.0053	323.40
G4A	G4	2325.57	RCP	8	2317.70	2316.97	0.0120	60.70
G5	G4A	2328.48	PVC	8	2318.93	2318.06	0.0048	183.00
G5-1	G5A	2336.33	RCP	8	2327.76	2326.02	0.0501	34.70
G5-1-1	G5-1	2341.54	PVC	8	2332.75	2328.09	0.0116	402.30
G5-2	G5-1	2345.75	PVC	8	2337.84	2328.35	0.0645	147.10
G5-3	G5-2	2345.91	PVC	8	2339.42	2337.98	0.0066	219.60
G5A	G5	2334.78	PVC	8	2325.98	2319.27	0.0513	130.90
G5A-1	G5A	2334.05	PVC	8	2326.74	2326.12	0.0048	129.30
G6	G5	2330.21	PVC	8	2320.58	2319.13	0.0040	364.40
G7	G6	2327.71	PVC	8	2321.61	2320.70	0.0041	219.60
G8	G7	2333.06	PVC	8	2327.35	2321.78	0.0309	180.00
G9	G8	2332.05	PVC	8	2327.73	2327.58	0.0041	37.00
G9-1	G9	2343.54	RCP	8	2333.86	2327.88	0.0127	471.30
H1	HA	2306.63	PVC	8	2298.98	2295.29	0.0098	377.90
H2	H1	2319.69	PVC	8	2312.87	2299.11	0.0385	357.30
HA	F	2300.05	PVC	8	2295.23	2278.56	0.0602	277.10
I	G	2311.90	PVC	8	2303.34	2301.58	0.0061	288.00
I.1	I-0	2232.79	RCP	8	2229.23	2221.45	0.0257	302.38
I.2	I.1	2236.43	RCP	8	2229.25	2229.23	0.0002	99.73
I.3	I.2	2236.77	PVC	8	2231.05	2229.25	0.0230	78.14
I.4	I.3	2239.58	PVC	8	2234.79	2231.05	0.0111	336.67
I1	I	2315.13	PVC	8	2308.44	2303.40	0.0130	387.10
J	I	2312.56	PVC	8	2304.18	2303.38	0.0055	146.00
J1	J	2313.90	PVC	8	2306.04	2304.40	0.0125	131.40
J2	J1	2317.85	PVC	8	2310.31	2306.17	0.0120	345.70
JS.3-1	JS-3	2276.58	PVC	8	2269.38	2262.24	0.0570	125.35
JS.3-2	JS.3-1	2282.83	PVC	8	2278.28	2269.38	0.0316	281.31
JS.3-3	JS.3-2	2302.18	PVC	8	2297.18	2278.28	0.0608	310.75
JS.9-1	JS-9	2311.10	PVC	8	2290.00	2275.20	0.0370	399.63
JS.9-2	JS.9-1	2313.00	PVC	8	2305.00	2290.10	0.0381	390.81
JS.9-3	JS.9-2	2316.60	PVC	8	2308.00	2305.20	0.0179	156.04
JS-1	A.4-12	2266.20	PVC	8	2257.44	2255.21	0.0508	43.92
JS-10	JS-9	2297.00	PVC	8	2286.00	2275.10	0.0470	231.68

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
JS-11	JS-10	2312.00	PVC	8	2302.10	2288.00	0.0806	175.00
JS-12	JS-11	2327.40	PVC	8	2318.40	2304.10	0.0998	143.32
JS-13	JS-12	2347.80	PVC	8	2338.80	2319.40	0.1186	163.56
JS-2	JS-1	2267.59	PVC	8	2260.89	2257.44	0.0155	223.22
JS-3	JS-2	2269.66	PVC	8	2262.24	2260.89	0.0068	198.40
JS-4	JS-3	2270.14	PVC	8	2264.94	2262.24	0.0054	501.77
JS-5	JS-4	2276.16	PVC	8	2267.66	2264.94	0.0059	463.87
JS-6	JS-5	2279.85	PVC	8	2272.01	2267.66	0.0138	314.28
JS-7	JS-6	2281.30	PVC	8	2272.54	2272.01	0.0056	94.20
JS-8	JS-7	2281.43	PVC	8	2272.67	2272.54	0.0057	22.90
JS-8A	JS-8	2281.71	PVC	8	2273.03	2272.67	0.0082	43.65
JS-9	JS-8A	2284.00	PVC	8	2275.00	2273.03	0.0041	476.64
K1	B.4-8	2311.50	PVC	8	2305.83	2301.02	0.0475	101.30
K2	K1	2319.44	PVC	8	2309.61	2305.91	0.0211	175.40
K3	K2	2323.07	PVC	8	2314.13	2309.75	0.0104	422.60
K4	K3	2329.33	PVC	8	2324.82	2316.28	0.0670	127.40
L	J	2322.47	PVC	8	2312.05	2304.24	0.0195	400.00
L.1-1	L	2326.98	RCP	8	2316.69	2312.05	0.0106	439.00
L.1-2	L.1-1	2326.79	RCP	8	2321.51	2318.65	0.0061	467.70
L.1-3	L.1-2	2331.28	RCP	6	2327.88	2321.67	0.0334	186.00
L1	L	2329.04	PVC	8	2321.40	2312.26	0.0221	413.30
L2	L1	2332.56	PVC	8	2327.58	2321.70	0.0275	214.20
L3	L2	2345.56	PVC	8	2339.97	2327.77	0.0286	426.40
LS-1	OF-DS	2232.86	PVC	18	2220.76	2219.60	0.0033	353.74
LS-10	LS-9	2380.94	PVC	8	2372.84	2360.09	0.0588	216.83
LS-11	LS-10	2413.48	PVC	8	2404.56	2373.04	0.1172	269.01
LS-12	LS-11	2440.18	PVC	8	2423.23	2404.76	0.0589	313.61
LS-13	LS-12	2441.14	PVC	8	2424.76	2423.43	0.0050	265.03
LS-14	LS-13	2438.30	PVC	8	2426.29	2424.96	0.0050	265.02
LS-15	LS-14	2437.98	PVC	8	2428.62	2426.49	0.0050	426.65
LS-16	LS-15	2433.79	PVC	8	2429.60	2428.82	0.0050	155.27
LS-17	LS-16	2440.21	PVC	8	2433.70	2429.80	0.0233	167.14
LS-2	LS-1	2233.17	PVC	18	2222.69	2220.96	0.0034	504.73
LS-3	LS-2	2235.23	PVC	18	2223.96	2222.89	0.0033	324.53
LS-4	LS-3	2235.28	PVC	18	2224.28	2224.16	0.0028	42.78
LS-5	LS-4	2234.90	PVC	18	2225.01	2224.28	0.0068	107.58
LS-6	LS-5	2234.96	PVC	18	2225.07	2225.01	0.0014	43.95
LS-7	LS-6	2243.18	PVC	18	2233.60	2225.37	0.0212	388.81
LS-8	A.4.10.6-3	2355.45	PVC	8	2347.34	2334.60	0.0480	265.28
LS-9	LS-8	2370.69	PVC	8	2360.09	2347.34	0.0486	262.43
M	B.6.A-1	2260.54	PVC	8	2257.10	2253.76	0.0186	180.00
M1	M	2276.33	PVC	8	2272.32	2257.27	0.0707	213.00
M10	M9	2322.11	PVC	8	2314.93	2310.09	0.0098	492.10

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Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
M11	M10	2323.50	PVC	8	2316.55	2315.10	0.0064	226.00
M12	M11	2325.69	PVC	8	2318.68	2316.55	0.0053	403.60
M13	M12	2332.08	PVC	8	2320.35	2318.79	0.0042	367.70
M14	M13	2328.47	PVC	8	2322.00	2320.64	0.0036	378.20
M15	M14	2334.44	PVC	8	2328.06	2322.14	0.0158	375.20
M16	M15	2343.70	PVC	8	2338.17	2328.18	0.0342	292.10
M16-1	M16	2360.48	PVC	8	2356.26	2338.49	0.0357	498.10
M16-2	M16-1	2377.52	PVC	8	2364.09	2356.45	0.0244	313.60
M16-3	M16-2	2375.39	PVC	8	2365.69	2364.21	0.0039	382.00
M16-4	M16-3	2387.50	PVC	8	2380.50	2366.00	0.0741	195.80
M17	M16	2349.04	PVC	8	2341.50	2338.49	0.0099	305.30
M18	M17	2368.28	PVC	8	2360.19	2341.76	0.0402	459.00
M19	M18	2390.20	PVC	8	2378.97	2360.52	0.0431	428.20
M19-1	M19	2396.96	RCP	8	2387.81	2379.04	0.1050	83.50
M2	M1	2285.20	PVC	8	2274.41	2272.52	0.0040	471.00
M20	M19	2388.25	PVC	8	2380.08	2379.09	0.0049	202.90
M2-1	M2	2297.70	PVC	8	2288.56	2277.85	0.0365	293.21
M2-2	M2-1	2300.16	PVC	8	2293.06	2288.68	0.0249	175.65
M3	M2	2296.91	PVC	8	2283.50	2274.71	0.0360	243.98
M3.1	M3	2304.39	PVC	8	2298.00	2288.48	0.0424	224.39
M4	M3	2301.15	PVC	8	2292.40	2291.81	0.0026	227.31
M5	M4	2302.77	PVC	8	2294.80	2292.65	0.0053	403.00
M5-1	M5	2300.39	PVC	8	2296.08	2295.05	0.0047	217.60
M5-10	M5-9	2401.68	PVC	8	2396.90	2380.81	0.0578	278.38
M5-11	M5-10	2415.89	PVC	8	2411.49	2397.10	0.0356	404.34
M5-12	M5-11	2430.67	PVC	8	2426.23	2411.69	0.1214	119.74
M5-2	M5-1	2300.64	PVC	8	2296.20	2296.08	0.0040	30.10
M5-3	M5-2	2301.21	PVC	8	2296.58	2296.38	0.0034	59.60
M5-3-1	M5-3	2305.05	PVC	8	2299.60	2296.70	0.0107	270.20
M5-4	M5-3	2307.84	PVC	8	2300.00	2296.68	0.0067	498.70
M5-4.1	M5-4	2314.80	PVC	8	2304.33	2301.07	0.0075	435.04
M5-4.2	M5-4.1	2322.00	PVC	8	2306.13	2304.54	0.0042	380.87
M5-4.3	M5-4.2	2325.31	PVC	8	2315.00	2306.20	0.0351	250.37
M5-4.4	M5-4.3	2345.20	PVC	8	2341.50	2315.10	0.1461	180.76
M5-5	M5-4	2309.29	PVC	8	2302.66	2300.00	0.0416	63.95
M5-6	M5-5	2325.50	PVC	8	2320.70	2304.74	0.0501	318.56
M5-7	M5-6	2352.50	PVC	8	2345.53	2320.90	0.0536	459.16
M5-8	M5-7	2370.88	PVC	8	2364.48	2347.53	0.0724	234.15
M5-8.1	M5-8	2378.90	PVC	8	2375.07	2364.68	0.1016	102.29
M5-9	M5-8	2386.09	PVC	8	2380.61	2364.68	0.0564	282.50
M6	M5	2305.39	RCP	8	2298.56	2295.05	0.0075	467.50
M7	M6	2306.59	PVC	8	2300.06	2298.74	0.0042	311.10
M8	M7	2311.17	PVC	8	2305.02	2300.24	0.0135	355.00

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
M9	M8	2316.29	PVC	8	2309.75	2305.23	0.0136	332.60
M9-1	M9	2317.55	RCP	8	2312.05	2310.35	0.0298	57.00
M9-2	M9-1	2332.65	RCP	8	2325.00	2312.17	0.0301	425.60
M9-3	M9-2	2350.32	RCP	8	2344.92	2325.05	0.0508	390.90
MC.1-1	MC-1	2345.07	PVC	8	2337.30	2333.50	0.0415	91.65
MC.1-2	MC.1-1	2347.88	PVC	8	2340.51	2337.50	0.0415	72.56
MC.1-3	MC.1-2	2356.31	PVC	8	2349.69	2340.71	0.0415	216.29
MC.1-4	MC.1-3	2357.93	PVC	8	2351.53	2349.89	0.0393	41.68
MC.3-1	MC-3	2344.47	PVC	8	2336.38	2334.99	0.0139	100.00
MC.3-2	MC.3-1	2346.46	PVC	8	2339.00	2336.48	0.0353	71.48
MC-1	SP-12	2341.53	PVC	8	2333.30	2321.63	0.0455	256.44
MC-2	MC-1	2342.16	PVC	8	2333.80	2333.43	0.0037	98.80
MC-3	MC-2	2343.33	PVC	8	2334.89	2333.90	0.0055	179.11
MC-4	MC-3	2344.05	PVC	8	2336.30	2334.99	0.0057	228.59
MC-5	MC-4	2345.46	PVC	8	2337.27	2336.40	0.0055	158.39
MC-6	MC-5	2352.33	PVC	8	2344.58	2338.36	0.0240	258.71
MC-7	MC-6	2353.53	PVC	8	2346.63	2344.68	0.0097	200.85
MC-8	MC-7	2353.94	PVC	8	2347.00	2346.73	0.0040	67.81
MC-9	MC-8	2354.84	PVC	8	2348.00	2347.10	0.0060	149.75
MH-01	OF-IPS	2266.60	PVC	24	2250.90	2250.70	0.0029	69.95
MH-02	MH-01	2264.80	PVC	24	2252.00	2251.00	0.0020	504.70
MH-02A	MH-02	2262.70	PVC	24	2252.59	2252.00	0.0019	303.26
MH-03	MH-02A	2265.60	PVC	24	2252.93	2252.59	0.0026	130.10
MH-04	MH-03	2263.40	PVC	24	2253.93	2252.93	0.0020	497.68
MH-04A	MH-04	2265.00	PVC	24	2254.51	2253.93	0.0036	162.87
MH-05	MH-04A	2265.35	PVC	24	2254.73	2254.51	0.0008	262.72
MH-06	MH-05	2267.00	PVC	24	2255.74	2254.83	0.0023	391.11
MH-07	MH-06	2265.60	PVC	24	2256.69	2255.74	0.0017	545.06
N.1	B-11	2273.55	PVC	8	2267.74	2262.43	0.0591	89.90
N.2	N.1	2293.14	PVC	8	2286.71	2267.74	0.0777	244.30
N1	N2	2322.60	RCP	8	2316.79	2314.74	0.0094	218.00
N1.1	N1	2332.50	RCP	8	2326.01	2316.84	0.0355	258.00
N1.1.1	N1.1	2333.50	RCP	6	2329.85	2326.89	0.0165	179.00
N1.2	N1.1	2342.02	RCP	8	2336.02	2326.10	0.0504	197.00
N1.3	N1.2	2358.31	RCP	8	2352.10	2336.42	0.0871	180.00
N1-1	N3	2334.40	RCP	8	2328.99	2319.32	0.0336	288.00
N1-2	N1-1	2352.83	RCP	8	2346.83	2329.13	0.0744	238.00
N2	M9-1	2317.87	RCP	8	2314.64	2312.18	0.0141	174.00
N3	N1	2324.50	RCP	8	2319.16	2316.89	0.0072	317.00
N4	N3	2331.87	RCP	8	2325.77	2319.32	0.0223	289.10
N4-1	N4	2345.13	PVC	8	2338.26	2325.77	0.0494	252.65
N4-2	N4-1	2355.13	PVC	8	2347.94	2338.26	0.0760	127.34
N5	N4	2339.28	PVC	8	2332.63	2325.77	0.0261	262.79

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim			Invert Elevations			
Upstream MH	Downstream MH	Elevation	Pipe Material	Pipe Diameter	Upstream	Downstream	Slope	Length
N5-1	N5	2351.75	PVC	8	2344.88	2332.63	0.0581	210.89
N5-2	N5-1	2361.71	PVC	8	2355.02	2344.88	0.0936	108.34
N6	N5	2341.56	PVC	8	2335.35	2332.63	0.0172	158.52
N7	N6	2347.78	PVC	8	2341.26	2335.35	0.0560	105.58
N8	N7	2359.55	PVC	8	2352.06	2341.26	0.0944	114.36
SH-1	MH-05	2271.61	PVC	8	2264.56	2256.25	0.0315	263.63
SH-10	SH-9	2302.12	PVC	8	2295.43	2290.36	0.0120	422.72
SH-11	SH-10	2303.64	PVC	8	2296.92	2295.67	0.0044	281.04
SH-12	SH-11	2305.25	PVC	8	2298.14	2297.12	0.0039	259.01
SH-13	SH-12	2305.54	PVC	8	2298.73	2298.34	0.0091	43.00
SH-14	SH-13	2310.81	PVC	8	2302.65	2298.93	0.0196	189.72
SH-15	SH-14	2334.10	PVC	8	2327.45	2304.65	0.0496	460.01
SH-16	SH-15	2338.59	PVC	8	2332.18	2327.65	0.0099	456.66
SH-17	SH-10	2307.33	PVC	8	2299.91	2295.54	0.0255	171.47
SH-18	SH-7	2291.15	PVC	8	2284.03	2282.53	0.0068	219.29
SH-19	SH-18	2301.58	PVC	8	2295.52	2284.87	0.0355	300.00
SH-2	SH-1	2286.97	PVC	8	2279.35	2264.76	0.0379	385.32
SH-20	SH-3	2300.40	PVC	8	2293.65	2280.13	0.0676	200.00
SH-21	SH-20	2304.36	PVC	8	2296.52	2293.85	0.0621	43.02
SH-22	SH-21	2310.30	PVC	8	2304.17	2296.72	0.0710	104.94
SH-23	SH-22	2321.59	PVC	8	2314.16	2304.37	0.0238	411.99
SH-24	SH-23	2330.17	PVC	8	2323.72	2314.36	0.0393	238.01
SH-25	SH-22	2315.00	PVC	8	2309.15	2304.37	0.0404	118.24
SH-26	SH-25	2321.58	PVC	8	2316.72	2309.35	0.0417	176.53
SH-27	SH-23	2352.21	PVC	8	2318.87	2314.36	0.0124	365.01
SH-28	SH-24	2333.67	PVC	8	2327.54	2323.92	0.0099	366.01
SH-3	SH-2	2288.78	PVC	8	2280.08	2279.42	0.0044	151.59
SH-4	SH-3	2303.24	PVC	8	2296.94	2280.28	0.0644	258.80
SH-5	SH-4	2319.98	PVC	8	2314.14	2297.14	0.0616	276.00
SH-6	SH-5	2324.07	PVC	8	2317.58	2314.34	0.0074	435.99
SH-7	SH-3	2288.91	PVC	8	2281.06	2280.28	0.0034	229.37
SH-8	SH-7	2294.19	PVC	8	2287.92	2281.36	0.0343	191.08
SH-9	SH-8	2295.87	PVC	8	2290.23	2287.96	0.0499	45.50
SP.12-1	SP-12	2334.01	PVC	8	2321.92	2321.70	0.0065	34.05
SP.12-2	SP.12-1	2337.22	PVC	8	2323.25	2322.02	0.0040	310.45
SP.12-3	SP.12-2	2337.78	PVC	8	2324.60	2323.35	0.0040	311.00
SP.13-1	SP-13	2343.77	PVC	8	2338.77	2322.91	0.0435	364.77
SP.6-1	SP-6	2297.50	PVC	8	2288.70	2286.00	0.0087	311.42
SP.7-1	SP-7	2302.00	PVC	8	2294.80	2289.50	0.0171	309.32
SP.7-2	SP.7-1	2303.50	PVC	8	2296.00	2295.00	0.0036	281.38
SP-1	JS-5	2276.66	PVC	8	2268.54	2267.66	0.0057	153.23
SP-10	SP-9	2318.03	PVC	8	2310.73	2302.44	0.0302	274.93
SP-11	SP-10	2325.74	PVC	8	2317.93	2310.73	0.0140	512.78

APPENDIX C2 - CITY SEWERS (MAIN COLLECTION SYSTEM)

Pipe Segment MH Designations		Upstream MH Rim Elevation	Pipe Material	Pipe Diameter	Invert Elevations		Slope	Length
Upstream MH	Downstream MH				Upstream	Downstream		
SP-12	SP-11	2334.29	PVC	8	2321.50	2317.93	0.0129	277.15
SP-13	SP-12	2330.70	PVC	8	2322.75	2321.70	0.0037	284.77
SP-14	5P-13	2328.00	PVC	8	2324.00	2322.95	0.0038	277.44
SP-15	SP-14	2339.45	PVC	8	2334.01	2324.20	0.0335	292.50
SP-16	SP-15	2349.23	PVC	8	2344.50	2336.01	0.0409	207.77
SP-17	SP-16	2353.96	PVC	8	2349.00	2344.70	0.0283	151.95
SP-18	SP-17	2354.90	PVC	8	2350.33	2349.20	0.0040	285.81
SP-2	SP-1	2277.29	PVC	8	2269.74	2268.54	0.0205	58.55
SP-3	SP-2	2279.83	PVC	8	2271.40	2269.74	0.0060	278.00
SP-4	SP-3	2283.70	PVC	8	2275.82	2271.40	0.0099	445.01
SP-4A	SP-4	2285.38	PVC	8	2277.55	2275.82	0.0107	161.34
SP-5	SP-4A	2289.00	PVC	8	2280.27	2277.55	0.0129	210.39
SP-6	SP-5	2293.57	PVC	8	2285.96	2280.27	0.0292	194.85
SP-7	SP-6	2296.78	PVC	8	2289.10	2285.96	0.0146	214.84
SP-8	SP-7	2301.68	PVC	8	2294.23	2289.10	0.0200	257.08
SP-9	SP-8	2309.75	PVC	8	2302.44	2294.23	0.0296	276.93
TP.10.1	TP-10	2262.19	PVC	8	2256.39	2255.63	0.0040	189.77
TP.1-1	TP-1	2265.12	PVC	8	2258.58	2256.78	0.0042	425.01
TP.5-1	TP-5	2262.43	PVC	8	2256.49	2255.67	0.0040	206.43
TP.6-1	TP-6	2261.73	PVC	8	2256.76	2256.18	0.0040	145.05
TP.8-1	TP-8	2264.12	PVC	8	2253.83	2253.71	0.0042	28.64
TP.9-1	TP-9	2263.07	PVC	8	2254.64	2254.31	0.0041	81.25
TP.9-2	TP.9-1	2263.30	PVC	8	2255.00	2254.84	0.0040	40.29
TP.9-3	TP.9-2	2262.52	PVC	8	2256.69	2255.20	0.0040	372.78
TP-1	MH-06	2263.36	PVC	8	2256.69	2256.00	0.0042	163.81
TP-10	TP-9	2263.08	PVC	8	2255.43	2254.31	0.0040	279.23
TP-11	TP-10	2261.30	PVC	8	2256.66	2255.63	0.0040	258.00
TP-12	TP-11	2262.40	PVC	8	2258.22	2256.86	0.0039	351.11
TP-2	TP-1	2262.33	PVC	8	2257.34	2256.79	0.0040	137.14
TP-3	TP-2	2261.86	PVC	8	2257.78	2257.44	0.0042	81.59
TP-4	TP-3	2261.98	PVC	8	2258.49	2257.88	0.0039	154.77
TP-5	MH-04A	2262.59	PVC	8	2255.57	2254.90	0.0042	158.15
TP-6	TP-5	2261.11	PVC	8	2256.08	2255.67	0.0040	103.00
TP-7	TP-6	2261.20	PVC	8	2256.79	2256.18	0.0040	152.67
TP-8	MH-02A	2264.38	PVC	8	2253.51	2252.61	0.0041	218.22
TP-9	TP-8	2262.67	PVC	8	2254.11	2253.71	0.0040	99.49

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX D

PUMP STATION INVENTORY AND CONDITION ASSESSMENTS

- D-1 "B" STREET SOUTH PS
- D-2 "B" STREET NORTH PS
- D-3 SOUTH 97 PS
- D-4 DEMERS PS
- D-5 GOLF COURSE PS (PROPOSED REPLACEMENT)

APPENDIX D1
SUMMARY PUMP STATION CONDITION ASSESSMENT

FACILITY NAME: "B" STREET SOUTH (B-SOUTH)
CONFIGURATION: SUBMERSIBLE PS

CONDITION RATING SCALE:

1. Very Good - No Significant Deterioration
2. Good - Slight/Minor Deterioration
3. Adequate - Moderate Deterioration/Requires Extra Maint.
4. Poor - Repairs/Replacement Warranted
5. Poor/Obsolete - Replacement Warranted/No Longer Available

STRUCTURAL COMPONENTS

WET WELL

MATERIAL: CONCRETE W/ALUMINUM HATCHES
SIZE: 12.0 FEET x 12.0 FEET
CONDITION: 1 [2] 3 4 5

VALVE CHAMBER

MATERIAL: CONCRETE W/ALUMINUM HATCHES
SIZE: 12.0 FEET x 6.17 FEET
CONDITION: 1 [2] 3 4 5

DIVERSION STRUCTURE (SPLITS FLOWS BETWEEN B-NORTH & B-SOUTH)

MATERIAL: CONCRETE W/ALUMINUM HATCHES
SIZE: 6.0 FEET x 16.5 FEET
CONDITION: 1 [2] 3 4 5

MECHANICAL EQUIPMENT

PUMPS

NO. OF PUMPS: TWO
DESIGN OPERATING POINT: 920 GPM @ 53 FEET TDH
MFR. & MODEL NO. XYLEM FLYGT MODEL CP3152.091-454
CONDITION: 1 [2] 3 4 5

PUMP MOTORS

SIZE & RATED SPEED: 23 HP & 1,750 RPM
DRIVE TYPE: CONSTANT SPEED
CONDITION: 1 [2] 3 4 5

CHECK VALVES

MFR.: GA INDUSTRIES
SIZE & TYPE: 8-INCH CUSHIONED SWING TYPE
CONDITION: 1 [2] 3 4 5 (RUSTING-NEED PAINT)

ISOLATION VALVES

MFR.: DEZURIK
SIZE & TYPE: 8-INCH PLUG
CONDITION: 1 [2] 3 4 5 (RUSTING-NEED PAINT)

APPENDIX D1

ISOLATION GATES AT DIVERSION STRUCTURE

MFR.:	NOT AVAILABLE
SIZE & TYPE:	24-INCH CAST IRON SLUICE GATES
CONDITION:	1 [2] 3 4 5

ELECTRICAL & CONTROLS (LOCATED IN B-NORTH PS BLDG.)

PUMP MOTOR CONTROLS (MCC-1) - POWER FEED EXTENDS FROM MCC-2

MCC DISCONNECT SIZE:	200 AMPS
MOTOR STARTER TYPE:	FULL-VOLTAGE, NON-REVERSING
CONDITION:	1 [2] 3 4 5

PS CONTROLS

SINGLE CONTROL PANEL SERVES BOTH B-NORTH & B-SOUTH (SEE FORM FOR B-NORTH PS)

PRIMARY LEVEL SENSOR

TYPE:	ULTRASONIC LEVEL SENSOR/TRANSMITTER
MFR. & MODEL	SIEMENS MILLTRONICS HYDRORANGER
CONDITION:	1 [2] 3 4 5

BACKUP LEVEL SENSOR

TYPE:	FLYGT FLOAT SWITCHES
CONDITION:	1 [2] 3 4 5

BACK-UP POWER

ONE GENSET SERVES BOTH B-NORTH & B-SOUTH (SEE FORM FOR B-NORTH PS)

MAJOR PS PIPING

PS INFLUENT LINE TO DIVERSION STRUCTURE (BURIED)

DIAMETER:	18 INCHES
MATERIAL:	CONCRETE PIPE TRANSITIONS TO DUCTILE IRON ONSITE

TRANSFER LINE TO WET WELL (BURIED)

DIAMETER:	24 INCHES
MATERIAL:	DUCTILE IRON

PUMP DISCHARGE (EXPOSED IN WET WELL & VALVE CHAMBER)

DIAMETER:	8-INCH DISCHARGE PIPES CONNECTED TO 12-INCH MANIFOLD
MATERIAL:	DUCTILE IRON (RUSTING-NEEDS PAINT)

PS FORCE MAIN (BURIED)

DIAMETER:	14 INCHES
MATERIAL:	PVC

VENT PIPE (BURIED)

DIAMETER:	12 INCHES
MATERIAL:	PVC

NOTES

1. PUMP STATION DESIGNED FOR FUTURE ADDITION OF TWO MORE PUMPS.
2. GREASE BUILDUP NOTED IN WET WELL.
3. CALCIUM NITRATE FED INTO B-SOUTH PS FOR ODOR CONTROL AT DISCHARGE MH (McTAGGART RD). CHEMICAL STORED IN 5,000 GAL. PLASTIC TANK ON PS SITE.

APPENDIX D2
SUMMARY PUMP STATION CONDITION ASSESSMENT

FACILITY NAME: "B" STREET NORTH (B-NORTH)
CONFIGURATION: WET WELL-DRY WELL

CONDITION RATING SCALE:

1. Very Good - No Significant Deterioration
2. Good - Slight/Minor Deterioration
3. Adequate - Moderate Deterioration/Requires Extra Maint.
4. Poor - Repairs/Replacement Warranted
5. Poor/Obsolete - Replacement Warranted/No Longer Available

STRUCTURAL COMPONENTS

WET WELL/DRY WELL

MATERIAL: CONCRETE
WET WELL SIZE: 8.0 FEET x 21.67 FEET WET WELL
DRY WELL SIZE: 18.5 FEET x 21.67 FEET
CONDITION: 1 [2] 3 4 5

PS SUPERSTRUCTURE

MATERIAL: CMU WALLS & METAL ROOF ON METAL FRAMING CONSTRUCTED OVER DRY WELL & PART OF WET WELL
SIZE: 22.67 FT. x 22.67 FT.
CONDITION: 1 2 [3] 4 5

GENERATOR BUILDING

MATERIAL: CONCRETE SLAB, CMU WALLS & WOOD FRAMED ROOF W/COMPOSITE SHINGLES
SIZE: 14.0 FT. x 22.0 FT.
CONDITION: 1 [2] 3 4 5

SEE B-SOUTH SUMMARY SHEET FOR INFO ON DIVERSION STRUCTURE

MECHANICAL EQUIPMENT

PUMPS

NO. OF PUMPS: FOUR - TWO PAIRS IN SERIES
DESIGN OPERATING POINT: 770 GPM @ 165 FEET TDH (EA PUMP)
MFR. & MODEL NO. CORNELL 4414T VERTICAL COUPLED
CONDITION: [1] 2 3 4 5

PUMP MOTORS

SIZE & RATED SPEED: 60 HP & 1,785 RPM (TYPICAL OF FOUR)
DRIVE TYPE: CONSTANT SPEED
CONDITION: [1] 2 3 4 5

SURGE ACCUMULATOR TANKS

NO. & SIZE: FIVE TANKS @ 120 GALLONS EACH
MATERIAL: CARBON STEEL (ASME PRESSURE VESSEL)
CONDITION: 1 2 [3] 4 5

APPENDIX D2

CHECK VALVES

MFR.: KENNEDY
SIZE & TYPE: 8-INCH SWING TYPE
CONDITION: 1 [2] 3 4 5

SUCTION-SIDE ISOLATION VALVES

MFR.: DEZURIK
SIZE & TYPE: 10-INCH KNIFE GATE
CONDITION: [1] 2 3 4 5

DISCHARGE-SIDE ISOLATION VALVES

MFR.: NOT AVAILABLE
SIZE & TYPE: 8-INCH GATE
CONDITION: 1 [2] 3 4 5

ACCUMULATOR ISOLATION VALVES

MFR.: DEZURIK
SIZE & TYPE: 6-INCH KNIFE GATE
CONDITION: 1 [2] 3 4 5

ELECTRICAL & CONTROLS

MAIN PS DISCONNECT

SIZE: 400 AMPS
CONDITION: 1 [2] 3 4 5

PUMP MOTOR CONTROLS (MCC-2)

MCC DISCONNECT SIZE: 400 AMPS
MOTOR STARTER TYPE: FULL-VOLTAGE, NON-REVERSING
CONDITION: 1 [2] 3 4 5

PS CONTROLS (SERVES BOTH B-NORTH & B-SOUTH)

PLC MFR.: ALLEN BRADLEY
TELEMETRY: RADIO
CONDITION: 1 [2] 3 4 5

PRIMARY LEVEL SENSOR

TYPE: ULTRASONIC LEVEL SENSOR/TRANSMITTER
MFR. & MODEL SIEMENS MILLTRONICS HYDRORANGER
CONDITION: 1 [2] 3 4 5

BACKUP LEVEL SENSOR

TYPE: Flygt Float Switches
CONDITION: 1 [2] 3 4 5

BACK-UP POWER (ALSO SERVES B-SOUTH PS)

GENERATOR MFR.: KOHLER
CAPACITY: 350 KW
FUEL & TANK CAPACITY: DIESEL - 500 GALLONS
TRANSFER SWITCH TYPE: 400-AMP AUTOMATIC
CONDITION: 1 [2] 3 4 5

APPENDIX D2

MAJOR PS PIPING

TRANSFER LINE TO WET WELL (BURIED - FROM DIVERSION STRUCTURE)

DIAMETER:	24 INCHES
MATERIAL:	DUCTILE IRON

PUMP SUCTION, PUMP DISCHARGE & ACCUMULATOR PIPING (EXPOSED IN DRY WELL)

DIAMETER:	8-INCH & 10-INCH PIPING & MANIFOLDS 6-INCH CONNECTIONS TO ACCUMULATORS
MATERIAL:	DUCTILE IRON PIPING & CARBON STEEL MANIFOLDS

PS FORCE MAIN (BURIED)

DIAMETER:	10 INCHES
MATERIAL:	DUCTILE IRON (NOT CONFIRMED)

NOTES

1. PS CONSTRUCTED IN THE MID 1970s & UPGRADED IN THE LATE 1990s.
2. ALL PUMPS & MOTORS REPLACED IN 2014 & 2015.
3. PUMPS SUBJECT TO CLOGGING FROM CLOTH "FLUSHABLE" ITEMS.
4. EXHAUST FAN VENTILATES PS DRY WELL - CONDITION IS POOR (KEY NO. 4).
5. ELECTRIC HEATER MOUNTED IN PS BLDG. TO HEAT UPSTAIRS AREA - CONDITION IS GOOD.
6. RV DUMP STATION REPLACED ON PS SITE 5-8 YRS. AGO. PLASTIC WASTE PIPE DISCHARGES INTO B-NORTH WET WELL.

APPENDIX D3
SUMMARY PUMP STATION CONDITION ASSESSMENT

FACILITY NAME: SOUTH 97
CONFIGURATION: SUBMERSIBLE PS

CONDITION RATING SCALE:

1. Very Good	- No Significant Deterioration
2. Good	- Slight/Minor Deterioration
3. Adequate	- Moderate Deterioration/Requires Extra Maint.
4. Poor	- Repairs/Replacement Warranted
5. Poor/Obsolete	- Replacement Warranted/No Longer Available

STRUCTURAL COMPONENTS

WET WELL

MATERIAL: CONCRETE W/ALUMINUM HATCH
SIZE: 6 FT. DIAMETER
CONDITION: [1] 2 3 4 5

VALVE VAULT

MATERIAL: CONCRETE W/ALUMINUM HATCH
SIZE: 7 FT. DIAMETER
CONDITION: [1] 2 3 4 5

MECHANICAL EQUIPMENT

PUMPS

NO. OF PUMPS: TWO
DESIGN OPERATING POINT: 40 GPM @ 49.6 FEET TDH
MFR. & MODEL NO. XYLEM FLYGT MODEL CP3067.090-9149
CONDITION: 1 [2] 3 4 5

PUMP MOTORS

SIZE & RATED SPEED: 1.9 HP & 3,395 RPM
DRIVE TYPE: VARIABLE FREQUENCY DRIVES
CONDITION: 1 [2] 3 4 5

CHECK VALVES

MFR.: NOT AVAILABLE
SIZE & TYPE: 4-INCH SWING TYPE
CONDITION: 1 2 [3] 4 5

ISOLATION VALVES

MFR.: NOT AVAILABLE
SIZE & TYPE: 4-INCH GATE
CONDITION: 1 2 [3] 4 5

APPENDIX D3

ELECTRICAL & CONTROLS

MAIN DISCONNECT SIZE: 100 AMPS
CONDITION: 1 [2] 3 4 5

PUMP CONTROLS

ENCLOSURE MATERIAL: PAINTED STEEL W/HEATER
PLC MFR.: ALLEN BRADLEY
STARTER TYPE: VARIABLE FREQUENCY DRIVES (EA PUMP)
TELEMETRY: RADIO
CONDITION: [1] 2 3 4 5

PRIMARY LEVEL SENSOR

TYPE: SIEMENS MILLTRONICS MINIRANGER PLUS
CONDITION: 1 [2] 3 4 5

BACKUP LEVEL SENSOR

TYPE: FLOAT SWITCHES
CONDITION: 1 2 [3] 4 5

BACK-UP POWER

MANUAL TRANSFER SWITCH & RECEPTACLE
PORTABLE GENSET REQUIRED

MAJOR PS PIPING

PS INFLUENT SEWER (BURIED)

DIAMETER: 8 INCHES
MATERIAL: PVC

PUMP DISCHARGE (EXPOSED IN WET WELL & VALVE CHAMBER)

DIAMETER: 4-INCH DISCHARGE PIPES & MANIFOLD
MATERIAL: DUCTILE IRON

PS FORCE MAIN (BURIED)

DIAMETER: 4 INCHES
MATERIAL: PVC

NOTES

1. ELECTRICAL & CONTROL PANEL ENCLOSURE MOUNTED ON WOODEN RACK
2. CITY CURRENTLY HAS 5-KW PORTABLE GENSET (COLEMAN POWERHOUSE 5000, FUELED W/GASOLINE).
3. NO PERIMETER FENCE OR OVERHEAD LIGHT.

APPENDIX D4
SUMMARY PUMP STATION CONDITION ASSESSMENT

FACILITY NAME: DEMERS
CONFIGURATION: SUBMERSIBLE PS

CONDITION RATING SCALE:

1. Very Good - No Significant Deterioration
2. Good - Slight/Minor Deterioration
3. Adequate - Moderate Deterioration/Requires Extra Maint.
4. Poor - Repairs/Replacement Warranted
5. Poor/Obsolete - Replacement Warranted/No Longer Available

STRUCTURAL COMPONENTS

WET WELL

MATERIAL: CONCRETE W/ALUMINUM HATCH
SIZE: 6 FT. DIAMETER
CONDITION: 1 [2] [3] 4 5
NOTE: HATCH FRAME & ACCESSORIES CORRODED; ONE PUMP RETRIEVAL RAIL BROKEN.

VALVE VAULT

MATERIAL: CONCRETE W/CAST IRON MH LID
SIZE: 6 FT. DIAMETER
CONDITION: 1 [2] 3 4 5

MECHANICAL EQUIPMENT

PUMPS

NO. OF PUMPS: TWO
DESIGN OPERATING POINT: 290 GPM @ 76 FEET TDH
MFR. & MODEL NO. XYLEM FLYGT MODEL CP3127.090-481
CONDITION: 1 2 [3] 4 5

PUMP MOTORS

SIZE & RATED SPEED: 10 HP & 1,750 RPM
DRIVE TYPE: CONSTANT SPEED
CONDITION: 1 2 [3] 4 5

CHECK VALVES (2)

MFR.: MUELLER (PER TENNESON PLAN)
SIZE & TYPE: 4-INCH SWING TYPE
CONDITION: 1 2 [3] 4 5

ISOLATION VALVES (3)

MFR.: UNKNOWN
SIZE & TYPE: 4-INCH GATE (ONE EA PUMP DISCHARGE & ONE CROSSOVER)
CONDITION: 1 2 [3] 4 5

AIR RELEASE VALVE

MFR.: VALMATIC MODEL 48-301BW
SIZE & TYPE: 2-INCH AIR & VACUUM FOR SEWAGE SERVICE
CONDITION: 1 2 [3] 4 5

APPENDIX D4

ELECTRICAL & CONTROLS

MAIN DISCONNECT SIZE: 200 AMPS
CONDITION: 1 [2] 3 4 5

PUMP CONTROLS

PLC MFR.: ALLEN BRADLEY
STARTER TYPE: FULL-VOLTAGE, NON-REVERSING
TELEMETRY: RADIO
SUPPORT RACK: STEEL SUPPORTS W/WOOD BACK BOARD
CONDITION: 1 [2] 3 4 5

PRIMARY LEVEL SENSOR

TYPE: PRESSURE/LEVEL TRANSDUCER
CONDITION: 1 [2] 3 4 5

BACKUP LEVEL SENSOR

TYPE: FLOAT SWITCHES
CONDITION: 1 [2] 3 4 5

BACK-UP POWER

MANUAL TRANSFER SWITCH & RECEPTACLE
PORTABLE GENSET REQUIRED (SEE NOTES BELOW)

MAJOR PS PIPING

PS INFLUENT SEWER (BURIED)

DIAMETER: 10 INCHES
MATERIAL: PVC

PUMP DISCHARGE (EXPOSED IN WET WELL & VALVE CHAMBER)

DIAMETER: 4-INCH DISCHARGE PIPES & MANIFOLD
MATERIAL: DUCTILE IRON

PS FORCE MAIN (BURIED)

DUAL FORCE MAINS
DIAMETER: 4 INCHES (BOTH)
MATERIAL: PVC (BOTH)

NOTES

1. ELECTRICAL & CONTROL PANEL ENCLOSURE MOUNTED ON METAL RACK
2. DEBRIS NOTED IN WET WELL.
3. CITY DOES NOT HAVE PORTABLE GENSET W/SUFFICIENT CAPACITY. MUST BORROW GENSET FROM PRISON.
4. NO PERIMETER FENCE OR OVERHEAD LIGHT.

APPENDIX D5
SUMMARY PUMP STATION CONDITION ASSESSMENT

FACILITY NAME: GOLF COURSE
CONFIGURATION: SUBMERSIBLE PS

CONDITION RATING SCALE:

1. Very Good	- No Significant Deterioration
2. Good	- Slight/Minor Deterioration
3. Adequate	- Moderate Deterioration/Requires Extra Maint.
4. Poor	- Repairs/Replacement Warranted
5. Poor/Obsolete	- Replacement Warranted/No Longer Available

GENERAL NOTE:
EXISTING PS IS IN POOR CONDITION & DUE FOR REPLACEMENT. SUMMARY EQUIPMENT INFORMATION PROVIDED BELOW IS FOR PROPOSED REPLACEMENT PS (SEE NOTES).

STRUCTURAL COMPONENTS

WET WELL

MATERIAL:	CONCRETE W/ALUMINUM HATCH
SIZE:	8 FT. DIAMETER (EXISTING IS 6 FT. DIAMETER)

VALVE VAULT

MATERIAL:	CONCRETE W/ALUMINUM HATCHES
SIZE:	8.0 FEET x10.0 FEET (EXISTING IS CIRCULAR MH SECTION)

MECHANICAL EQUIPMENT

PUMPS

NO. OF PUMPS:	TWO
DESIGN OPERATING POINT:	140 GPM @ 57 FEET TDH
MFR. & MODEL NO.	XYLEM FLYGT MODEL CP3102.095

NOTE: EXISTING PUMPS - ABS MODEL AFP1040 (1.75 HP)

PUMP MOTORS

SIZE & RATED SPEED:	10 HP & 1,750 RPM
DRIVE TYPE:	VARIABLE FREQUENCY DRIVES

CHECK VALVES (2)

MFR.:	TO BE DETERMINED
SIZE & TYPE:	4-INCH CUSHIONED SWING TYPE

ISOLATION/BYPASS VALVES (3)

MFR.:	TO BE DETERMINED
SIZE & TYPE:	4-INCH ECCENTRIC PLUG

BACK DRAIN VALVE

MFR.:	TO BE DETERMINED
SIZE & TYPE:	4-INCH ECCENTRIC PLUG W/MOTORIZED ACTUATOR

NOTE: EXISTING AIR COMPRESSOR FOR CORROSION CONTROL NO LONGER FUNCTIONS.

APPENDIX D5

AIR RELEASE VALVE

MFR.:	TO BE DETERMINED
SIZE & TYPE:	1-INCH SEWAGE COMBINATION AIR VALVE

NOTE: NO EXISTING AIR RELEASE VALVE.

ELECTRICAL & CONTROLS

MAIN DISCONNECT SIZE:	200 AMPS

PUMP CONTROLS

ENCLOSURE MATERIAL:	STAINLESS STEEL
PLC MFR.:	ALLEN BRADLEY
STARTER TYPE:	VARIABLE FREQUENCY DRIVES
TELEMETRY:	RADIO

NOTE: NO EXISTING TELEMETRY SYSTEM. EXISTNG PUMPS CONSTANT SPEED.

PRIMARY LEVEL SENSOR

TYPE:	PRESSURE TRANSDUCER & TRANSMITTER

BACKUP LEVEL SENSOR

TYPE:	POLYPROPYLENE FLOAT SWITCHES

NOTE: NO EXISTING BACKUP LEVEL SENSOR.

BACK-UP POWER

MANUAL TRANSFER SWITCH & RECEPTACLE
PORTABLE GENSET REQUIRED

MAJOR PS PIPING

PS INFLUENT SEWER (NEW BURIED PIPE)

DIAMETER:	8 INCHES (TWO INLET SEWERS W/INSIDE DROP ASSEMBLIES)
MATERIAL:	PVC

PUMP DISCHARGE (EXPOSED IN WET WELL & VALVE CHAMBER)

DIAMETER:	4-INCH DISCHARGE PIPES & MANIFOLD
MATERIAL:	DUCTILE IRON

PS FORCE MAIN (BURIED)

DIAMETER:	4 INCHES
MATERIAL:	PVC
CASING:	6-INCH STEEL

NOTE: EXISTING FORCE MAIN TO REMAIN AFTER PS REPLACEMENT.

NOTES

1. LIMITED INFORMATION AVAILABLE ON EXISTING EQUIPMENT.
2. CITY CURRENTLY HAS 5-KW PORTABLE GENSET (COLEMAN POWERHOUSE 5000, FUELED W/GASOLINE).
3. REPLACEMENT ELEC. & CONTROL ENCLOSURES TO BE MOUNTED ON SS RACK.
4. NO EXISTING FENCE. PROPOSED PS TO HAVE PERIMETER FENCE & OVERHEAD LIGHT.
5. PROPOSED PS TO HAVE WATER SERVICE W/YARD HYDRANT & BACKFLOW PREVENTER.

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX E

WASTEWATER TREATMENT PLANT
INVENTORY AND CONDITION ASSESSMENTS

- E-1 NORTH WASTEWATER TREATMENT PLANT
- E-2 SOUTH WASTEWATER TREATMENT PLANT

APPENDIX E1

SUMMARY WWTP CONDITION ASSESSMENT

FACILITY NAME: NORTH WASTEWATER TREATMENT PLANT

CONDITION RATING SCALE:

1. Very Good - No Significant Deterioration
2. Good - Slight/Minor Deterioration
3. Adequate - Moderate Deterioration/Requires Extra Maint.
4. Poor - Repairs/Replacement Warranted
5. Poor/Obsolete - Replacement Warranted/No Longer Available

STRUCTURAL COMPONENTS

LAGOON INLET STRUCTURE

MATERIAL: CONCRETE W/ALUMINUM WEIR GATES & GRATING
INTERIOR DIMENSIONS: 2.0 FT. x 6.0 FT.
CONDITION: 1 2 [3] 4 5

LAGOON SYSTEM

NO. OF CELLS: FIVE
MATERIAL: EARTHEN BASINS W/PVC LINERS

LAGOON SYSTEM TRANSFER & OUTLET STRUCTURES

NO. OF STRUCTURES: FIVE
MATERIAL: CONCRETE W/ALUMINUM WEIR GATE, ALUMINUM GRATING & WOODEN WALKWAY
INTERIOR DIMENSIONS: 3.0 FT. x 4.0 FT.
CONDITION: 1 2 [3] 4 5

FLOTATION/FILTRATION CLARIFIER SUPPORT & ACCESS STRUCTURE

MATERIAL: CONCRETE W/ALUMINUM ACCESS PLATFORM & STAIRWAY
INTERIOR DIMENSIONS: 3.0 FT. x 4.0 FT.
CONDITION: 1 2 [3] 4 5

CHLORINE CONTACT BASIN

MATERIAL: CONCRETE W/ALUMINUM GRATING & LADDER
INTERIOR DIMENSIONS: 66.33 FT. x 14.83 FT.
CONDITION: 1 2 [3] 4 5

OPERATIONS/CHEMICAL BUILDING

MATERIAL: CONCRETE SLAB & STEM WALLS, CMU WALLS & WOOD FRAMED ROOF W/COMPOSITE SHINGLES
INTERIOR DIMENSIONS: 38.67 FT. x 16.0 FT.
CONDITION: 1 2 [3] 4 5

SITE DRAIN PS WET WELL

MATERIAL: CONCRETE
SIZE: 8.0 FT. DIAMETER
CONDITION: 1 2 [3] 4 5

DRYING BED UNDERDRAIN PS WET WELL

MATERIAL: PRECAST CONCRETE W/ALUMINUM HATCHES
SIZE: 4.0 FT. DIAMETER WET WELL & 3.5-FT. SQUARE VALVE VAULT
CONDITION: 1 2 [3] 4 5

APPENDIX E1

CHLORINE BUILDING

MATERIAL: CONCRETE SLAB, CMU WALLS & WOOD FRAMED, BUILT-UP ROOF
INTERIOR DIMENSIONS: 8.67 FT. x 8.67 FT.
CONDITION: 1 2 [3] 4 5

DAF PUMP BUILDING

MATERIAL: CONCRETE SLAB & STEM WALLS, WOOD-FRAME WALLS W/WOOD SIDING, & WOOD-FRAME ROOF W/COMPOSITION SHINGLES
INTERIOR DIMENSIONS: 8.67 FT. x 8.67 FT.
CONDITION: 1 [2] 3 4 5

SLUDGE DRYING BEDS

MATERIAL: AC PAVING, CONCRETE & GRANULAR DRAIN MATERIAL
APPROX. OVERALL SIZE: 200 FT. x 150 FT. (BEDS) & 200 FT. x 50 FT. (DRIED SLUDGE AREA)
CONDITION: 1 [2] 3 4 5

SEPTAGE RECEIVING TANK

MATERIAL: CONCRETE
(DOES NOT DISCHARGE TO LAGOONS - LEASED TO OTHERS, SEPTAGE HAULED OFFSITE)

MECHANICAL EQUIPMENT

INFLUENT FLOW METER

TYPE: ELECTROMAGNETIC FLOW TUBE
MFR. & MODEL NO. ROSEMOUNT MODEL 8705
CONDITION: 1 [2] 3 4 5
(RECENTLY REPAIRED BY TAURUS)

LAGOON AERATORS (PONDS A & B)

NO. OF UNITS: 20 TOTAL (10 IN EACH LAGOON)
TYPE: FLOAT-MOUNTED, SURFACE ASPIRATING AERATORS
MFR. & MODEL: AEROMIX SYSTEMS TORNADO
MOTOR SIZE & SPEED: 5 HP & 1,725 RPM
CONDITION: 1 2 3 [4] 5
(AERATORS WORN DUE TO AGE, SOME NO LONGER FUNCTIONING)

POND E PUMPER

TYPE: FLOAT-MOUNTED CHOPPER PUMP
DESIGN OPERATING POINT: 250 GPM @ 28 FEET TDH
MOTOR SIZE & SPEED: 5 HP & 1,750 RPM
MFR. & MODEL NO. VAUGHAN P-V4P-103 (29-INCH LONG)
DRIVE TYPE: CONSTANT SPEED
CONDITION: 1 [2] 3 4 5

SLUDGE POND PUMPER (NOT USED - DOESN'T WORK ON THICK/DEWATERED SLUDGE)

TYPE: FLOAT-MOUNTED CHOPPER PUMP
DESIGN OPERATING POINT: 250 GPM @ 28 FEET TDH
MOTOR SIZE & SPEED: 5 HP & 1,750 RPM
MFR. & MODEL NO. VAUGHAN P-V3G-065 (26-INCH LONG)
DRIVE TYPE: CONSTANT SPEED
CONDITION: FUNCTIONAL, BUT NOT SUITABLE FOR APPLICATION

APPENDIX E1

INTERMEDIATE LIFT PUMP

TYPE:	VERTICAL TURBINE
DESIGN OPERATING POINT:	700 GPM @ 42 FEET TDH
MOTOR SIZE & SPEED:	30 HP & 1,755 RPM
MFR. & MODEL NO.	AMERICAN TURBINE 10H75 (SINGLE STAGE)
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 [2] 3 4 5

FLOTATION/FILTRATION CLARIFIER PROCESS (ONLY CLARIFIER USED)

TYPE:	FRAME-MOUNTED, DISSOLVED-AIR FLOTATION CLARIFIER & SINGLE-MEDIA FILTER
MFR. & MODEL NO.	KROFTA SANDFLOAT SASF 20
MAIN COMPONENTS (SEE SEPARATE EQUIP. SUMMARIES):	MIX TANK, FLOCCULATION TANK, ROTATING CLARIFIER CARRIAGE ASSY., SLUDGE SCOOP, AIR COMPRESSOR ASSY., PRESSURE PUMPS, AIR DISSOLVING TUBES, SAND FILTER, BACKWASH SYSTEM, CONTROL VALVES, LEVEL CONTROLLER, CHEMICAL FEED SYSTEMS & MFR'S. PROCESS CONTROLS
DESIGN CAPACITY:	1.0 MGD (695 GPM)
DESIGN FILTRATION RATE:	2.5 GPM/SQ. FT. OF SURFACE AREA @ 1.0 MGD
OVERALL CONDITION:	1 2 [3] [4] 5

NOTES:

SOME REPAIRS MADE TO CLARIFIER PROCESS, CONDITION ADEQUATE

NOT COST EFFECTIVE TO OPERATE SAND FILTER, CITY DOES NOT NEED TO PRODUCE CLASS A EFFLUENT - FILTER CONDITION POOR

ADT PRESSURE PUMPS (FLOTATION/FILTRATION CLARIFIER)

NO. & TYPE OF UNITS:	TWO CENTRIFUGAL PUMPS	
DESIGN OPERATING POINT:	130 GPM @ 180 FEET TDH	(FROM ORIGINAL SPECIFICATION)
MOTOR SIZE & SPEED:	10 HP & 3,450 RPM	
MFR. & MODEL NO.	BERKELEY PUMP MODEL B	
DRIVE TYPE:	CONSTANT SPEED	
CONDITION:	1 [2] 3 4 5	

AIR COMPRESSOR (FLOTATION/FILTRATION CLARIFIER)

TYPE:	RECIPROCATING	
MOTOR SIZE & SPEED:	10 HP & 1,765 RPM	
MFR. & MODEL NO.	INGERSOLL RAND MODEL 2545	
DRIVE TYPE:	CONSTANT SPEED	
CONDITION:	[1] 2 3 4 5	(PURCHASED 2015)

SPC DRIVES (FLOTATION CLARIFIER)

NO. OF UNITS:	TWO (SPC ROTATING CARRIAGE & SPC SLUDGE SCOOP DRIVES)	
MOTOR SIZE & SPEED:	1.0 HP & 1,735 RPM	
MFR.:	YASKAWA	
DRIVE TYPE:	VARIABLE FREQUENCY DRIVE W/GEAR REDUCER	
CONDITION:	1 [2] 3 4 5	(REPLACED 6-7 YRS. AGO)

SASF CARRIAGE & SCOOP DRIVES (FILTRATION DRIVES - NO LONGER USED)

NO. OF UNITS:	TWO (SASF CARRIAGE & SASF SLUDGE SCOOP DRIVES)	
MOTOR SIZE & SPEED:	1.5 HP & 1,720 RPM	
MFR.:	SIEMENS	
DRIVE TYPE:	VARIABLE FREQUENCY DRIVE W/GEAR REDUCER	
CONDITION:	1 2 3 [4] 5	

APPENDIX E1

SASF BACKWASH PUMP (FLOTATION/FILTRATION CLARIFIER - NO LONGER USED)

TYPE:	VERTICAL TURBINE
DESIGN OPERATING POINT:	326 GPM @ 30 FEET TDH
MOTOR SIZE & SPEED:	3 HP & 1,765 RPM
MFR. & MODEL NO.	PEERLESS
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 2 3 [4] 5

DAF SLUDGE PUMP

TYPE:	PLUNGER TYPE POSITIVE DISPLACEMENT
DESIGN CAPACITY:	170 GPM @ 30 FEET TDH
MOTOR SIZE & SPEED:	3 HP & 1,160 RPM
MFR. & MODEL NO.	CARTER FIGURE 800 SIMPLEX
DRIVE TYPE:	CONSTANT SPEED - VARIABLE STROKE LENGTH
CONDITION:	1 [2] 3 4 5

CHEMICAL FEED SYSTEM (FLOTATION/FILTRATION CLARIFIER)

CHEMCIAL USED:	POLYALUMINUM CHLORHYDRATE
STORAGE TANK SIZE:	5,000 GALLONS
PUMP TYPE:	DIAPHRAGM METERING
DESIGN CAPACITY:	45 GPH @ 150 PSI
MOTOR SIZE & SPEED:	3/4 HP & 1,150 RPM
MFR. & MODEL NO.	WALLACE & TIERNAN ENCORE 700
CONDITION:	1 2 3 4 [5]

CHLORINE SOLUTION FEED

STORAGE TANK SIZE & MATERIAL:	1,700-GALLON HDPE TANK W/CONTAINMENT TUB
PUMP TYPE:	PERISTALTIC
PUMP DESIGN CAPACITY:	170 GPD @ 25 PSI (MAX.)
MOTOR SIZE:	1/3 HP
MFR. & MODEL NO.	STENNER 170DM5
DRIVE TYPE:	VARIABLE SPEED
CONDITION:	1 [2] 3 4 5 (INSTALLED 2014)

CHLORINE RESIDUAL ANALYZER

MFR. & MODEL NO.	CAPITOL CONTROLS 1870E (SAME MODEL NO LONGER AVAILABLE)
CONDITION:	1 2 [3] 4 5

TURBIDIMETER

MFR. & MODEL NO.	HF SCIENTIFIC MICROTOL
CONDITION:	1 [2] 3 4 5

EFFLUENT IRRIGATION PUMPS

TYPE:	VERTICAL TURBINE
DESIGN OPERATING POINT:	700 GPM @ 215 FEET TDH
MOTOR SIZE & SPEED:	60 HP & 1,780 RPM
MFR. & MODEL NO.	AMERICAN TURBINE HH25
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	[1] 2 3 4 5 (REBUILT 2016)

SITE DRAIN PUMP

TYPE:	SUBMERSIBLE
DESIGN OPERATING POINT:	120 GPM @ 17 FEET TDH
MOTOR SIZE & SPEED:	3 HP & 1,750 RPM
MFR. & MODEL NO.	AFP M22/411.60
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 [2] 3 4 5

APPENDIX E1

UNDERDRAIN PUMP (SLUDGE DRYING BEDS)

TYPE:	SUBMERSIBLE
DESIGN OPERATING POINT:	NOT AVAILABLE
MOTOR SIZE & SPEED:	3 HP & 1,750 RPM
MFR. & MODEL NO.	ABS AFP-M22/4FM
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 [2] 3 4 5

ELECTRICAL & CONTROLS

MAIN DISCONNECTS

DISCONNECT 1 SIZE (MCC-1):	400 AMPS (PUMPS & OTHER PROCESS EQUIPMENT)
CONDITION:	1 2 [3] 4 5
DISCONNECT 2 SIZE (MCC-2):	200 AMPS (LAGOON AERATORS)
CONDITION:	1 2 [3] 4 5

LAGOON AERATION CONTROLS

PLC MFR.:	ALLEN BRADLEY
TELEMETRY:	RADIO
MOTOR STARTERS:	FULL-VOLTAGE, NON-REVERSING
CONDITION:	[1] 2 3 4 5

FLOTATION CLARIFIER CONTROLS (SASF FILTRATION CONTROLS NOT USED)

MAIN COMPONENTS:	PANELBOARD, BREAKERS, PROCESS MOTOR STARTERS, VARIABLE FREQUENCY DRIVES, ALARM CONTACTS
TELEMETRY:	RADIO
CONDITION:	[1] 2 3 [4] 5
	(CLARIFIER CONTROL SYSTEM BEING UPGRADED BY TAURUS)

PIPING & VALVES

MAJOR YARD PIPING

10-INCH PLANT INFLUENT (DIP & CONCRETE)
12-INCH LAGOON TRANSFER (CONCRETE)
10-INCH SECONDARY EFFLUENT (PVC)
36-INCH SECONDARY EFFLUENT (CONCRETE - ORIGINALLY CHLORINE CONTACT PIPE)
10-INCH PLANT EFFLUENT/IRRIGATION (PVC)
MISCELLANEOUS WATER, WASTEWATER, SLUDGE & CHEMICAL PIPING (PVC)

PROCESS VALVES

PUMP DISCHARGE CHECK VALVES (SWING TYPE)
PUMP DISCHARGE ISOLATION VALVES (GATE, PLUG, OR KNIFE GATE)
SECONDARY EFFLUENT & PLANT EFFLUENT ISOLATION VALVES (PLUG)
FLOATION/FILTRATION CLARIFIER PNEUMATICALLY-ACTUATED CONTROL VALVES
MISCELLANEOUS ISOLATION VALVES (GATE, PLUG, & BALL TYPE)

NOTES

1. EARTHEN LAGOONS W/PVC LINER CONSTRUCTED IN THE MID 1970s.
2. FLOTATION/FILTRATION CLARIFIER & NEW DISINFECTION PROCESSES CONSTRUCTED IN 1993.
3. LAGOON AERATORS & DAF PUMP INSTALLED IN 1999.
4. KROFTA SASF FILTRATION PROCESS FUNCTIONAL, BUT NO LONGER USED.
5. NO STANDBY POWER FOR PUMPING & NO INFLUENT BAR RACK OR SCREEN.
6. PROXIMITY TO AIRPORT REQUIRES MITIGATION OF POTENTIAL WILDLIFE ATTRACTANTS.

APPENDIX E2

SUMMARY WWTP CONDITION ASSESSMENT

FACILITY NAME: SOUTH WASTEWATER TREATMENT PLANT

CONDITION RATING SCALE:

1. Very Good	- No Significant Deterioration
2. Good	- Slight/Minor Deterioration
3. Adequate	- Moderate Deterioration/Requires Extra Maint.
4. Poor	- Repairs/Replacement Warranted
5. Poor/Obsolete	- Replacement Warranted/No Longer Available

STRUCTURAL COMPONENTS

INFLUENT PUMP STATION STRUCTURE

MATERIAL:	CONCRETE W/ALUMINUM HATCHES
WET WELL SIZE:	12.0 FEET x 12.0 FEET
VALVE CHAMBER SIZE:	6.83 FEET x 12.0 FEET
CONDITION:	[1] 2 3 4 5

HEADWORKS PROCESS STRUCTURE

MATERIAL:	CONCRETE W/ALUMINUM GRATING
APPROX. OVERALL FOOTPRINT:	54.0 FT. x 16.0 FT.
SCREENING CHANNELS:	TWO @ 1.67 FT. WIDE x 16.0 FT. LONG
GRIT CHAMBER:	7.0 FT. DIAMETER
CONDITION:	[1] 2 3 4 5

HEADWORKS BUILDING

MATERIAL:	CONCRETE SLAB, CMU WALLS & WOOD FRAMED ROOF W/METAL DECK
INTERIOR DIMENSIONS:	10.0 FT. x 26.0 FT.
CONDITION:	[1] 2 3 4 5

CENTRAL PROCESS COMPLEX (SBR BASINS, DIGESTERS, SLUDGE TANK, & PROCESS BLDG.)

MATERIAL:	CONCRETE BASINS & FLOOR SLABS, CMU WALLS & WOOD FRAMED ROOF W/METAL DECKING
APPROX. OVERALL FOOTPRINT:	162.5 FT. x 150.0 FT.
COMPONENT DIMENSIONS:	
SBR BASINS	TWO @ 72.0 FT. SQUARE
POST-EQUALIZATION BASIN	56.0 FT. SQUARE
DIGESTERS 1A & 1B	TWO TANKS @ 28.0 FT. x 35.25 FT.
DIGESTER 2	28.0 FT. x 73.0 FT.
SLUDGE HOLDING TANK	39.0 FT. x 50.75 FT.
PROCESS BLDG.	26.67 FT. x 50.67 FT.
CONDITION:	[1] 2 3 4 5

FILTRATION & DISINFECTION STRUCTURE & BUILDING

MATERIAL:	CONCRETE TANKS & FLOOR SLABS, CMU WALLS, WOOD FRAMED ROOF W/METAL DECKING & ALUMINUM HATCHES
APPROX. OVERALL FOOTPRINT:	27.0 FT. x 29.0 FT.
COMPONENT DIMENSIONS:	
EFFLUENT PS WET WELL	8.0 FT. x 27.0 FT.
PLANT DRAIN WET WELL	8.0 FT. x 14.0 FT.
FILTER BACKWASH GALLERY	8.6 FT. x 14.0 FT.
FILTER BASIN & EFFL. CHAMBER	8.6 FT. x 14.0 FT.
CONDITION:	[1] 2 3 4 5

APPENDIX E2

VALVE & FLOWMETER VAULTS

MATERIAL:	PRECAST CONCRETE W/ALUMINUM HATCH
APPLICATIONS & SIZES:	
SBR INFLUENT VALVE VAULT -	8.0 FT. x 10.0 FT.
EFFLUENT FLOWMETER VAULT -	5.0 FT. x 10.5 FT.
PLANT DRAIN VALVE VAULT -	5.33 FT. x 6.83 FT.
POND BYPASS VAULT -	8.0 FT. x 10.0 FT.
UPPER POND PRV VAULT -	5.0 FT. x 10.0 FT.
ALTITUDE VALVE VAULT -	5.0 FT. x 10.0 FT.
CONDITION:	[1] 2 3 4 5

OPERATIONS BUILDING

MATERIAL:	CONCRETE SLAB, CMU WALLS & WOOD FRAMED ROOF W/METAL DECK
INTERIOR DIMENSIONS:	30.67 FT. x 56.67 FT.
CONDITION:	[1] 2 3 4 5

STORAGE/SHOP BUILDING (LESS THAN 15 YRS. OLD)

MATERIAL:	CONCRETE SLAB & METAL BLDG. (FRAMING, SIDING, & ROOF DECK)
INTERIOR DIMENSIONS:	40.0 FT. x 40.0 FT.
CONDITION:	[1] 2 3 4 5

GARAGE (CONSTRUCTED 2010)

MATERIAL:	CONCRETE SLAB & METAL BLDG. (FRAMING, SIDING, & ROOF DECK)
INTERIOR DIMENSIONS:	40.0 FT. x 70.0 FT.
CONDITION:	[1] 2 3 4 5

MECHANICAL EQUIPMENT

INFLUENT PUMPS

NO. OF UNITS:	TWO (SPACE FOR TWO ADDITIONAL PUMPS)
TYPE:	SUBMERSIBLE
DESIGN OPERATING POINT:	960 GPM @ 49 FEET TDH
MOTOR SIZE & SPEED:	23 HP & 1,745 RPM
MFR. & MODEL NO.	XYLEM FLYGT CP3152.091/454
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 [2] 3 4 5

INFLUENT SCREENING EQUIPMENT

NO. OF UNITS:	ONE MECHANICALLY-CLEANED, ONE BYPASS BAR RACK
MECHANICAL TYPE:	PERFORATED FINE SCREEN W/HELICAL CLEANING BRUSH
MFR. & MODEL:	PARKSON HELICLEAN HLC400
CLEAR OPENING:	0.25 INCH
DESIGN HYDRAULIC CAPACITY:	4.0 MGD
GEAR MOTOR SIZE & SPEED:	1.0 HP & 1,700 RPM
CONDITION:	1 [2] 3 4 5

GRIT REMOVAL EQUIPMENT

TYPE:	LOW-ENERGY VORTEX W/CIRCULAR CHAMBER
MFR. & MODEL NO.	SMITH & LOVELESS, INC. PISTA GRIT
MAIN COMPONENTS (SEE SEPARATE EQUIP. SUMMARIES):	CHAMBER PADDLE, GRIT PUMP, DEWATERING SCREW CONVEYOR & MFR'S. PROCESS CONTROLS
DESIGN HYDRAULIC CAPACITY:	2.5 MGD
CONDITION:	SEE SEPARATE EQUIP. SUMMARIES

APPENDIX E2

GRIT CHAMBER AGITATING PADDLE

TYPE:	VERTICAL TURBINE
MOTOR SIZE & SPEED:	0.75 HP & 1,800 RPM
MFR.	SMITH & LOVELESS, INC.
DRIVE TYPE:	CONSTANT SPEED W/GEAR REDUCER
CONDITION:	1 [2] 3 4 5

GRIT PUMP

TYPE:	VACUUM-PRIMED CENTRIFUGAL
DESIGN OPERATING POINT:	250 GPM @ 30.4 FEET TDH
MOTOR SIZE & SPEED:	10 HP & 1,800 RPM
MFR. & MODEL NO.	SMITH & LOVELESS, INC. MODEL 4B2H
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 2 [3] 4 5

GRIT DEWATERING SCREW CONVEYOR

TYPE:	CONCENTRATOR, SEPARATOR & SCREW CONVEYOR
MOTOR SIZE & SPEED:	1.0 HP & 1,150 RPM
MFR. & MODEL NO.	SMITH & LOVELESS, INC. MODEL 15
DRIVE TYPE:	CONSTANT SPEED W/GEAR REDUCER
CONDITION:	1 [2] 3 4 5

SBR PROCESS SUMMARY

TYPE:	AUTOMATED, TIME-BASED ACTIVATED SLUDGE PROCESS
MFR. & MODEL NO.	AQUA-AEROBIC SYSTEMS, INC. AQUASBR
MAIN COMPONENTS (SEE SEPARATE EQUIP. SUMMARIES):	INFLUENT & EFFLUENT CONTROL VALVES, MIXER, DECANTER, FINE-BUBBLE DIFFUSER GRIDS, BLOWERS, SLUDGE WASTING PUMPS, & MFR'S. PROCESS CONTROLS
CONDITION:	SEE SEPARATE EQUIP. SUMMARIES

SBR INFLUENT CONTROL VALVES

NO. OF VALVES:	TWO
SIZE & TYPE:	16-INCH PLUG W/MOTORIZED ACTUATOR
VALVE MFR.:	DEZURIK
ACTUATOR MFR.:	LIMITORQUE (NOT CONFIRMED)
CONDITION:	1 [2] 3 4 5

SBR BASIN MIXERS

NO.:	TWO
TYPE:	FLOAT-MOUNTED PROPELLER TYPE
PUMPING RATE:	12,450 GPM
MOTOR SIZE & SPEED:	25 HP & 900 RPM
MFR. & MODEL NO.	AQUA-AEROBIC SYS. ENDURA SERIES DDM
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 [2] 3 4 5

SBR BASIN DECANTERS

NO.:	TWO
TYPE:	FLOAT-MOUNTED CIRCULAR WEIR W/ELECTRIC ACTUATOR
MFR.	AQUA-AEROBIC SYS.
CONDITION:	1 [2] 3 4 5

SBR BASIN FINE-BUBBLE AIR DIFFUSER GRIDS

NO.:	10 GRIDS (FIVE PER BASIN)
TYPE:	EPDM MEMBRANE TUBES MOUNTED ON GRID FRAME
MFR.	AQUA-AEROBIC SYS.
CONDITION:	1 2 [3] [4] 5 (SBR #1 DIFFUSERS NEED REPLACEMENT)

APPENDIX E2

SBR BLOWERS

NO.:	FOUR
TYPE:	ROTARY-LOBE POSITIVE DISPLACEMENT
DESIGN CAPACITY & PRESSURE:	467 SCFM @ 10.7 PSI (MAX.)
MOTOR SIZE & SPEED:	40 HP & 1,780 RPM
MFR. & MODEL NO.	GARDNER DENVER SUTORBILT MODEL 6M
DRIVE TYPE:	CONSTANT SPEED W/BELT DRIVES
CONDITION:	1 [2] 3 4 5

SBR SLUDGE WASTING PUMPS

NO. OF UNITS:	TWO
TYPE:	SUBMERSIBLE
DESIGN OPERATING POINT:	NOT AVAILABLE
MOTOR SIZE & SPEED:	2.0 HP & 1,670 RPM
MFR. & MODEL NO.	XYLEM FLYGT CP3085.182
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 [2] 3 4 5

SBR EFFLUENT CONTROL VALVES

NO. OF VALVES:	TWO
SIZE & TYPE:	16-INCH BUTTERFLY W/MOTORIZED ACTUATOR (SBR #1) 24-INCH BUTTERFLY W/MOTORIZED ACTUATOR (SBR #2)
VALVE MFR.:	DEZURIK
ACTUATOR MFR.:	LIMITORQUE
CONDITION:	1 [2] 3 4 5

POST EQUALIZATION BASIN AERATOR

TYPE:	FLOAT-MOUNTED MECHANICAL SURFACE AERATOR
MOTOR SIZE & SPEED:	25 HP & 1,800 RPM (HORSEPOWER NEEDS TO BE CHECKED)
MFR. & MODEL NO.	AQUA-AEROBIC SYS. ENDURA SERIES AQUA-JET AERATOR
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 [2] 3 4 5

EFFLUENT FLOW METER

SIZE & TYPE:	16-INCH ELECTROMAGNETIC FLOW TUBE
MFR. & MODEL NO.:	NOT AVAILABLE
CONDITION:	1 [2] 3 4 5

FILTRATION PROCESS

TYPE:	CLOTH-MEDIA DISK FILTERS
MFR. & MODEL NO.	AQUA-AEROBIC SYSTEMS, INC. AQUADISK MODEL ADC-4E
MAIN COMPONENTS (SEE SEPARATE EQUIP. SUMMARIES):	DISKS W/MEDIA, CENTER TUBE, FILTER DRIVE ASSY., BACKWASH SYSTEM, LEVEL SENSOR, & MFR'S. PROCESS CONTROLS
NO. OF DISKS:	FOUR
PEAK DESIGN CAPACITY:	2.4 MGD
DESIGN FILTRATION RATE:	7.75 GPM/SQ. FT. OF SURFACE AREA @ 2.4 MGD
OVERALL CONDITION:	1 2 [3] 4 5

FILTER UNIT DRIVE ASSEMBLY

MOTOR SIZE & SPEED:	0.5 HP & 1,750 RPM
MFRS.	AQUA-AEROBIC SYS. & WEG
DRIVE TYPE:	CHAIN & SPROCKET W/CONSTANT SPEED MOTOR & GEAR REDUCER
CONDITION:	1 2 [3] 4 5

APPENDIX E2

BACKWASH/SOLIDS REMOVAL CONTROL VALVES

NO. OF VALVES:	THREE (TWO BW CONTROL & ONE SOLIDS DRAWOFF CONTROL)
SIZE & TYPE:	2-INCH BALL TYPE W/MOTORIZED ACTUATOR
VALVE MFR.:	NOT AVAILABLE
ACTUATOR MFR.:	NOT AVAILABLE
CONDITION:	1 2 [3] 4 5

FILTER BACKWASH PUMP

TYPE:	HORIZONTAL END SUCTION CENTRFUGAL
DESIGN OPERATING POINT:	130 GPM @ 24 FEET TDH
MOTOR SIZE & SPEED:	3.0 HP & 1,750 RPM
MFR. & MODEL NO.	GORMAN RUPP MODEL 12B20-B
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 2 3 [4] 5

CHLORINE SOLUTION FEED

STORAGE TANK SIZE & MATERIAL:	1,700-GALLON HDPE TANK W/CONTAINMENT TUB
PUMP TYPE:	PERISTALTIC
PUMP DESIGN CAPACITY:	170 GPD @ 25 PSI (MAX.)
MOTOR SIZE:	1/3 HP
MFR. & MODEL NO.	STENNER 170DM5
DRIVE TYPE:	VARIABLE SPEED
CONDITION:	1 [2] 3 4 5 (INSTALLED 2014)

EFFLUENT PUMPS

TYPE:	VERTICAL TURBINE - 8 STAGE
DESIGN OPERATING POINT:	1,050 GPM @ 592 FEET TDH
MOTOR SIZE & SPEED:	250 HP & 1,790 RPM
MFR. & MODEL NO.	FLOWAY MODEL 12JKH
DRIVE TYPE:	VARIABLE FREQUENCY DRIVES
CONDITION:	[1] 2 3 4 5

PLANT EFFLUENT CONTROL VALVES - UPPER & LOWER POND FEED

NO. OF VALVES:	TWO
SIZE & TYPE:	12-INCH BUTTERFLY W/MOTORIZED ACTUATOR
VALVE MFR.:	PRATT TRITON
ACTUATOR MFR.:	LIMITORQUE
CONDITION:	1 [2] 3 4 5

CHLORINE RESIDUAL ANALYZER

MFR. & MODEL NO.	HACH CL17
CONDITION:	1 [2] 3 4 5

TURBIDIMETER

MFR. & MODEL NO.	HACH
CONDITION:	1 [2] 3 4 5

LIQUID POLYMER BLENDING & FEED UNIT (NO LONGER USED)

MFRS.	POLYBLEND UNIT & LMI METERING PUMP
CONDITION:	1 [2] 3 4 5

LIQUID ALUM FEED PUMP (NO LONGER USED)

MFR.	LMI METERING PUMP
CONDITION:	1 [2] 3 4 5

APPENDIX E2

PLANT DRAIN PUMPS

NO. OF UNITS:	TWO (SPACE FOR TWO ADDITIONAL PUMPS)
TYPE:	SUBMERSIBLE
DESIGN OPERATING POINT:	280 GPM @ 36.5 FEET TDH
MOTOR SIZE & SPEED:	5.0 HP & 1,715 RPM
MFR. & MODEL NO.	XYLEM FLYGT CP3102.090/432
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 [2] 3 4 5

DIGESTER MIXERS

NO.:	FOUR (ONE EACH IN DIG. 1A & DIG. 1B, TWO IN DIG. #2)
TYPE:	FLOAT-MOUNTED PROPELLER TYPE
PUMPING RATE:	5,250 GPM
MOTOR SIZE & SPEED:	7.5 HP & 1,200 RPM
MFR. & MODEL NO.	AQUA-AEROBIC SYS. ENDURA SERIES DDM
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 [2] 3 4 5

SLUDGE HOLDING TANK MIXER

TYPE:	FLOAT-MOUNTED PROPELLER TYPE
PUMPING RATE:	8,690 GPM
MOTOR SIZE & SPEED:	15 HP & 900 RPM
MFR. & MODEL NO.	AQUA-AEROBIC SYS. ENDURA SERIES DDM
DRIVE TYPE:	CONSTANT SPEED
CONDITION:	1 [2] 3 4 5

DIGESTER & SLUDGE HOLDING TANK BLOWERS

NO.:	FOUR
TYPE:	ROTARY-LOBE POSITIVE DISPLACEMENT
MOTOR SIZE & SPEED:	25 HP & 1,755 RPM
MFR. & MODEL NO.	GARDNER DENVER SUTORBILT MODEL 6HP
DRIVE TYPE:	CONSTANT SPEED W/BELT DRIVES
CONDITION:	1 [2] 3 4 5

SLUDGE PUMPS

TYPE:	DUPLEX PLUNGER TYPE POSITIVE DISPLACEMENT
DESIGN CAPACITY:	250 GPM @ 50 FEET TDH
MOTOR SIZE & SPEED:	7.5 HP & 1,750 RPM
MFR. & MODEL NO.	CARTER FIGURE 801H DUPLEX
DRIVE TYPE:	CONSTANT SPEED W/GEAR REDUCER - VARIABLE STROKE LENGTH
CONDITION:	1 [2] 3 4 5

ELECTRICAL & CONTROLS

MAIN DISCONNECTS

DISCONNECT 1 SIZE (TO MCCE):	800 AMPS (EMERGENCY SIDE)
DISCONNECT 2 SIZE (TO MCCA):	800 AMPS (NORMAL NONEMERGENCY SIDE)
DISCONNECT 3 SIZE (TO MCCB):	1,600 AMPS (NORMAL NONEMERGENCY SIDE)
CONDITION (TYPICAL):	1 [2] 3 4 5

BACK-UP POWER

GENERATOR MFR.:	GENERAC MODEL 572RSL5024
CAPACITY:	500 KW
FUEL & TANK CAPACITY:	DIESEL - 500 GALLONS
TRANSFER SWITCH TYPE:	800-AMP AUTOMATIC
CONDITION:	1 [2] 3 4 5

APPENDIX E2

SCADA SYSTEM NETWORK TERMINALS

OPERATIONS BLDG MAIN TERMINAL
INFLUENT PS PROCESSOR
HEADWORKS PROCESSOR
INFLUENT SCREEN (PARKSON RELAY CONTROLS)
GRIT REMOVAL PROCESS CONTROL PANEL (SMITH & LOVELESS RELAY CONTROLS)
SBR PROCESS CONTROL PANEL (AQUA-AEROBIC SYS. PLC)
DISK FILTER PROCESS CONTROL PANEL (AQUA-AEROBIC SYS. PLC)
EFFLUENT/PLANT DRAIN/DISINFECTION PROCESSOR
OFFSITE TERMINALS AT NWWTP & PUMP STATIONS (REMOTE RADIO TELEMETRY)
OFFSITE MONITORING & ALARM REPORTING (REMOTE LAPTOP - TELEPHONE MODEM)

PUMP STATION LEVEL SENSORS

PRIMARY SENSOR TYPE:	SIEMENS MILLTRONICS ULTRASONIC SENSOR/TRANSMITTER
BACKUP TYPE:	FLOAT SWITCHES
LOCATIONS:	PS WET WELLS (INFLUENT, EFFLUENT & PLANT DRAIN
CONDITION:	1 2 [3] 4 5

PROCESS LEVEL SENSORS

PRIMARY SENSOR TYPE:	LEVEL TRANSDUCER/TRANSMITTER
BACKUP TYPE:	FLOAT SWITCHES
LOCATIONS:	SBR BASINS (2) & FILTER TANK
CONDITION:	1 2 [3] 4 5

PIPING & VALVES

MAJOR YARD PIPING

12-INCH INFLUENT PS DISCHARGE (PVC)
16-INCH SECONDARY INFLUENT (DIP)
16-INCH SECONDARY EFFLUENT - TO FILTER & LOWER EFFL. POND (DIP)
24-INCH PLANT EFFLUENT (DIP)
EFFLUENT TRANSMISSION MAIN (12-INCH & 16-INCH DIP, 16-INCH HDPE, 12-INCH PVC)
MISCELLANEOUS PROCESS & WATER PIPING, 6 INCH & LESS (PVC, CU & OTHER)

PROCESS VALVES

PUMP DISCHARGE CHECK VALVES:	6-INCH & 8-INCH CUSHIONED SWING TYPE
PUMP DISCHARGE ISOLATION:	6-INCH & 8-INCH ECCENTRIC PLUG TYPE
EFFL. PUMP DISCHARGE ISOLATION:	8-INCH BUTTERFLY VALVES
EFFLUENT SURGE RELIEF VALVE:	6-INCH ANGLE TYPE
EFFLUENT PRV & ALTITUDE VALVES:	8-INCH GLOBE TYPE
SECONDARY EFFLUENT VALVES:	16-INCH BUTTERFLY VALVES

MISCELLANEOUS ISOLATION VALVES LESS THAN 6 INCH (PLUG, GATE, BUTTERFLY, BALL TYPE)

NOTES

1. SWWTP CONSTRUCTED IN 2001 & EXPANDED IN 2008.
2. UPPER EFFL. STORAGE POND & TRANSMISSION MAIN CONSTRUCTED IN 2008.
3. NO EFFLUENT PUMPING IS ON EMERGENCY POWER & STANDBY GENSET IS NOT USED TO CAPACITY.
4. ONSITE SCADA TERMINALS CONNECTED BY DATA HIGHWAY CABLING

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX F

RECOMMENDED MAJOR MAINTENANCE AND CORRECTIVE WORK PLANS

- F-1 COLLECTION SYSTEM PUMP STATIONS
- F-2 NORTH WASTEWATER TREATMENT PLANT
- F-3 SOUTH WASTEWATER TREATMENT PLANT

SUMMARY OF PROJECTED MAJOR MAINTENANCE & CORRECTIVE WORK FOR COLLECTION-SYSTEM PUMP STATIONS

MAJOR MAINT BUDGET ITEM
ANNUAL BUDGET ITEM
CIP ITEM (Excl. from Maint. Budget)

I. "B" STREET SOUTH PS

	ITEM DESCRIPTION	RATING	RECOMMENDED UPGRADE	SCHEDULE (YEARS FROM PRESENT) 1 - 2	3 - 5	6 - 10	11 - 15	16 - 20
1	STRUCTURAL COMPONENTS (CONC.)	2	CONCRETE WATERPROOFING					
2	PUMPS & MOTORS	3	REBUILD/REPLACE/ NEW	REBUILD				ADD & REBUILD
3	DISCHARGE VALVES	2	RECOAT / REPLACE	COAT				ADD & REPLACE
4	LEVEL INSTRUMENTS	2	REPLACE					REPLACE
5	ODOR CONTROL TANK & CHEM. PUMP	1	REPLACE CHEM PUMP & VALVES					
6	MOTOR CONTROLS (MCC-1)	4	REPLACE BREAKERS & STARTERS					ADD & REPLACE
7	EXPOSED DISCHARGE PIPING	2	RECOAT/ADD NEW	COAT				RECOAT & ADD
8	SCADA COMPONENTS		(SEE B-NORTH PS)					
9	BACK-UP POWER		(SEE B-NORTH PS)					

CONDITION RATING SCALE: 1. VERY GOOD / 2. GOOD / 3. ADEQUATE / 4. POOR / 5. POOR-OBSELETE

APPENDIX F1

SUMMARY OF PROJECTED MAJOR MAINTENANCE & CORRECTIVE WORK FOR COLLECTION-SYSTEM PUMP STATIONS

MAJOR MAINT BUDGET ITEM
ANNUAL BUDGET ITEM
CIP ITEM (Excl. from Maint. Budget)

II. "B" STREET NORTH PS

	ITEM DESCRIPTION	RATING	RECOMMENDED UPGRADE	SCHEDULE (YEARS FROM PRESENT) 1 - 2	3 - 5	6 - 10	11 - 15	16 - 20
1	PS STRUCTURAL COMPONENTS							
	A. ROOF (SEE NOTE)	3	RECOAT WOOD/ REPLACE DECK	COAT			REPLACE DECK	COAT
	B. WALLS & DOORS	2	RECOAT / REPLACE DOORS				REPLACE DOORS	COAT
	C. CONC. WET WELL/DRY WELL	2	WATERPROOFING					
2	PUMPS & MOTORS	1	REBUILD					
3	SURGE ACCUMULATORS - 3 OLDER	3	RECOAT / REPLACE BLADDER & GAUGE		COAT		REPLACE PARTS	
4	SURGE ACCUMULATORS - 2 NEWER	2	RECOAT / REPLACE BLADDER & GAUGE		COAT			REPLACE PARTS
5	VALVES - ISOLATION & CHECK	2	RECOAT / REPLACE		COAT			REPLACE
6	LEVEL INSTRUMENTS	2	REPLACE					
7	INTERIOR PIPING & SUPPORTS	2	RECOAT					
8	MOTOR CONTROLS (MCC-2)	2	REPLACE BREAKERS & STARTERS					
9	SCADA COMPONENTS	2	REPLACE					UPDATE - B SOUTH
10	HOIST & TROLLEY	2	REPLACE					
11	HEATER & EXHAUST FAN	3 & 4	REPLACE					
12	DUCTWORK	1	REPLACE					
12	BACK-UP GENERATOR & ATS	2	RECOAT / REPLACE		COAT		REPLACE	
13	GENERATOR BLDG.							
	A. ROOF (SEE NOTE)	3	RECOAT WOOD/ REPLACE DECK	COAT			REPLACE DECK	COAT
	B. WALLS & DOORS	2	RECOAT / REPLACE		COAT		REPLACE DOORS	
	C. CONC. FLOORS & WALLS	1	WATERPROOFING		COAT		COAT	

NOTE: Replacement of metal roof deck or composite shingles may also require replacement of underlying roof members.
CONDITION RATING SCALE: 1. VERY GOOD / 2. GOOD / 3. ADEQUATE / 4. POOR / 5. POOR-OBSELETE

SUMMARY OF PROJECTED MAJOR MAINTENANCE & CORRECTIVE WORK FOR COLLECTION-SYSTEM PUMP STATIONS

MAJOR MAINT BUDGET ITEM
ANNUAL BUDGET ITEM
CIP ITEM (Excl. from Maint. Budget)

III. SOUTH 97 PS (SEE NOTE)

	ITEM DESCRIPTION	RATING	RECOMMENDED UPGRADE	SCHEDULE (YEARS FROM PRESENT) 1 - 2	3 - 5	6 - 10	11 - 15	16 - 20
1	STRUCTURAL COMPONENTS (PRECAST CONC.)	1	WATERPROOFING					
2	PUMPS & MOTORS	2	REBUILD					
3	DISCHARGE VALVES	3	RECOAT / REPLACE	COAT			REPLACE	
4	LEVEL INSTRUMENTS	2	REPLACE					
5	EXPOSED DISCHARGE PIPING	2	RECOAT					
6	ELECTRICAL COMPONENTS	2	REPLACE BREAKERS / STARTERS					
7	SCADA COMPONENTS	2	REPLACE					

CONDITION RATING SCALE: 1. VERY GOOD / 2. GOOD / 3. ADEQUATE / 4. POOR / 5. POOR-OBSELETE

APPENDIX F1

SUMMARY OF PROJECTED MAJOR MAINTENANCE & CORRECTIVE WORK FOR COLLECTION-SYSTEM PUMP STATIONS

MAJOR MAINT BUDGET ITEM
ANNUAL BUDGET ITEM

CIP ITEM
(Excl. from Maint. Budget)

IV. DEMERS PS

	ITEM DESCRIPTION	RATING	RECOMMENDED UPGRADE	SCHEDULE (YEARS FROM PRESENT) 1 - 2	3 - 5	6 - 10	11 - 15	16 - 20
1	WET WELL LID, ACCESS HATCH, BRACKETS & HOOKS (SEE NOTE)	3 & 4	REPLACE					
2	VALVE VAULT	4	REPLACE ENTIRE VAULT					
3	PUMPS & MOTORS	1	REPLACE					
4	DISCHARGE VALVES	4	REPLACE					
5	LEVEL INSTRUMENTS	2	REPLACE					
6	DISCHARGE PIPING IN VAULT	4	REPLACE					
7	ELECTRICAL COMPONENTS	2	REPLACE					REPLACE ALL
8	SCADA COMPONENTS	2	REPLACE					

NOTE: Corrosion evident on pump retrieval & other metal components.

CONDITION RATING SCALE: 1. VERY GOOD / 2. GOOD / 3. ADEQUATE / 4. POOR / 5. POOR-OBSELETE

SUMMARY OF PROJECTED MAJOR MAINTENANCE & CORRECTIVE WORK FOR COLLECTION-SYSTEM PUMP STATIONS

MAJOR MAINT BUDGET ITEM
ANNUAL BUDGET ITEM
CIP ITEM (Excl. from Maint. Budget)

V. GOLF COURSE PS - POOR CONDITION & OBSELETE

	ITEM DESCRIPTION	RATING	RECOMMENDED UPGRADE	SCHEDULE (YEARS FROM PRESENT) 1 - 2	3 - 5	6 - 10	11 - 15	16 - 20
1	PUMPS & MOTORS	4	REPLACE/REBUILD	REBUILD		REPLACE		
2	DISCHARGE VALVES	3	REPLACE/RECOAT	RECOAT		REPLACE		COAT
3	LEVEL INSTRUMENTS	3	REPLACE			REPLACE		
4	DISCHARGE PIPING	3	REPLACE/RECOAT			REPLACE		COAT
5	ELECTRICAL COMPONENTS	3	REPLACE			REPLACE		
6	SCADA COMPONENTS	--	INSTALL/REPLACE			INSTALL		REPLACE

CONDITION RATING SCALE: 1. VERY GOOD / 2. GOOD / 3. ADEQUATE / 4. POOR / 5. POOR-OBSELETE

APPENDIX F2

SUMMARY OF PROJECTED MAJOR MAINTENANCE & CORRECTIVE WORK AT NORTH WWTP

MAJOR MAINT BUDGET ITEM
ANNUAL BUDGET ITEM
CIP ITEM (Excl. from Maint. Budget)

	ITEM DESCRIPTION	RATING	RECOMMENDED UPGRADE	SCHEDULE (YEARS FROM PRESENT) 1 - 2	3 - 5	6 - 10	11 - 15	16 - 20
1	STRUCTURAL COMPONENTS							
	A. LAGOON SYS. STRUCTURES	3	REPLACE WOOD & METAL COMPONENTS		REPLACE WOOD		REPLACE	
	B. DAF CLARIFIER/FILTER	3	REPLACE UNIT/ RECOAT METAL		REPLACE			RECOAT
	C. CONC. CL2 CONTACT BASIN	3	WATERPROOFING					
	D. BLDGS - OPER, CL2 & SLUDGE PUMP	3	RECOAT / REPLACE ROOF (SEE NOTE 1)				RECOAT BLDGS	
	E. SITE DRAIN & UNDERDRAIN PS	3	WATERPROOFING					
	F. SEPTAGE STATION	3	WATERPROOFING					
	G. SLUDGE DRYING BEDS	2	SLURRY SEAL AC					
2	GRAVEL ACCESS ROADS	2	RESURFACE (REGRADE TWICE/YR)		PARTIAL	PARTIAL	REPLACE	
3	EARTHEN LAGOONS	3	DREDGE				REPLACE	
4	LAGOON AERATORS & STARTERS	4	REPLACE					
5	POND E PUMPER	2	REBUILD					
6	INTERMEDIATE PUMP & MOTOR	2	REPLACE/REBUILD		REPLACE		REBUILD	
7	DAF SPC ADT PUMP & MOTOR	3	REPLACE/REBUILD		REPLACE		REBUILD	
8	DAF AIR COMPRESSOR	1	RELOCATE/REBUILD		RELOCATE		REBUILD	
9	DAF CLARIFIER DRIVES (MOTORS, GEARS & VFDS)	4 & 2	REPLACE/REBUILD				REBUILD	
10	DAF CLARIFIER CONTROL VALVE	3	REPLACE		ALL		ACTUATOR	

APPENDIX F2

SUMMARY OF PROJECTED MAJOR MAINTENANCE & CORRECTIVE WORK AT NORTH WWTP

MAJOR MAINT BUDGET ITEM
ANNUAL BUDGET ITEM
CIP ITEM (Excl. from Maint. Budget)

	ITEM DESCRIPTION	RATING	RECOMMENDED UPGRADE	SCHEDULE (YEARS FROM PRESENT) 1 - 2	3 - 5	6 - 10	11 - 15	16 - 20
11	DAF SLUDGE PUMP	2	REPLACE/REBUILD				REBUILD	
12	PACL FEED PUMP	4	REPLACE					
13	POLYMER FEED PUMP	4	REPLACE					
14	CL2 SOLUTION FEED PUMP	2	REPLACE					
15	CL2 RESIDUAL ANALYZER	3	REPLACE					
16	TURBIDIMETER	1	REPLACE					
17	EFFLUENT PUMP & MOTOR	1	REPLACE/REBUILD		REPLACE		REBUILD	
18	LEVEL SENSORS & FLOATS-PLANTWIDE	3	REPLACE					
19	PUMP DISCHARGE VALVES	3-4	REPLACE/RECOAT				RECOAT	
20	EXPOSED PUMP DISCHARGE PIPING	3	REPLACE/RECOAT		REPLACE		RECOAT	
21	SITE DRAIN & UNDERDRAIN PUMPS	3	REBUILD/REPLACE		REBUILD		REPLACE	
22	ELECTRICAL BREAKERS & STARTERS	3	REPLACE		PARTIAL		PARTIAL	
23	SCADA COMPONENTS	3	REPLACE		PARTIAL		PARTIAL	
24	EFFLUENT RECYCING/IRRIGATION COMPONENTS	3	REPLACE PARTS ANNUALLY					

NOTE:

1. Replacement of metal roof deck or composite shingles may also require replacement of underlying roof members.
2. Plan retrofit of existing NWWTP in coordination future expansions for industrial development.

CONDITION RATING SCALE: 1. VERY GOOD / 2. GOOD / 3. ADEQUATE / 4. POOR / 5. POOR-OBSELETE

APPENDIX F3

SUMMARY OF PROJECTED MAJOR MAINTENANCE & CORRECTIVE WORK
SOUTH WWTP & MISCELLANEOUS EQUIPMENT

MAJOR MAINT BUDGET ITEM
ANNUAL BUDGET ITEM
CIP ITEM (Excl. from Maint. Budget)

	ITEM DESCRIPTION	RATING	RECOMMENDED UPGRADE	SCHEDULE (YEARS FROM PRESENT) 1 - 2	3 - 5	6 - 10	11 - 15	16 - 20
1	STRUCTURAL COMPONENTS							
	A. CIP CONC. PROCESS STRUCTURES	1	NONE					
	B. PROCESS & OPERATIONS BLDGS.	2	RESEAL CMU & CONC CRACKS					
			RECOAT CMU & WOOD					
			REPLACE ROOF DECK (SEE NOTE 1)					
	C. PRECAST VAULTS	1	NONE					
	D. STORAGE/SHOP BLDG. & GARAGE	1	RECOAT					
2	AC DRIVEWAYS	2	SLURRY SEAL AC					
3	INFLUENT PUMPS	3	REBUILD					
4	INFLUENT SCREENING EQUIPMENT	2	REFURBISH OR REPLACE					
5	GRIT PUMP W/VACUUM PRIME	1	REBUILD OR REPLACE					
6	GRIT CHAMBER PADDLE & GRIT REMOVAL PROCESS CONTROLS	2/4	REFURBISH OR REPLACE	PADDLE				
7	GRIT DEWATERING CONVEYOR	4	RECOAT					
			REFURBISH OR REPLACE					
8	SBR INFL. & EFFL. CONTROL VALVES	2/3	REPLACE	EFFL		INFL		
9	SBR FINE-BUBBLE DIFFUSERS	4	REPLACE DIFFUSER TUBES					

APPENDIX F3

SUMMARY OF PROJECTED MAJOR MAINTENANCE & CORRECTIVE WORK
SOUTH WWTP & MISCELLANEOUS EQUIPMENT

MAJOR MAINT BUDGET ITEM
ANNUAL BUDGET ITEM
CIP ITEM (Excl. from Maint. Budget)

	ITEM DESCRIPTION	RATING	RECOMMENDED UPGRADE	SCHEDULE (YEARS FROM PRESENT) 1 - 2	3 - 5	6 - 10	11 - 15	16 - 20
10	MIXERS (SBR/DIGESTER/SLUDGE HOLDING TANK) & POST-EQ AERATOR	3	REPLACE MOTORS					
11	DECANTERS (SBR/DIGESTER/SLUDGE HOLDING TANK)	2	REPLACE ACTUATOR MECHANISM					
12	SBR & DIGESTER BLOWERS	1-SBR 4-DIG	REPLACE					
13	EFFLUENT FLOW METER	2	REPLACE ELECTRONICS					
14	DIGESTER SLUDGE PUMPS	2	REBUILD					
15	FILTRATION PROCESS	3	REPLACE BW PUMP & BW VALVES					
		4	REPLACE FILTER MEDIA					
		3	REBUILD OR REPLACE FILTER DRIVE					
16	CL2 SOLUTION FEED PUMP	1	REPLACE					
17	CL2 RESIDUAL ANALYZER	1	REPLACE					
18	TURBIDIMETER	1	REPLACE					
19	ADD DISSOLVED OXYGEN (DO) PROBES TO DIGESTERS FOR DO CONTROL	--	INSTALL					
20	EFFLUENT PUMPS & MOTORS	1	REBUILD					
21	LEVEL SENSORS & FLOATS-PLANTWIDE	3	REPLACE					
22	EFFLUENT (POND) CONTROL VALVES	2	REFURBISH OR REPLACE					
23	PLANT DRAIN PUMPS	2	REBUILD					

APPENDIX F3

SUMMARY OF PROJECTED MAJOR MAINTENANCE & CORRECTIVE WORK
SOUTH WWTP & MISCELLANEOUS EQUIPMENT

MAJOR MAINT BUDGET ITEM
ANNUAL BUDGET ITEM
CIP ITEM (Excl. from Maint. Budget)

	ITEM DESCRIPTION	RATING	RECOMMENDED UPGRADE	SCHEDULE (YEARS FROM PRESENT) 1 - 2	3 - 5	6 - 10	11 - 15	16 - 20
24	SBR SLUDGE WASTING & DIG. SLUDGE TRANSFER PUMPS	2	REBUILD					
25	SBR/DIGESTER PROCESS INSTRUMENTATION & CONTROLS	2	REPLACE					
26	ELECTRICAL BREAKERS & STARTERS	2	REPLACE					
27	EXPOSED PIPING IN VAULTS	3	RECOAT					
28	VACTOR TRUCK	4	REPLACE					
29	SLUDGE TANK TRUCK	1	REPLACE					
30	DRIED SLUDGE SPREADER TRUCK	1	REPLACE					
31	SEWER INSPECTION CAMERA	5	REPLACE					
32	BACKHOE	4	PURCHASE					
33	SCADA COMPONENTS	3	REPLACE					
34	IRRIGATION COMPONENTS	2-3	REPLACEMENT PARTS					

NOTES:

1. Replacement of metal roof deck or composite shingles may also require replacement of underlying roof members.
2. Plan overhaul of pumps, process equipment, valves & other components in 8-10 years w/incremental expansion to 0.65 MGD.
3. SCADA System becoming obselete & needs to be updated to current hardware & software technologies. Windows XP work station OS no longer supported. PLC modeled being phased out. Need to migrate from DH+ to Ethernet w/new PLCs.

CONDITION RATING SCALE: 1. VERY GOOD / 2. GOOD / 3. ADEQUATE / 4. POOR / 5. POOR-OBSELETE

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX G

COMPARISON OF
SEWER MODELING SOFTWARE

Appendix G
Comparison of Sewer Modeling Software

Item	InfoSWMM	SewerCAD	SewerGEMS	Autodesk SSA
Import Data File Types	ASCII, .shp, .mif/.mid, ODBC Connection to dBase, Excel, i-model and MS Access	ASCII, .shp, .dwg, .dgn, .mdb, .sqlite, .xml, Landxml, .stsw, .swc, .swr, .mdb, .xin, .dat, .idf, .sdb, .fbx, .wmf, .stm	ASCII, .shp, .dwg, .dgn, .mdb, .sqlite, .xml, Landxml, .stsw, .swc, .swr, .mdb, .xin, .dat, .idf, .sdb, .fbx, .wmf, .stm	SWMM 5.0, Landxml, GIS import, .dwg, .dxf, .tiff, .jpg, .bmp, .wmf, .emf, .pbm, .pgm, .png, .ppm, Hydraflow storm sewer files, XPSWMM
Export Data File Types	ASCII, .shp, .mif/.mid, .dbf, .shx	ASCII, .shp, .dwg, .dgn, .mdb, .sqlite, .xml, Landxml, .stsw, .swc, .swr, .mdb, .xin, .dat, .idf, .sdb, .fbx, .wmf, .stm	ASCII, .shp, .dwg, .dgn, .mdb, .sqlite, .xml, Landxml, .stsw, .swc, .swr, .mdb, .xin, .dat, .idf, .sdb, .fbx, .wmf, .stm	SWMM 5.0, Landxml, GIS import, .dwg, .dxf, .tiff, .jpg, .bmp, .wmf, .emf, .pbm, .pgm, .png, .ppm, Hydraflow storm sewer files, XPSWMM, .map, .hsf, .xls
Graphics Engine	ArcMap	AutoCAD, Civil3D, Microstation V8i, InRoads, Standalone	AutoACAD, Civil3D, Microstation V8i, InRoads, ArcMap, Standalone	Standalone, can export to Civil 3D
Operating Units	cfs, gpm, mgd, m3/s, L/s, ML/s, user unit	acre-ft/day, acre-ft/hr, acre-in/hr, acre-in/min, cfs, cfm, ft3/day, gpd, gpm, gps, mgd, L/day, L/h, L/min, L/s, m3/d, m3/h, m3/m, m3/s,MLD	acre-ft/day, acre-ft/hr, acre-in/hr, acre-in/min, cfs, cfm, ft3/day, gpd, gpm, gps, mgd, L/day, L/h, L/min, L/s, m3/d, m3/h, m3/m, m3/s,MLD	cfs, gpm, mgd, cms, lps, mld
Simulation Options for Routing Model Hydraulic Calculations	Steady State, Kinematic Wave, Dynamic Wave	Steady State, Extended Period Simulation (EPS)	Steady State, Extended Period Simulation (EPS), Implicit and Explicit Dynamic Wave	Steady State, Kinematic Wave, Hydrodynamic
Friction Formulas for Gravity Networks	Manning's	Manning's, Darcy-Weisbach, Hazen-Williams, Kutters	Manning's, Darcy-Weisbach, Hazen-Williams, Kutters	
Friction Formulas for Forcemain Networks	Hazen-Williams, Manning's	Hazen-Williams, Darcy-Weisbach, Manning's	Hazen-Williams, Darcy-Weisbach, Manning's	Hazen-Williams, Manning's
Sanitary Flow Input	Yes	Yes	Yes	Yes
I/I Input	Yes	Yes	Yes	Yes
Infiltration Modeling Options	Horton, Modified Horton, Green Ampt, NRCS Curve Number	Horton, Green Ampt, SCS CN	Horton, Green Ampt, SCS CN	Horton, Green Ampt, SCS CN

Appendix G
Comparison of Sewer Modeling Software

Item	InfoSWMM	SewerCAD	SewerGEMS	Autodesk SSA
Hydraulic Profile Generation	Yes	Yes	Yes	Yes
Animation	Yes	Yes	Yes	Yes
Reports	Yes	Yes	Yes	Yes
Level and Velocity Plots	Yes	Yes	Yes	Yes
Thematic Representation	Yes	Yes	Yes	Yes
Scenario Management	Yes	Yes	Yes	No
Existing Data Import	Yes	Yes	Yes	No
Capabilities to Modify Design	Yes	Yes	Yes	Yes
Data Entry compatible with existing data	Yes	Yes	Yes	No
Cost or ownership status	$3,000 for single user license	$6,500 for Standalone $10,000 for C3D	$12,000 for C3D	$7,000 - $10,000 for single seat license
Additional requirements to make operational				Import will need extensive data manipulation That could require use of an outside consultant.

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX H

COMMUNITY DEVELOPMENT DIRECTOR MEMO – RESIDENTIAL SUBDIVISION DEVELOPMENT TIMING FOR WASTEWATER MASTER PLAN

THE CITY OF MADRAS

125 SW "E" Street
Madras, OR 97741
541-475-2344
www.ci.madras.or.us

MEMORANDUM

DATE:	September 28, 2016
TO:	Wen Jou, City Engineer
CC:	Jeff Hurd, Public Works Director
FROM:	Nicholas Snead, Community Development Director
SUBJECT:	Residential subdivision development timing for City of Madras Waste Water Master Plan.

OVERVIEW:

The City of Madras is in the process of updating the 1996 Wastewater Master Plan. In doing so, the City Engineer requested that the Community Development Director estimate when certain vacant residential properties in the City would be subdivided and developed with housing to better understand the wastewater system collection and treatment system demands over time. This memorandum is not to be used for any other purpose beyond preparing the City of Madras Wastewater Master Plan.

CONSIDERATIONS:

Below are general factors and classifications used to estimate when the residentially zoned properties identified on Attachment A would develop.

1. **Wastewater system needs to serve a particular development:**
   This will consider need and associated cost for conveyance and or capacity improvements needed to serve a development?

   Classification of Wastewater Improvement Costs:

   Short Term: Capacity is available in the system to serve the development and public infrastructure is adjacent to the property to be developed.

   Mid Term: Capacity is available in the system and public infrastructure is not adjacent to the property to be developed but within 500'.

   Long Term: Capacity improvements to the system are required (plant upgrade, downstream improvements, pump station improvements, etc). Public infrastructure is beyond 500'.

2. **Transportation system needs as identified in the City's 2012 Transportation System Plan and current street and development site conditions:**

Classification of Transportation Improvement Costs:

Short Term: Capacity in the system is available. Only adjacent property public improvements required for development.

Mid Term: Minor capacity improvements needed to the system (i.e. widening, striping, etc.) adjacent to the development along with adjacent property public improvements required.

Long Term: Capacity improvements are required to the system and can range from adjacent property improvements to offsite improvements (i.e. roundabout, collector, signal, etc.). Adjacent public improvements required as well.

3. **Timing of Development:**

The time period by which each subdivision will be developed has been estimated (Figure 1 below) based on the required wastewater and transportation improvements associated with each subdivision. These costs are some of the most significant costs for residential development, whereby the lower the cost the easier and more likely a property is to be developed sooner than later. Conversely, the higher the wastewater and transportation costs, the longer it will take to develop the property.

There are several subdivisions that are reliant upon a large wastewater collection system improvement. These subdivisions cannot solely bare the cost for the large wastewater collection system improvement. Therefore, it was estimated that these subdivisions would be developed in either the Long-Term or Build-Out time periods. It is assumed that during these two time periods that subdivisions that have lower wastewater and transportation costs would be developed and therefore the market demand for housing would move to subdivisions that have higher wastewater and transportation costs. The purpose of estimating the development timeline for each property is to allow the City Engineer to determine what and when wastewater system improvements are needed to for additional development.

Figure 1. Development Timing Classification.

Short-Term:	0-5 Years
Mid-Term:	5-10 Years
Long-Term:	10-20 Years
Build Out:	20+ Years

ANALYSIS:

There is a potential of 2198residential dwellings (i.e. lots) that may be developed on vacant residentially zone properties in the Madras Urban Growth Boundary. Based on the classification of wastewater and transportation costs, there are 321 residential lots in the Short-Term Wastewater Areas 2, 3, 4, 7, and 9 that may be developed (Tables 1 & 2). In the Mid-Term there are 930 lots that are located within Wastewater Areas 1, 2, 3, 5, 6, 7, and 10 that may be developed in the Mid-Term. There are 446 lots that are located in Wastewater Areas 3, 5, 6, and 8 that may be developed in the Long-Term Finally, there are 501 lots located Wastewater Areas 1, 3, 5, and 8 that may be developed in the Build-Out time period.

Table 1. Number of Lots by Subdivision & Development Timing.

Subdivision	Development Timing				Total # of Lots
	Short (0-5 yrs)	Mid (5-10 yrs)	Long (10-20 yrs)	Build Out (20+ yrs)	
Ashwood Heights		60			60
Belmont Basin			17		17
Cascade View Estates				230	230
El Dorado Estates				133	133
Fairgrounds				48	48
Grizzly Estates		61			61
Kinkade Crossing	15				15
Kinkade Heights	5				5
Lincoln Heights	5				5
Meridian Park		238			238
Miller Crossing			50		50
Mule Deer Estates		54			54
North Unit		38			38
Park Place Phase 2		41			41
Parkside Manor	8				8
Roadrunner Estates			23		23
S & P Estates			147		147
Sonrise View	8				8
South Town Center				90	90
Strawberry Heights Phase 4		96			96
Sun Ridge		150			150
Sunnyside Estates			30		30
Sunset View			30		30
The Ridge			149		149
Willow Heights		39			39
Willowbrook		153			153
Yarrow	280				280
Total	**321**	**930**	**446**	**501**	**2198**

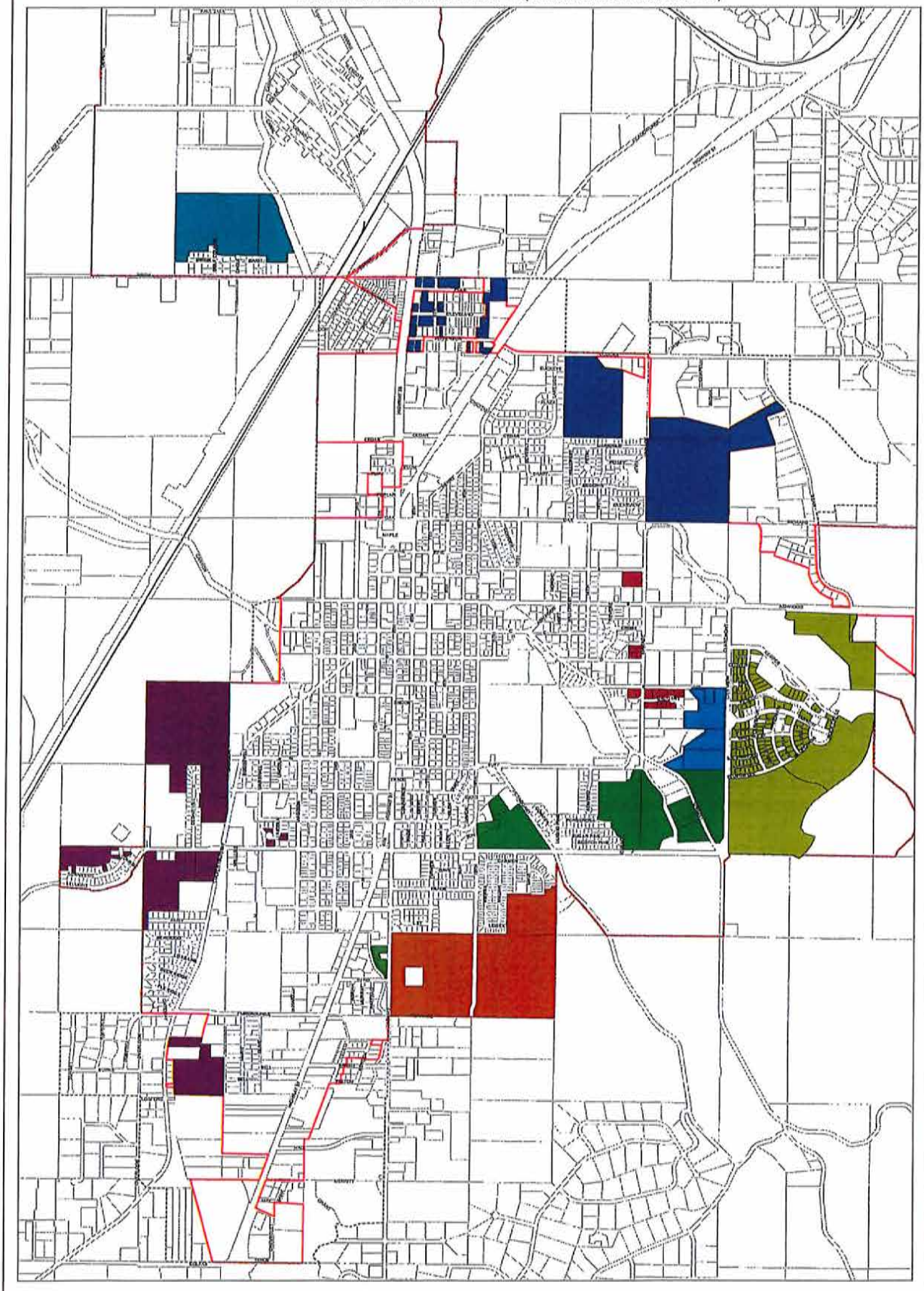
Table 2. Number of Lots by Wastewater Area

Wastewater Area*	Development Timing				Total # of Lots
	Short-Term (0-5 yrs)	Mid-Term (5-10 yrs)	Long-Term (10-20 yrs)	Build-Out (20+ yrs)	
1		153		90	243
2		38			38
3	5	191	97	48	341
4	8				8
5		96	149	133	378
6		61	30		91
7	280	60			340
8			147	230	377
9	28				28
10		331	23		354
Total	**321**	**930**	**446**	**501**	**2198**

CONCLUSIONS:

Only the South Town Center, Fairgrounds, El Dorado Estates and the Cascade View Estates subdivisions were classified as having high transportation improvements costs; all others were classified as having low or moderate transportation improvement costs. The subdivisions in Wastewater Areas 2 and 8 are dependent upon the North Y Sewer project and very likely cannot be permitted unless this wastewater project is constructed. Similarly, the subdivisions in Wastewater Area 3 largely cannot be permitted without the Culver Highway sewer project. In effect, there is approximately 861 lots that cannot be developed without the North Y Sewer or the Culver Highway projects being constructed.

Attachment A: Vacant Residential Properties & Wastewater Areas Map



CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX I

SELECTED PRINTOUTS OF SEWER MODELING RESULTS

- I-1 MAIN COLLECTION SYSTEM – FUTURE BUILDOUT CONDITIONS
- I-2 INDUSTRIAL PARK COLLECTION SYSTEM – FUTURE WILLOWBROOK BUILDOUT CONDITIONS

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX I-1

MODELING RESULTS PRINTOUT
MAIN COLLECTION SYSTEM
FUTURE BUILDOUT CONDITIONS

```
  US-EPA Storm Water Management Model - Version 5.1 (Build 5.1.009)
```

```
  NOTE: The summary statistics displayed in this report are
  based on results found at every computational time step,
  not just on results from each reporting time step.
```

```
  Analysis Options
```

```
Flow Units ..... MGD
Process Models:
  Rainfall/Runoff ..... NO
  RDII ..... NO
  Snowmelt ..... NO
  Groundwater ..... NO
  Flow Routing ..... YES
  Ponding Allowed ..... YES
  Water Quality ..... NO
Flow Routing Method ..... DYNWAVE
Starting Date ..... JAN-01-2015 00:00:00
Ending Date ..... JAN-01-2015 23:00:00
Antecedent Dry Days ..... 5.0
Report Time Step ..... 23:00:00
Routing Time Step ..... 20.00 sec
Variable Time Step ..... NO
Maximum Trials ..... 4
Head Tolerance ..... 0.005000 ft
```

Flow Routing Continuity	Volume acre-feet	Volume 10^6 gal
Dry Weather Inflow	3.518	1.146
Wet Weather Inflow	0.000	0.000
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	3.446	1.123
Internal Outflow	0.000	0.000
Evaporation Loss	0.000	0.000
Exfiltration Loss	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.071	0.023
Continuity Error (%)	0.034	

```
  Highest Continuity Errors
```

Node CV.19-3	-60.72%	-0.0001
Node CV.26-3	-51.99%	-0.0001
Node CV.14.5-3	-27.57%	-0.0000
Node CV.14-9	-26.12%	-0.0001
Node CV.16-5	-24.71%	-0.0000
Node CV.12-2	18.89%	0.0001
Node CV.12-3	-18.33%	-0.0001
Node CV.16-4	16.75%	0.0000
Node CV.19-2	13.89%	0.0000

Node A.17-8	11.96%	0.0001
Node CV.14-8	11.84%	0.0001
Node A.14-5	9.58%	0.0004
Node M5-4.3	8.62%	0.0002
Node CV.14.5-2	8.43%	0.0000
Node A.14.1-1	-8.31%	-0.0001
Node CV.26-1	-7.03%	-0.0000
Node CV.14.3-1	6.83%	0.0000
Node CV.12-6	-6.02%	-0.0000
Node CV.26-2	5.85%	0.0000
Node CV.14-7	-5.26%	-0.0000
		0.0002 Mgal

****
Highest Flow Instability Indexes
****
Link M5-4.4 (61)
Link CV.12-3 (44)
Link CV.14-9 (43)
Link CV-20 (41)
Link I-A (38)
Link I-0 (35)
Link A.10-2 (28)
Link CV.19-5 (27)
Link A.17-9 (27)
Link M5-12 (25)
Link A.4.10-7 (25)
Link B.7.2-1 (22)
Link A.14-3 (20)
Link CV.19-4 (18)
Link CV.16-5 (18)
Link CV.14-2 (18)
Link CV.19-3 (17)
Link A.14.1-1 (17)
Link CV.14.5-3 (17)
Link F4 (17)

****
Routing Time Step Summary
****

Minimum Time Step	:	20.00 sec
Average Time Step	:	20.00 sec
Maximum Time Step	:	20.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	2.57
Percent Not Converging	:	22.78
Total Steps	:	4140
Total Iterations	:	10651

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum Run HGL Feet	Time of Max Occurrence days hr:min	Rep Max
1.2.3-2	JUNCTION	0.26	0.53	2279.63	0 11:01	
1.2.3-3	JUNCTION	0.09	0.17	2296.23	0 11:00	
A-1	JUNCTION	0.09	0.17	2231.45	0 11:00	

A-11	JUNCTION	0.03	0.06	2257.64	0	11:00
A-12	JUNCTION	0.06	0.11	2258.31	0	11:00
A-13	JUNCTION	0.03	0.05	2267.12	0	11:00
A-14	JUNCTION	0.03	0.04	2268.41	0	11:00
A-15	JUNCTION	0.01	0.02	2289.08	0	11:00
A-2	JUNCTION	0.13	0.26	2233.25	0	11:00
A-3	JUNCTION	0.08	0.16	2235.74	0	11:00
A-4	JUNCTION	0.10	0.20	2237.52	0	11:00
A-5	JUNCTION	0.11	0.21	2237.83	0	11:00
A-6	JUNCTION	0.11	0.21	2238.22	0	11:00
A-7	JUNCTION	0.05	0.09	2239.85	0	11:00
A-8	JUNCTION	0.06	0.12	2242.94	0	11:00
A-9	JUNCTION	0.08	0.15	2244.49	0	11:00
A.1-1	JUNCTION	0.15	0.29	2232.50	0	11:10
A.1-10	JUNCTION	0.05	0.10	2258.54	0	11:00
A.1-11	JUNCTION	0.03	0.05	2265.46	0	11:00
A.1-12	JUNCTION	0.02	0.04	2274.04	0	11:00
A.1-13	JUNCTION	0.02	0.04	2279.95	0	11:00
A.1-14	JUNCTION	0.02	0.03	2294.01	0	11:00
A.1-15	JUNCTION	0.01	0.03	2299.19	0	11:00
A.1-3	JUNCTION	0.18	0.36	2234.70	0	11:08
A.1-4	JUNCTION	0.11	0.22	2241.21	0	11:05
A.1-5	JUNCTION	0.11	0.21	2251.94	0	11:04
A.1-6	JUNCTION	0.15	0.31	2254.49	0	11:03
A.1-7	JUNCTION	0.18	0.38	2255.64	0	11:02
A.1-8	JUNCTION	0.17	0.36	2256.58	0	11:01
A.1-9	JUNCTION	0.17	0.35	2257.60	0	11:01
A.1.1-1	JUNCTION	0.02	0.04	2267.68	0	11:00
A.1.1-2	JUNCTION	0.03	0.06	2272.49	0	11:00
A.1.1-3	JUNCTION	0.02	0.04	2278.41	0	11:00
A.1.1-4	JUNCTION	0.02	0.03	2288.33	0	11:00
A.1.2-1	JUNCTION	0.12	0.23	2274.71	0	11:00
A.1.2-2	JUNCTION	0.17	0.35	2276.87	0	11:01
A.1.2-3	JUNCTION	0.02	0.04	2279.72	0	11:00
A.1.2-4	JUNCTION	0.01	0.03	2287.02	0	11:00
A.1.2-5	JUNCTION	0.01	0.01	2288.82	0	11:00
A.1.2-6	JUNCTION	0.01	0.01	2294.55	0	11:00
A.1.2.1-1	JUNCTION	0.01	0.01	2281.34	0	11:00
A.1.2.2-1	JUNCTION	0.01	0.01	2290.76	0	11:00
A.1.3-1	JUNCTION	0.03	0.05	2263.41	0	11:00
A.1.3-2	JUNCTION	0.02	0.04	2269.95	0	11:00
A.1.3-3	JUNCTION	0.01	0.02	2290.45	0	11:00
A.1.3-4	JUNCTION	0.01	0.03	2295.32	0	11:00
A.1.3.1-1	JUNCTION	0.01	0.01	2276.91	0	10:54
A.1.4-1	JUNCTION	0.01	0.02	2266.03	0	11:00
A.10-1	JUNCTION	0.09	0.17	2233.37	0	11:01
A.10-10	JUNCTION	0.02	0.03	2272.19	0	11:00
A.10-11	JUNCTION	0.01	0.02	2277.52	0	11:00
A.10-12	JUNCTION	0.00	0.01	2283.13	0	11:00
A.10-13	JUNCTION	0.01	0.01	2287.14	0	11:00
A.10-2	JUNCTION	0.03	0.06	2252.46	0	11:00
A.10-3	JUNCTION	0.10	0.19	2253.33	0	11:00
A.10-4	JUNCTION	0.07	0.12	2255.69	0	11:00
A.10-5	JUNCTION	0.04	0.07	2263.15	0	11:00
A.10-6	JUNCTION	0.04	0.07	2264.46	0	11:00
A.10-7	JUNCTION	0.04	0.08	2265.98	0	11:00
A.10-8	JUNCTION	0.02	0.04	2266.44	0	11:00
A.10-9	JUNCTION	0.02	0.03	2269.03	0	11:00
A.10.1-1	JUNCTION	0.04	0.08	2265.31	0	11:00
A.10.1-10	JUNCTION	0.03	0.05	2319.33	0	11:00
A.10.1-11	JUNCTION	0.01	0.02	2328.41	0	11:00
A.10.1-12	JUNCTION	0.01	0.02	2332.77	0	11:00
A.10.1-13	JUNCTION	0.00	0.00	2341.04	0	00:00

A.10.1-14	JUNCTION	0.00	0.00	2350.13	0	00:00
A.10.1-15	JUNCTION	0.00	0.00	2352.00	0	00:00
A.10.1-16	JUNCTION	0.00	0.00	2353.70	0	00:00
A.10.1-17	JUNCTION	0.00	0.00	2354.40	0	00:00
A.10.1-18	JUNCTION	0.00	0.00	2358.15	0	00:00
A.10.1-2	JUNCTION	0.06	0.11	2272.71	0	11:00
A.10.1-3	JUNCTION	0.04	0.08	2274.44	0	11:00
A.10.1-4	JUNCTION	0.02	0.04	2282.71	0	11:00
A.10.1-5	JUNCTION	0.02	0.04	2289.25	0	11:00
A.10.1-6	JUNCTION	0.02	0.04	2297.49	0	11:00
A.10.1-7	JUNCTION	0.02	0.03	2311.36	0	11:00
A.10.1-8	JUNCTION	0.02	0.05	2317.71	0	11:00
A.10.1-9	JUNCTION	0.03	0.05	2318.65	0	11:00
A.10.1.1-1	JUNCTION	0.02	0.03	2266.95	0	11:00
A.10.1.1-2	JUNCTION	0.01	0.02	2270.05	0	11:00
A.10.1.10-1	JUNCTION	0.00	0.01	2354.51	0	11:00
A.10.1.8-1	JUNCTION	0.01	0.02	2350.02	0	11:00
A.10.2-1	JUNCTION	0.04	0.08	2268.98	0	10:37
A.10.2-2	JUNCTION	0.05	0.09	2270.49	0	10:20
A.10.2-3	JUNCTION	0.05	0.09	2270.97	0	11:00
A.10.2-4	JUNCTION	0.03	0.05	2279.24	0	10:59
A.10.2-5	JUNCTION	0.02	0.04	2308.49	0	10:05
A.11-1	JUNCTION	0.06	0.11	2234.79	0	11:00
A.11-2	JUNCTION	0.06	0.11	2236.82	0	11:00
A.11-3	JUNCTION	0.05	0.10	2238.49	0	11:00
A.11-4	JUNCTION	0.03	0.06	2248.76	0	11:00
A.11-5	JUNCTION	0.02	0.04	2268.06	0	11:00
A.11.1-1	JUNCTION	0.03	0.06	2240.35	0	11:14
A.11.1-2	JUNCTION	0.03	0.06	2241.97	0	11:05
A.11.1-3	JUNCTION	0.03	0.06	2243.67	0	11:02
A.11.1-4	JUNCTION	0.03	0.06	2245.31	0	11:00
A.11.1.4-1	JUNCTION	0.03	0.05	2247.65	0	11:00
A.11.1.4-2	JUNCTION	0.03	0.05	2249.39	0	11:00
A.11.1.4-3	JUNCTION	0.03	0.06	2250.68	0	11:00
A.11.1.4-4	JUNCTION	0.03	0.06	2252.48	0	11:00
A.12-1	JUNCTION	0.03	0.05	2237.45	0	11:00
A.12-2	JUNCTION	0.01	0.02	2238.42	0	11:00
A.13-1	JUNCTION	0.02	0.04	2240.07	0	11:00
A.14-1	JUNCTION	0.03	0.06	2260.12	0	11:00
A.14-1.1	JUNCTION	0.06	0.11	2260.81	0	11:00
A.14-1.2	JUNCTION	0.04	0.07	2261.47	0	11:00
A.14-1.3	JUNCTION	0.02	0.04	2265.93	0	11:00
A.14-1.4	JUNCTION	0.02	0.03	2273.93	0	11:00
A.14-1.5	JUNCTION	0.01	0.02	2281.40	0	11:00
A.14-1.6	JUNCTION	0.01	0.01	2285.01	0	10:38
A.14-1.7	JUNCTION	0.01	0.01	2277.51	0	10:54
A.14-1.8	JUNCTION	0.01	0.02	2278.02	0	10:50
A.14-2	JUNCTION	0.03	0.05	2274.35	0	11:00
A.14-3	JUNCTION	0.02	0.04	2276.04	0	11:00
A.14-4	JUNCTION	0.04	0.07	2279.19	0	11:00
A.14-5	JUNCTION	0.20	0.28	2286.81	0	11:00
A.14-6	JUNCTION	0.02	0.04	2288.74	0	11:00
A.14-7	JUNCTION	0.00	0.00	2288.70	0	00:00
A.14-8	JUNCTION	0.00	0.00	2302.73	0	00:00
A.14.1-1	JUNCTION	0.01	0.02	2264.02	0	10:53
A.14.1-1A	JUNCTION	0.01	0.02	2243.55	0	10:54
A.14.1-2	JUNCTION	0.01	0.02	2281.54	0	11:00
A.14.1-3	JUNCTION	0.01	0.02	2286.51	0	10:26
A.14.2-1	JUNCTION	0.01	0.02	2282.22	0	11:00
A.14.3-1	JUNCTION	0.02	0.03	2280.05	0	11:00
A.14.4-1	JUNCTION	0.01	0.03	2295.65	0	11:00
A.14.5-1	JUNCTION	0.00	0.00	2292.63	0	00:00
A.14.7-1	JUNCTION	0.00	0.00	2312.87	0	00:00

A.14.7-2	JUNCTION	0.00	0.00	2322.65	0	00:00
A.14.7-A	JUNCTION	0.00	0.00	2290.61	0	00:00
A.15-1	JUNCTION	0.06	0.10	2245.98	0	11:00
A.15-2	JUNCTION	0.05	0.09	2247.49	0	11:00
A.15-3	JUNCTION	0.02	0.04	2269.64	0	11:00
A.15-4	JUNCTION	0.01	0.02	2289.14	0	10:58
A.15-5	JUNCTION	0.01	0.02	2301.79	0	10:58
A.15-6	JUNCTION	0.01	0.02	2308.47	0	10:59
A.15-8	JUNCTION	0.00	0.00	2312.81	0	00:00
A.15.5-1	JUNCTION	0.00	0.00	2304.22	0	00:00
A.16-1	JUNCTION	0.01	0.02	2286.55	0	10:58
A.17-1	JUNCTION	0.03	0.05	2275.05	0	11:00
A.17-2	JUNCTION	0.05	0.09	2275.75	0	11:00
A.17-3	JUNCTION	0.05	0.08	2276.44	0	11:00
A.17-4	JUNCTION	0.03	0.05	2278.84	0	10:56
A.17-4.1	JUNCTION	0.01	0.03	2282.11	0	11:00
A.17-5	JUNCTION	0.02	0.03	2297.66	0	10:52
A.17-6	JUNCTION	0.01	0.01	2307.93	0	10:49
A.17-7	JUNCTION	0.01	0.01	2339.44	0	10:42
A.17-8	JUNCTION	0.01	0.01	2359.59	0	10:39
A.17-9	JUNCTION	0.00	0.00	2380.00	0	00:26
A.17.1-1	JUNCTION	0.02	0.04	2276.58	0	10:57
A.2-1	JUNCTION	0.14	0.28	2227.16	0	11:00
A.2-10	JUNCTION	0.09	0.18	2272.95	0	11:00
A.2-11	JUNCTION	0.03	0.05	2275.45	0	11:00
A.2-12	JUNCTION	0.02	0.03	2283.09	0	11:00
A.2-13	JUNCTION	0.03	0.05	2289.10	0	11:00
A.2-14	JUNCTION	0.02	0.03	2297.82	0	11:00
A.2-2	JUNCTION	0.11	0.22	2230.58	0	11:00
A.2-3	JUNCTION	0.14	0.28	2231.49	0	11:00
A.2-4	JUNCTION	0.10	0.19	2236.67	0	11:00
A.2-5	JUNCTION	0.09	0.17	2242.73	0	11:00
A.2-6	JUNCTION	0.08	0.16	2247.24	0	11:00
A.2-7	JUNCTION	0.09	0.18	2249.86	0	11:00
A.2-8	JUNCTION	0.07	0.13	2259.02	0	11:00
A.2-9	JUNCTION	0.07	0.14	2268.71	0	11:00
A.2.1-1	JUNCTION	0.02	0.04	2237.78	0	11:00
A.2.1-2	JUNCTION	0.02	0.03	2241.10	0	11:00
A.2.1-3	JUNCTION	0.01	0.02	2244.85	0	10:54
A.2.1A-1	JUNCTION	0.04	0.07	2234.57	0	11:00
A.2.1A-2	JUNCTION	0.05	0.09	2236.37	0	11:00
A.2.1A-3	JUNCTION	0.05	0.08	2236.85	0	11:00
A.2.1A-4	JUNCTION	0.04	0.08	2237.57	0	11:00
A.2.1A-5	JUNCTION	0.03	0.05	2238.08	0	11:00
A.2.1A-6	JUNCTION	0.01	0.02	2240.86	0	10:11
A.2.1A.1-1	JUNCTION	0.01	0.01	2244.65	0	11:00
A.2.1A.2-1	JUNCTION	0.02	0.04	2238.60	0	10:45
A.2.2-1	JUNCTION	0.03	0.05	2254.45	0	10:31
A.2.2-2	JUNCTION	0.03	0.06	2257.58	0	10:19
A.2.2-3	JUNCTION	0.02	0.05	2260.29	0	10:57
A.2.2-4	JUNCTION	0.02	0.05	2262.93	0	10:09
A.2.2-5	JUNCTION	0.03	0.06	2263.83	0	10:59
A.2.2.1-1	JUNCTION	0.01	0.01	2260.76	0	10:57
A.2.2.2-1	JUNCTION	0.00	0.00	2261.13	0	00:00
A.3.1-1	JUNCTION	0.01	0.02	2231.22	0	11:00
A.3A-1	JUNCTION	0.00	0.00	2233.41	0	00:00
A.4-1	JUNCTION	0.01	0.02	2226.67	0	11:02
A.4-10	JUNCTION	0.16	0.30	2248.14	0	11:00
A.4-11	JUNCTION	0.15	0.30	2254.11	0	11:00
A.4-12	JUNCTION	0.24	0.47	2255.47	0	11:00
A.4-13	JUNCTION	0.04	0.07	2257.57	0	11:00
A.4-14	JUNCTION	0.07	0.13	2264.14	0	11:00
A.4-15	JUNCTION	0.08	0.15	2265.60	0	11:00

A.4-16	JUNCTION	0.08	0.15	2267.39	0	11:00
A.4-17	JUNCTION	0.04	0.07	2272.42	0	11:00
A.4-18	JUNCTION	0.04	0.07	2283.21	0	11:00
A.4-2	JUNCTION	0.01	0.02	2227.85	0	11:00
A.4-3	JUNCTION	0.01	0.02	2228.70	0	11:00
A.4-4	JUNCTION	0.00	0.00	2229.39	0	00:00
A.4-5	JUNCTION	0.20	0.40	2236.89	0	11:00
A.4-6	JUNCTION	0.25	0.51	2238.18	0	11:01
A.4-7	JUNCTION	0.18	0.35	2240.27	0	11:01
A.4-8	JUNCTION	0.26	0.54	2241.50	0	11:01
A.4-9	JUNCTION	0.19	0.38	2243.32	0	11:00
A.4.1-1	JUNCTION	0.01	0.02	2248.06	0	11:00
A.4.1-1A	JUNCTION	0.00	0.01	2248.49	0	10:16
A.4.1-2	JUNCTION	0.01	0.01	2253.52	0	10:12
A.4.10-1	JUNCTION	0.08	0.15	2257.50	0	11:00
A.4.10-1A	JUNCTION	0.07	0.13	2252.61	0	11:01
A.4.10-2	JUNCTION	0.06	0.11	2261.91	0	11:00
A.4.10-3	JUNCTION	0.08	0.14	2264.14	0	11:00
A.4.10-4	JUNCTION	0.06	0.11	2283.64	0	11:00
A.4.10-5	JUNCTION	0.09	0.18	2285.00	0	11:00
A.4.10-6	JUNCTION	0.06	0.11	2291.90	0	11:00
A.4.10-7	JUNCTION	0.02	0.04	2302.07	0	10:52
A.4.10-8	JUNCTION	0.00	0.00	2327.71	0	00:00
A.4.10.6-1	JUNCTION	0.06	0.12	2294.92	0	11:01
A.4.10.6-2	JUNCTION	0.06	0.11	2300.87	0	11:00
A.4.10.6-3	JUNCTION	0.05	0.09	2334.69	0	11:00
A.4.16-1	JUNCTION	0.00	0.00	2278.29	0	00:00
A.4.2-1	JUNCTION	0.01	0.01	2246.98	0	11:00
A.4.2-2	JUNCTION	0.01	0.01	2256.30	0	10:48
A.4.5-1	JUNCTION	0.02	0.03	2249.55	0	10:37
A.4.5-2	JUNCTION	0.00	0.00	2251.03	0	00:00
A.4.5-3	JUNCTION	0.00	0.00	2251.73	0	00:00
A.4.8-1	JUNCTION	0.00	0.00	2245.62	0	00:00
A.5-1	JUNCTION	0.12	0.23	2227.13	0	11:00
A.5-2	JUNCTION	0.11	0.20	2228.98	0	11:00
A.5-3	JUNCTION	0.10	0.20	2230.65	0	11:00
A.5-4	JUNCTION	0.05	0.09	2231.78	0	11:00
A.5-5	JUNCTION	0.05	0.09	2232.31	0	11:00
A.5-6	JUNCTION	0.05	0.09	2236.74	0	11:00
A.5-7	JUNCTION	0.02	0.04	2243.05	0	10:58
A.5-8	JUNCTION	0.02	0.03	2268.84	0	10:50
A.5-9	JUNCTION	0.02	0.03	2296.84	0	10:57
A.5.1-1	JUNCTION	0.04	0.07	2233.49	0	11:00
A.5.1-2	JUNCTION	0.04	0.06	2235.28	0	11:00
A.5.1-3	JUNCTION	0.03	0.05	2235.60	0	11:00
A.5.1-4	JUNCTION	0.02	0.05	2236.77	0	11:00
A.5.2-1	JUNCTION	0.10	0.19	2235.77	0	10:59
A.5.2-2	JUNCTION	0.12	0.23	2236.50	0	10:56
A.5.2-3	JUNCTION	0.05	0.09	2239.29	0	10:56
A.5.2.1-1	JUNCTION	0.03	0.05	2236.55	0	10:01
A.5.3-1	JUNCTION	0.03	0.05	2237.34	0	11:00
A.5.3-2	JUNCTION	0.01	0.02	2244.64	0	11:00
A.5.3.1-1	JUNCTION	0.01	0.03	2238.52	0	11:00
A.6-1	JUNCTION	0.07	0.14	2230.94	0	11:00
A.6-2	JUNCTION	0.07	0.13	2231.67	0	11:00
A.6-3	JUNCTION	0.12	0.14	2244.88	0	11:00
A.6-4	JUNCTION	0.03	0.05	2255.15	0	11:00
A.6-5	JUNCTION	0.03	0.05	2262.25	0	11:00
A.6-6	JUNCTION	0.03	0.05	2273.84	0	11:00
A.6-7	JUNCTION	0.03	0.05	2276.93	0	11:00
A.6-8	JUNCTION	0.02	0.04	2279.77	0	11:00
A.6-9	JUNCTION	0.01	0.02	2285.94	0	11:00
A.6.1-1	JUNCTION	0.02	0.03	2232.23	0	11:00

A.6.2-1	JUNCTION	0.02	0.03	2262.98	0	11:00
A.6.2-2	JUNCTION	0.03	0.06	2263.69	0	11:00
A.6.2-3	JUNCTION	0.02	0.03	2276.09	0	11:00
A.6.2-4	JUNCTION	0.01	0.02	2292.20	0	11:00
A.6.3-1	JUNCTION	0.01	0.02	2279.77	0	11:00
A.6.4-1	JUNCTION	0.03	0.05	2282.66	0	11:00
A.6.4-2	JUNCTION	0.01	0.02	2284.07	0	11:00
A.6.4.1-1	JUNCTION	0.02	0.03	2293.87	0	11:00
A.7-1	JUNCTION	0.02	0.04	2234.32	0	11:00
A.7-2	JUNCTION	0.01	0.03	2236.19	0	10:47
A.7-3	JUNCTION	0.01	0.03	2236.95	0	10:13
A.8-1	JUNCTION	0.06	0.11	2229.69	0	11:00
A.8-2	JUNCTION	0.06	0.11	2231.09	0	11:00
A.8-3	JUNCTION	0.06	0.11	2236.31	0	11:00
A.8-4	JUNCTION	0.05	0.10	2237.54	0	11:00
A.8-5	JUNCTION	0.04	0.07	2243.99	0	11:00
A.8-6	JUNCTION	0.02	0.04	2258.96	0	11:00
A.8-7	JUNCTION	0.02	0.04	2276.60	0	11:00
A.8-8	JUNCTION	0.02	0.04	2305.46	0	11:00
A.8.1-1	JUNCTION	0.01	0.02	2278.79	0	11:00
A.9-1	JUNCTION	0.06	0.11	2236.32	0	11:00
A.9-2	JUNCTION	0.05	0.10	2237.99	0	11:00
A.9-3	JUNCTION	0.05	0.09	2239.66	0	11:00
A.9-4	JUNCTION	0.04	0.07	2242.67	0	11:00
A.9-5	JUNCTION	0.02	0.05	2248.98	0	10:23
A.9-6	JUNCTION	0.01	0.03	2280.03	0	10:19
A.9-7	JUNCTION	0.01	0.03	2289.05	0	10:06
A.9A-1	JUNCTION	0.04	0.08	2231.62	0	11:00
A.9A-2	JUNCTION	0.03	0.05	2248.25	0	11:00
A.9A-3	JUNCTION	0.02	0.04	2270.94	0	11:00
A.9A-4	JUNCTION	0.01	0.03	2291.29	0	10:52
A.9A.2-1	JUNCTION	0.00	0.00	2249.62	0	00:00
A.A5-7	JUNCTION	0.00	0.00	2310.26	0	00:00
A1	JUNCTION	0.01	0.03	2299.93	0	11:00
A2	JUNCTION	0.02	0.04	2306.41	0	11:00
A3	JUNCTION	0.02	0.04	2307.86	0	11:00
B-1	JUNCTION	0.15	0.30	2231.43	0	11:00
B-10	JUNCTION	0.03	0.06	2260.43	0	11:00
B-11	JUNCTION	0.07	0.12	2262.34	0	11:00
B-2	JUNCTION	0.17	0.34	2235.78	0	11:00
B-3	JUNCTION	0.17	0.35	2238.37	0	11:00
B-4	JUNCTION	0.18	0.34	2240.07	0	11:00
B-5	JUNCTION	0.17	0.34	2245.47	0	11:01
B-6	JUNCTION	0.14	0.27	2250.15	0	11:00
B-7	JUNCTION	0.28	0.63	2250.78	0	11:04
B-8	JUNCTION	0.25	0.60	2252.31	0	11:02
B.1-1	JUNCTION	0.02	0.03	2232.46	0	11:00
B.1A	JUNCTION	0.15	0.29	2231.42	0	11:06
B.2-1	JUNCTION	0.04	0.07	2236.42	0	10:23
B.2A	JUNCTION	0.17	0.33	2235.73	0	11:04
B.3-1	JUNCTION	0.01	0.02	2256.26	0	10:16
B.3-2	JUNCTION	0.02	0.03	2265.51	0	10:08
B.3A-1	JUNCTION	0.15	0.30	2240.03	0	11:02
B.4-1	JUNCTION	0.04	0.07	2245.91	0	11:00
B.4-2	JUNCTION	0.03	0.05	2272.38	0	11:00
B.4-3	JUNCTION	0.04	0.08	2277.71	0	11:00
B.4-4	JUNCTION	0.06	0.11	2278.78	0	11:00
B.4-5	JUNCTION	0.04	0.07	2284.19	0	11:00
B.4-6	JUNCTION	0.05	0.10	2285.12	0	11:00
B.4-7	JUNCTION	0.02	0.03	2293.88	0	11:00
B.4-8	JUNCTION	0.02	0.03	2300.97	0	11:00
B.4A-1	JUNCTION	0.25	0.50	2241.27	0	11:02
B.5A	JUNCTION	0.14	0.28	2245.41	0	11:01

B.6-1	JUNCTION	0.02	0.03	2250.88	0	11:00
B.6-1A	JUNCTION	0.10	0.19	2252.19	0	11:00
B.6-2	JUNCTION	0.01	0.02	2263.02	0	10:52
B.6-2A	JUNCTION	0.07	0.13	2255.13	0	11:00
B.6-3	JUNCTION	0.01	0.02	2269.64	0	10:58
B.6-3A	JUNCTION	0.07	0.14	2257.13	0	11:00
B.6-4A	JUNCTION	0.08	0.14	2259.14	0	11:00
B.6-5A	JUNCTION	0.09	0.18	2259.88	0	11:00
B.6.A-1	JUNCTION	0.27	0.61	2253.27	0	11:00
B.7-1	JUNCTION	0.01	0.03	2266.94	0	10:30
B.7-2	JUNCTION	0.01	0.02	2271.54	0	10:31
B.7-3	JUNCTION	0.02	0.03	2272.03	0	10:10
B.7.1-1	JUNCTION	0.01	0.01	2272.00	0	11:00
B.7.2-1	JUNCTION	0.00	0.00	2274.95	0	22:29
B1	JUNCTION	0.01	0.02	2271.94	0	11:00
B2	JUNCTION	0.01	0.03	2275.99	0	11:00
B3	JUNCTION	0.01	0.02	2294.59	0	11:00
B4	JUNCTION	0.02	0.03	2296.74	0	11:00
B5	JUNCTION	0.01	0.02	2323.56	0	11:00
C1	JUNCTION	0.03	0.06	2308.44	0	11:00
C2	JUNCTION	0.03	0.05	2311.60	0	11:00
C3	JUNCTION	0.01	0.02	2315.58	0	10:50
C4	JUNCTION	0.01	0.02	2322.81	0	10:38
CV-01	JUNCTION	0.20	0.42	2291.12	0	10:59
CV-02	JUNCTION	0.14	0.26	2296.26	0	10:58
CV-03	JUNCTION	0.13	0.25	2303.25	0	10:57
CV-04	JUNCTION	0.10	0.20	2319.70	0	10:56
CV-05	JUNCTION	0.23	0.45	2320.65	0	10:56
CV-06	JUNCTION	0.21	0.40	2321.07	0	10:54
CV-07	JUNCTION	0.20	0.39	2321.39	0	10:54
CV-08	JUNCTION	0.13	0.25	2323.47	0	10:53
CV-09	JUNCTION	0.12	0.24	2325.24	0	10:52
CV-10	JUNCTION	0.11	0.21	2328.01	0	10:52
CV-11	JUNCTION	0.12	0.22	2331.48	0	10:51
CV-12	JUNCTION	0.17	0.34	2331.94	0	10:51
CV-13	JUNCTION	0.17	0.32	2332.75	0	10:50
CV-14	JUNCTION	0.17	0.34	2332.95	0	10:48
CV-15	JUNCTION	0.15	0.28	2333.65	0	10:47
CV-16	JUNCTION	0.08	0.15	2336.75	0	10:52
CV-17	JUNCTION	0.08	0.15	2347.15	0	10:44
CV-18	JUNCTION	0.09	0.17	2349.47	0	10:38
CV-19	JUNCTION	0.07	0.13	2373.93	0	10:44
CV-20	JUNCTION	0.07	0.14	2377.92	0	10:37
CV-21	JUNCTION	0.17	0.32	2379.73	0	11:00
CV-22	JUNCTION	0.16	0.30	2381.12	0	10:45
CV-23	JUNCTION	0.15	0.28	2381.74	0	10:14
CV-24	JUNCTION	0.12	0.22	2385.44	0	10:41
CV-25	JUNCTION	0.12	0.22	2388.20	0	10:41
CV-26	JUNCTION	0.09	0.17	2397.67	0	10:39
CV-27	JUNCTION	0.06	0.11	2415.80	0	10:50
CV-28	JUNCTION	0.06	0.11	2431.38	0	10:55
CV-29	JUNCTION	0.06	0.11	2470.98	0	10:47
CV-30	JUNCTION	0.06	0.12	2487.70	0	10:50
CV-31	JUNCTION	0.08	0.15	2497.21	0	10:29
CV.10-1	JUNCTION	0.00	0.00	2328.16	0	00:00
CV.10-2	JUNCTION	0.00	0.00	2345.70	0	00:00
CV.10-3	JUNCTION	0.00	0.00	2356.94	0	00:00
CV.10-4	JUNCTION	0.00	0.00	2364.02	0	00:00
CV.10-5	JUNCTION	0.00	0.00	2366.02	0	00:00
CV.10-6	JUNCTION	0.00	0.00	2366.75	0	00:00
CV.10.4-1	JUNCTION	0.00	0.00	2368.47	0	00:00
CV.12-1	JUNCTION	0.02	0.03	2331.94	0	09:01
CV.12-10	JUNCTION	0.00	0.00	2421.23	0	00:00

CV.12-11	JUNCTION	0.00	0.00	2429.90	0	00:00
CV.12-2	JUNCTION	0.01	0.01	2343.91	0	10:39
CV.12-3	JUNCTION	0.00	0.00	2352.40	0	08:58
CV.12-4	JUNCTION	0.01	0.01	2365.20	0	11:00
CV.12-5	JUNCTION	0.01	0.01	2374.17	0	10:57
CV.12-6	JUNCTION	0.01	0.01	2384.48	0	10:59
CV.12-7	JUNCTION	0.00	0.00	2395.99	0	00:00
CV.12-8	JUNCTION	0.00	0.00	2399.78	0	00:00
CV.12-9	JUNCTION	0.00	0.00	2410.29	0	00:00
CV.12.5-1	JUNCTION	0.00	0.00	2376.70	0	00:00
CV.12.5-2	JUNCTION	0.00	0.00	2379.79	0	00:00
CV.12.5-3	JUNCTION	0.00	0.00	2380.42	0	00:00
CV.12.6-1	JUNCTION	0.00	0.00	2390.40	0	00:00
CV.12.6-2	JUNCTION	0.00	0.00	2393.96	0	00:00
CV.12.6-3	JUNCTION	0.00	0.00	2395.64	0	00:00
CV.12.7-1	JUNCTION	0.00	0.00	2401.16	0	00:00
CV.12.7-2	JUNCTION	0.00	0.00	2415.79	0	00:00
CV.12.7-3	JUNCTION	0.00	0.00	2425.20	0	00:00
CV.12.7-4	JUNCTION	0.00	0.00	2430.50	0	00:00
CV.12.8-1	JUNCTION	0.00	0.00	2400.48	0	00:00
CV.12.8-2	JUNCTION	0.00	0.00	2408.53	0	00:00
CV.12.8-3	JUNCTION	0.00	0.00	2415.49	0	00:00
CV.12.8-4	JUNCTION	0.00	0.00	2419.74	0	00:00
CV.12.8-5	JUNCTION	0.00	0.00	2423.48	0	00:00
CV.12.8-6	JUNCTION	0.00	0.00	2425.43	0	00:00
CV.12.8-7	JUNCTION	0.00	0.00	2428.77	0	00:00
CV.12.8-8	JUNCTION	0.00	0.00	2432.40	0	00:00
CV.14-1	JUNCTION	0.02	0.04	2333.50	0	10:53
CV.14-10	JUNCTION	0.00	0.00	2430.74	0	00:00
CV.14-2	JUNCTION	0.01	0.02	2339.19	0	10:50
CV.14-3	JUNCTION	0.01	0.02	2349.60	0	10:50
CV.14-4	JUNCTION	0.01	0.02	2359.71	0	10:48
CV.14-5	JUNCTION	0.01	0.02	2369.35	0	10:47
CV.14-6	JUNCTION	0.01	0.01	2379.91	0	10:45
CV.14-7	JUNCTION	0.01	0.01	2387.91	0	10:42
CV.14-8	JUNCTION	0.01	0.01	2411.34	0	10:39
CV.14-9	JUNCTION	0.00	0.00	2420.46	0	00:19
CV.14.3-1	JUNCTION	0.01	0.01	2351.41	0	10:52
CV.14.3-2	JUNCTION	0.01	0.01	2355.87	0	10:39
CV.14.3-3	JUNCTION	0.00	0.00	2363.60	0	00:00
CV.14.3.2-1	JUNCTION	0.00	0.00	2370.87	0	00:00
CV.14.5-1	JUNCTION	0.01	0.02	2370.23	0	10:15
CV.14.5-2	JUNCTION	0.01	0.01	2374.40	0	10:14
CV.14.5-3	JUNCTION	0.00	0.00	2384.87	0	04:46
CV.14.5-4	JUNCTION	0.00	0.00	2388.56	0	00:00
CV.14.5-5	JUNCTION	0.00	0.00	2396.72	0	00:00
CV.14.5.2-1	JUNCTION	0.00	0.00	2385.00	0	00:00
CV.16-1	JUNCTION	0.01	0.02	2336.98	0	10:47
CV.16-2	JUNCTION	0.01	0.01	2339.60	0	10:43
CV.16-3	JUNCTION	0.01	0.01	2341.56	0	10:40
CV.16-4	JUNCTION	0.00	0.01	2351.76	0	10:41
CV.16-5	JUNCTION	0.00	0.00	2360.91	0	01:39
CV.16-6	JUNCTION	0.00	0.00	2368.00	0	00:00
CV.18-1	JUNCTION	0.00	0.00	2349.63	0	00:00
CV.18-2	JUNCTION	0.00	0.00	2360.36	0	00:00
CV.18-3	JUNCTION	0.00	0.00	2362.81	0	00:00
CV.18-4	JUNCTION	0.00	0.00	2375.35	0	00:00
CV.18-5	JUNCTION	0.00	0.00	2377.90	0	00:00
CV.18-6	JUNCTION	0.00	0.00	2382.32	0	00:00
CV.19-1	JUNCTION	0.01	0.02	2374.18	0	10:42
CV.19-2	JUNCTION	0.01	0.02	2374.69	0	10:32
CV.19-3	JUNCTION	0.00	0.00	2387.31	0	09:18
CV.19-4	JUNCTION	0.00	0.00	2394.21	0	18:04

CV.19-5	JUNCTION	0.00	0.00	2399.78	0	09:06
CV.19.2-1	JUNCTION	0.00	0.00	2377.56	0	00:00
CV.19.2-2	JUNCTION	0.00	0.00	2383.52	0	00:00
CV.19.2-3	JUNCTION	0.00	0.00	2392.35	0	00:00
CV.21-1	JUNCTION	0.04	0.07	2398.08	0	11:00
CV.21-10	JUNCTION	0.00	0.00	2434.47	0	00:00
CV.21-11	JUNCTION	0.00	0.00	2436.29	0	00:00
CV.21-2	JUNCTION	0.04	0.07	2402.53	0	11:00
CV.21-3	JUNCTION	0.01	0.02	2410.96	0	11:00
CV.21-4	JUNCTION	0.01	0.01	2416.12	0	11:00
CV.21-5	JUNCTION	0.01	0.01	2422.28	0	11:00
CV.21-6	JUNCTION	0.01	0.01	2428.77	0	11:00
CV.21-7	JUNCTION	0.01	0.01	2431.38	0	11:00
CV.21-8	JUNCTION	0.01	0.01	2432.86	0	11:00
CV.21-9	JUNCTION	0.01	0.01	2433.79	0	11:00
CV.26-1	JUNCTION	0.01	0.01	2401.32	0	10:39
CV.26-2	JUNCTION	0.00	0.00	2424.20	0	11:05
CV.26-3	JUNCTION	0.00	0.00	2451.73	0	03:23
CV.26-4	JUNCTION	0.01	0.01	2452.88	0	11:00
CV.26.3-1	JUNCTION	0.00	0.00	2456.43	0	00:00
CV.8-1	JUNCTION	0.00	0.00	2323.56	0	00:00
CV.8-2	JUNCTION	0.00	0.00	2329.45	0	00:00
CV.8-3	JUNCTION	0.00	0.00	2350.22	0	00:00
CV.8-4	JUNCTION	0.00	0.00	2369.87	0	00:00
CV.8-5	JUNCTION	0.00	0.00	2383.04	0	00:00
CV14-11	JUNCTION	0.00	0.00	2433.39	0	00:00
D1	JUNCTION	0.02	0.03	2308.54	0	11:00
D2	JUNCTION	0.02	0.04	2311.74	0	11:00
E1	JUNCTION	0.08	0.16	2279.19	0	11:00
E10	JUNCTION	0.03	0.06	2334.12	0	10:37
E11	JUNCTION	0.03	0.06	2353.96	0	10:55
E11-1	JUNCTION	0.00	0.00	2359.40	0	00:00
E12	JUNCTION	0.03	0.06	2365.88	0	10:52
E3	JUNCTION	0.11	0.21	2280.05	0	11:00
E4	JUNCTION	0.12	0.22	2280.83	0	11:00
E4-1	JUNCTION	0.00	0.00	2291.69	0	00:00
E4-2	JUNCTION	0.00	0.00	2292.94	0	00:00
E5	JUNCTION	0.12	0.22	2282.56	0	11:00
E5-1	JUNCTION	0.04	0.08	2293.44	0	11:00
E5-2	JUNCTION	0.08	0.16	2295.71	0	11:00
E5-3	JUNCTION	0.04	0.08	2301.94	0	11:00
E5-3-1	JUNCTION	0.01	0.03	2310.69	0	11:00
E5-3.1	JUNCTION	0.06	0.11	2304.93	0	11:00
E5-3.1.1	JUNCTION	0.02	0.03	2320.27	0	11:00
E5-3.1.2	JUNCTION	0.00	0.00	2321.71	0	00:00
E5-3.1.3	JUNCTION	0.00	0.00	2322.44	0	00:00
E5-3.2	JUNCTION	0.05	0.08	2310.19	0	11:00
E5-3.2.1	JUNCTION	0.00	0.00	2314.12	0	00:00
E5-3.2.2	JUNCTION	0.03	0.06	2317.77	0	11:00
E5-3.2.3	JUNCTION	0.01	0.02	2322.53	0	11:00
E5-3.3	JUNCTION	0.04	0.07	2312.57	0	10:56
E5-3.3.1	JUNCTION	0.00	0.00	2313.93	0	00:00
E5-3.3.2	JUNCTION	0.00	0.00	2318.51	0	00:00
E5-3.3.3	JUNCTION	0.00	0.00	2329.77	0	00:00
E5-3.4	JUNCTION	0.00	0.00	2315.19	0	00:00
E5-3.5	JUNCTION	0.00	0.00	2319.72	0	00:00
E5-3.6	JUNCTION	0.00	0.00	2327.45	0	00:00
E5-4	JUNCTION	0.01	0.03	2330.93	0	11:00
E5-5	JUNCTION	0.02	0.03	2332.12	0	11:00
E5A	JUNCTION	0.04	0.07	2287.91	0	11:00
E6	JUNCTION	0.04	0.08	2299.94	0	11:00
E7	JUNCTION	0.05	0.08	2303.71	0	11:00
E8	JUNCTION	0.05	0.09	2312.06	0	11:00

E9	JUNCTION	0.04	0.08	2320.46	0	10:53
F	JUNCTION	0.18	0.36	2278.59	0	11:00
F1	JUNCTION	0.02	0.04	2285.93	0	11:00
F1-1	JUNCTION	0.02	0.03	2296.12	0	11:00
F1-2	JUNCTION	0.03	0.05	2298.10	0	11:00
F2	JUNCTION	0.01	0.03	2296.87	0	11:00
F3	JUNCTION	0.02	0.03	2305.81	0	11:00
F4	JUNCTION	0.01	0.02	2310.20	0	10:33
G	JUNCTION	0.11	0.21	2301.64	0	11:00
G1	JUNCTION	0.08	0.16	2306.42	0	11:00
G1-1	JUNCTION	0.06	0.12	2308.27	0	11:02
G1-2	JUNCTION	0.03	0.06	2312.84	0	11:01
G1-3	JUNCTION	0.06	0.12	2315.08	0	11:00
G1-4	JUNCTION	0.04	0.07	2330.78	0	11:00
G1-5	JUNCTION	0.04	0.07	2347.85	0	10:58
G1-6	JUNCTION	0.03	0.06	2366.43	0	10:53
G1-7	JUNCTION	0.04	0.07	2375.17	0	10:54
G10	JUNCTION	0.07	0.14	2331.23	0	11:00
G11	JUNCTION	0.08	0.14	2332.08	0	11:00
G11-1	JUNCTION	0.01	0.01	2345.43	0	11:00
G12	JUNCTION	0.04	0.08	2342.38	0	11:00
G13	JUNCTION	0.04	0.08	2354.75	0	11:00
G13-1	JUNCTION	0.03	0.06	2365.12	0	11:00
G13-2	JUNCTION	0.05	0.10	2368.20	0	11:00
G13-3	JUNCTION	0.05	0.10	2371.20	0	11:00
G13-4	JUNCTION	0.06	0.11	2371.79	0	11:00
G15	JUNCTION	0.04	0.08	2375.96	0	11:00
G16	JUNCTION	0.07	0.12	2378.30	0	11:00
G16-1	JUNCTION	0.02	0.04	2379.08	0	11:00
G16-2	JUNCTION	0.02	0.03	2381.00	0	11:00
G17	JUNCTION	0.05	0.10	2380.36	0	11:00
G2	JUNCTION	0.07	0.14	2313.17	0	11:00
G3	JUNCTION	0.12	0.23	2315.23	0	11:00
G4	JUNCTION	0.11	0.21	2317.12	0	11:00
G4A	JUNCTION	0.08	0.16	2317.86	0	11:00
G5	JUNCTION	0.09	0.18	2319.11	0	11:00
G5-1	JUNCTION	0.02	0.03	2327.79	0	11:00
G5-1-1	JUNCTION	0.02	0.03	2332.78	0	11:00
G5-2	JUNCTION	0.01	0.02	2337.86	0	11:00
G5-3	JUNCTION	0.01	0.02	2339.44	0	11:00
G5A	JUNCTION	0.02	0.03	2326.01	0	11:00
G5A-1	JUNCTION	0.01	0.02	2326.76	0	11:00
G6	JUNCTION	0.10	0.18	2320.76	0	11:00
G7	JUNCTION	0.09	0.17	2321.78	0	11:00
G8	JUNCTION	0.05	0.10	2327.45	0	11:00
G9	JUNCTION	0.09	0.18	2327.91	0	11:00
G9-1	JUNCTION	0.01	0.01	2333.87	0	09:42
H1	JUNCTION	0.03	0.05	2299.03	0	11:00
H2	JUNCTION	0.01	0.02	2312.89	0	11:00
HA	JUNCTION	0.02	0.04	2295.27	0	11:00
I	JUNCTION	0.07	0.13	2303.47	0	11:00
I-0	JUNCTION	0.36	0.80	2221.07	0	11:13
I-1	JUNCTION	0.50	0.97	2221.59	0	11:06
I-10	JUNCTION	0.19	0.38	2228.23	0	11:00
I-11	JUNCTION	0.14	0.26	2229.80	0	11:01
I-12	JUNCTION	0.16	0.31	2230.53	0	11:00
I-2	JUNCTION	0.37	0.82	2221.77	0	11:07
I-3	JUNCTION	0.30	0.56	2222.14	0	10:32
I-4	JUNCTION	0.20	0.41	2222.35	0	11:06
I-5	JUNCTION	0.20	0.39	2223.28	0	11:04
I-6	JUNCTION	0.24	0.48	2224.64	0	11:03
I-7	JUNCTION	0.21	0.42	2225.38	0	11:00
I-8	JUNCTION	0.17	0.34	2225.93	0	11:01

I-9	JUNCTION	0.16	0.33	2226.90	0	11:01
I-A	JUNCTION	0.30	0.76	2220.76	0	11:06
I.1	JUNCTION	0.00	0.00	2229.23	0	00:00
I.1A	JUNCTION	0.45	0.95	2221.65	0	11:04
I.2	JUNCTION	0.00	0.00	2229.25	0	00:00
I.3	JUNCTION	0.00	0.00	2231.05	0	00:00
I.4	JUNCTION	0.00	0.00	2234.79	0	00:00
I1	JUNCTION	0.02	0.03	2308.47	0	11:00
J	JUNCTION	0.07	0.13	2304.31	0	11:00
J1	JUNCTION	0.02	0.04	2306.08	0	11:00
J2	JUNCTION	0.01	0.02	2310.33	0	11:00
JS-1	JUNCTION	0.13	0.27	2257.71	0	11:00
JS-10	JUNCTION	0.02	0.03	2286.03	0	10:46
JS-11	JUNCTION	0.02	0.03	2302.13	0	10:34
JS-12	JUNCTION	0.01	0.02	2318.42	0	10:56
JS-13	JUNCTION	0.01	0.02	2338.82	0	10:55
JS-2	JUNCTION	0.18	0.36	2261.25	0	11:00
JS-3	JUNCTION	0.21	0.46	2262.70	0	11:00
JS-4	JUNCTION	0.22	0.46	2265.40	0	11:01
JS-5	JUNCTION	0.21	0.44	2268.10	0	11:00
JS-6	JUNCTION	0.08	0.16	2272.17	0	11:00
JS-7	JUNCTION	0.11	0.21	2272.75	0	11:00
JS-8	JUNCTION	0.12	0.22	2272.88	0	11:00
JS-8A	JUNCTION	0.09	0.17	2273.20	0	11:00
JS-9	JUNCTION	0.06	0.11	2275.11	0	11:00
JS.3-1	JUNCTION	0.00	0.00	2269.38	0	00:00
JS.3-2	JUNCTION	0.00	0.00	2278.28	0	00:00
JS.3-3	JUNCTION	0.00	0.00	2297.18	0	00:00
JS.9-1	JUNCTION	0.02	0.04	2290.04	0	11:00
JS.9-2	JUNCTION	0.02	0.04	2305.04	0	11:00
JS.9-3	JUNCTION	0.02	0.03	2308.03	0	11:00
K1	JUNCTION	0.01	0.03	2305.86	0	11:00
K2	JUNCTION	0.02	0.03	2309.64	0	11:00
K3	JUNCTION	0.02	0.04	2314.17	0	11:00
K4	JUNCTION	0.01	0.02	2324.84	0	10:55
L	JUNCTION	0.04	0.08	2312.13	0	11:00
L.1-1	JUNCTION	0.05	0.09	2316.78	0	10:07
L.1-2	JUNCTION	0.01	0.02	2321.53	0	11:00
L.1-3	JUNCTION	0.01	0.01	2327.89	0	11:00
L1	JUNCTION	0.02	0.03	2321.43	0	11:00
L2	JUNCTION	0.01	0.03	2327.61	0	11:00
L3	JUNCTION	0.01	0.03	2340.00	0	11:00
LS-1	JUNCTION	0.23	0.45	2221.21	0	11:04
LS-10	JUNCTION	0.06	0.11	2372.95	0	11:00
LS-11	JUNCTION	0.05	0.09	2404.65	0	11:00
LS-12	JUNCTION	0.04	0.07	2423.30	0	11:00
LS-13	JUNCTION	0.07	0.14	2424.90	0	11:00
LS-14	JUNCTION	0.07	0.14	2426.43	0	11:00
LS-15	JUNCTION	0.06	0.11	2428.73	0	11:00
LS-16	JUNCTION	0.06	0.11	2429.71	0	10:44
LS-17	JUNCTION	0.04	0.07	2433.77	0	10:25
LS-2	JUNCTION	0.22	0.44	2223.13	0	11:03
LS-3	JUNCTION	0.23	0.45	2224.41	0	11:02
LS-4	JUNCTION	0.25	0.51	2224.79	0	11:01
LS-5	JUNCTION	0.18	0.35	2225.36	0	11:00
LS-6	JUNCTION	0.29	0.55	2225.62	0	11:00
LS-7	JUNCTION	0.14	0.27	2233.87	0	11:00
LS-8	JUNCTION	0.06	0.12	2347.46	0	11:00
LS-9	JUNCTION	0.06	0.11	2360.20	0	11:00
M	JUNCTION	0.16	0.33	2257.43	0	11:00
M1	JUNCTION	0.11	0.22	2272.54	0	11:00
M10	JUNCTION	0.13	0.24	2315.17	0	11:00
M11	JUNCTION	0.14	0.28	2316.83	0	11:00

M12	JUNCTION	0.15	0.29	2318.97	0	11:00
M13	JUNCTION	0.16	0.32	2320.67	0	11:00
M14	JUNCTION	0.06	0.11	2322.11	0	11:00
M15	JUNCTION	0.04	0.07	2328.13	0	11:00
M16	JUNCTION	0.03	0.06	2338.23	0	11:00
M16-1	JUNCTION	0.02	0.04	2356.30	0	11:00
M16-2	JUNCTION	0.02	0.04	2364.13	0	11:00
M16-3	JUNCTION	0.03	0.05	2365.74	0	11:00
M16-4	JUNCTION	0.01	0.02	2380.52	0	11:00
M17	JUNCTION	0.03	0.05	2341.55	0	11:00
M18	JUNCTION	0.02	0.04	2360.23	0	11:00
M19	JUNCTION	0.02	0.03	2379.00	0	11:00
M19-1	JUNCTION	0.01	0.02	2387.83	0	10:49
M2	JUNCTION	0.26	0.63	2275.04	0	11:00
M2-1	JUNCTION	0.01	0.02	2288.58	0	11:00
M2-2	JUNCTION	0.01	0.02	2293.08	0	11:00
M20	JUNCTION	0.02	0.03	2380.11	0	11:00
M3	JUNCTION	0.12	0.24	2283.96	0	11:00
M3.1	JUNCTION	0.01	0.03	2298.03	0	10:51
M4	JUNCTION	0.28	0.63	2293.03	0	11:00
M5	JUNCTION	0.21	0.44	2295.24	0	11:00
M5-1	JUNCTION	0.12	0.23	2296.31	0	11:00
M5-10	JUNCTION	0.03	0.06	2395.58	0	10:58
M5-11	JUNCTION	0.04	0.06	2410.17	0	10:55
M5-12	JUNCTION	0.02	0.04	2424.89	0	10:40
M5-2	JUNCTION	0.13	0.25	2296.45	0	11:00
M5-3	JUNCTION	0.14	0.26	2296.84	0	11:00
M5-3-1	JUNCTION	0.01	0.01	2299.61	0	11:00
M5-4	JUNCTION	0.10	0.19	2300.19	0	11:00
M5-4.1	JUNCTION	0.06	0.10	2303.75	0	11:00
M5-4.2	JUNCTION	0.04	0.07	2305.82	0	10:39
M5-4.3	JUNCTION	0.02	0.03	2314.68	0	11:00
M5-4.4	JUNCTION	0.00	0.00	2341.15	0	00:13
M5-5	JUNCTION	0.07	0.12	2303.18	0	10:59
M5-6	JUNCTION	0.04	0.07	2319.39	0	11:00
M5-7	JUNCTION	0.04	0.07	2344.22	0	10:59
M5-8	JUNCTION	0.03	0.06	2363.16	0	10:57
M5-8.1	JUNCTION	0.00	0.00	2373.69	0	00:00
M5-9	JUNCTION	0.03	0.06	2379.29	0	11:00
M6	JUNCTION	0.15	0.30	2298.86	0	11:00
M7	JUNCTION	0.18	0.37	2300.43	0	11:00
M8	JUNCTION	0.13	0.25	2305.27	0	11:00
M9	JUNCTION	0.13	0.25	2310.00	0	11:00
M9-1	JUNCTION	0.05	0.09	2312.14	0	10:44
M9-2	JUNCTION	0.02	0.03	2325.03	0	11:00
M9-3	JUNCTION	0.01	0.02	2344.94	0	11:00
MC-1	JUNCTION	0.02	0.04	2333.34	0	11:00
MC-2	JUNCTION	0.03	0.05	2333.85	0	11:00
MC-3	JUNCTION	0.02	0.04	2334.93	0	11:00
MC-4	JUNCTION	0.00	0.00	2336.30	0	00:00
MC-5	JUNCTION	0.00	0.00	2337.27	0	00:00
MC-6	JUNCTION	0.00	0.00	2344.58	0	00:00
MC-7	JUNCTION	0.00	0.00	2346.63	0	00:00
MC-8	JUNCTION	0.00	0.00	2347.00	0	00:00
MC-9	JUNCTION	0.00	0.00	2348.00	0	00:00
MC.1-1	JUNCTION	0.01	0.02	2337.32	0	11:00
MC.1-2	JUNCTION	0.01	0.02	2340.53	0	11:00
MC.1-3	JUNCTION	0.01	0.02	2349.71	0	11:00
MC.1-4	JUNCTION	0.01	0.02	2351.55	0	11:00
MC.3-1	JUNCTION	0.01	0.02	2336.40	0	10:59
MC.3-2	JUNCTION	0.01	0.01	2339.01	0	10:40
MH-01	JUNCTION	0.22	0.42	2251.32	0	11:00
MH-02	JUNCTION	0.23	0.42	2252.42	0	11:00

MH-02A	JUNCTION	0.19	0.35	2252.94	0	11:00
MH-03	JUNCTION	0.17	0.33	2253.26	0	11:01
MH-04	JUNCTION	0.19	0.36	2254.29	0	11:00
MH-04A	JUNCTION	0.16	0.30	2254.81	0	11:00
MH-05	JUNCTION	0.26	0.47	2255.20	0	11:00
MH-06	JUNCTION	0.07	0.13	2255.87	0	11:00
MH-07	JUNCTION	0.00	0.00	2256.69	0	00:00
N.1	JUNCTION	0.03	0.06	2267.80	0	10:58
N.2	JUNCTION	0.03	0.06	2286.77	0	10:01
N1	JUNCTION	0.06	0.11	2316.90	0	10:43
N1-1	JUNCTION	0.02	0.03	2329.02	0	11:00
N1-2	JUNCTION	0.01	0.02	2346.85	0	10:59
N1.1	JUNCTION	0.02	0.03	2326.04	0	10:38
N1.1.1	JUNCTION	0.00	0.00	2329.85	0	00:00
N1.2	JUNCTION	0.01	0.02	2336.04	0	10:14
N1.3	JUNCTION	0.00	0.00	2352.10	0	02:08
N2	JUNCTION	0.05	0.10	2314.74	0	10:43
N3	JUNCTION	0.05	0.10	2319.26	0	11:00
N4	JUNCTION	0.03	0.06	2325.83	0	11:00
N4-1	JUNCTION	0.00	0.00	2338.26	0	00:00
N4-2	JUNCTION	0.00	0.00	2347.94	0	00:00
N5	JUNCTION	0.00	0.00	2332.63	0	00:00
N5-1	JUNCTION	0.00	0.00	2344.88	0	00:00
N5-2	JUNCTION	0.00	0.00	2355.02	0	00:00
N6	JUNCTION	0.00	0.00	2335.35	0	00:00
N7	JUNCTION	0.00	0.00	2341.26	0	00:00
N8	JUNCTION	0.00	0.00	2352.06	0	00:00
SH-1	JUNCTION	0.12	0.22	2263.73	0	11:00
SH-10	JUNCTION	0.12	0.23	2294.61	0	11:00
SH-11	JUNCTION	0.11	0.20	2296.07	0	11:00
SH-12	JUNCTION	0.11	0.20	2297.29	0	11:00
SH-13	JUNCTION	0.08	0.16	2297.84	0	10:39
SH-14	JUNCTION	0.07	0.12	2301.72	0	10:43
SH-15	JUNCTION	0.05	0.10	2326.50	0	10:59
SH-16	JUNCTION	0.00	0.00	2331.13	0	00:00
SH-17	JUNCTION	0.07	0.14	2299.00	0	10:56
SH-18	JUNCTION	0.03	0.06	2283.04	0	11:00
SH-19	JUNCTION	0.02	0.04	2294.51	0	10:58
SH-2	JUNCTION	0.11	0.21	2278.51	0	11:00
SH-20	JUNCTION	0.02	0.04	2292.64	0	11:00
SH-21	JUNCTION	0.02	0.04	2295.51	0	11:00
SH-22	JUNCTION	0.02	0.04	2303.16	0	11:00
SH-23	JUNCTION	0.02	0.04	2313.15	0	11:00
SH-24	JUNCTION	0.01	0.01	2322.68	0	11:00
SH-25	JUNCTION	0.01	0.02	2308.12	0	10:49
SH-26	JUNCTION	0.01	0.02	2315.69	0	10:52
SH-27	JUNCTION	0.02	0.04	2317.86	0	11:00
SH-28	JUNCTION	0.00	0.00	2326.49	0	00:00
SH-3	JUNCTION	0.21	0.43	2279.46	0	11:00
SH-4	JUNCTION	0.02	0.03	2295.92	0	11:00
SH-5	JUNCTION	0.01	0.02	2313.11	0	10:58
SH-6	JUNCTION	0.00	0.00	2316.53	0	00:00
SH-7	JUNCTION	0.18	0.37	2280.38	0	11:00
SH-8	JUNCTION	0.09	0.18	2287.05	0	11:00
SH-9	JUNCTION	0.09	0.17	2289.35	0	11:00
SP-1	JUNCTION	0.18	0.37	2268.91	0	11:01
SP-10	JUNCTION	0.10	0.19	2310.92	0	11:00
SP-11	JUNCTION	0.13	0.24	2318.17	0	11:00
SP-12	JUNCTION	0.12	0.22	2321.72	0	11:00
SP-13	JUNCTION	0.06	0.10	2322.85	0	11:00
SP-14	JUNCTION	0.05	0.09	2324.09	0	11:00
SP-15	JUNCTION	0.02	0.04	2334.05	0	11:00
SP-16	JUNCTION	0.02	0.04	2344.54	0	11:00

SP-17	JUNCTION	0.02	0.03	2349.03	0	11:00
SP-18	JUNCTION	0.02	0.04	2350.37	0	11:00
SP-2	JUNCTION	0.13	0.26	2270.00	0	11:00
SP-3	JUNCTION	0.20	0.40	2271.80	0	11:00
SP-4	JUNCTION	0.16	0.31	2276.13	0	11:00
SP-4A	JUNCTION	0.16	0.32	2277.87	0	11:00
SP-5	JUNCTION	0.15	0.29	2280.56	0	11:00
SP-6	JUNCTION	0.10	0.19	2286.15	0	11:00
SP-7	JUNCTION	0.12	0.24	2289.34	0	11:01
SP-8	JUNCTION	0.11	0.21	2294.44	0	11:00
SP-9	JUNCTION	0.10	0.19	2302.63	0	11:00
SP.12-1	JUNCTION	0.14	0.27	2322.19	0	11:00
SP.12-2	JUNCTION	0.15	0.30	2323.55	0	11:00
SP.12-3	JUNCTION	0.15	0.29	2324.89	0	11:00
SP.13-1	JUNCTION	0.01	0.02	2338.79	0	11:00
SP.6-1	JUNCTION	0.02	0.03	2288.73	0	11:00
SP.7-1	JUNCTION	0.00	0.00	2294.80	0	00:00
SP.7-2	JUNCTION	0.00	0.00	2296.00	0	00:00
TP-1	JUNCTION	0.04	0.08	2256.77	0	11:00
TP-10	JUNCTION	0.04	0.08	2255.51	0	11:00
TP-11	JUNCTION	0.04	0.07	2256.73	0	11:00
TP-12	JUNCTION	0.03	0.05	2258.27	0	11:00
TP-2	JUNCTION	0.04	0.06	2257.40	0	11:00
TP-3	JUNCTION	0.02	0.04	2257.82	0	11:00
TP-4	JUNCTION	0.02	0.04	2258.53	0	11:00
TP-5	JUNCTION	0.03	0.06	2255.63	0	11:00
TP-6	JUNCTION	0.02	0.04	2256.12	0	11:00
TP-7	JUNCTION	0.01	0.03	2256.82	0	11:00
TP-8	JUNCTION	0.05	0.10	2253.61	0	11:00
TP-9	JUNCTION	0.05	0.09	2254.20	0	11:00
TP.1-1	JUNCTION	0.00	0.00	2258.58	0	00:00
TP.10.1	JUNCTION	0.00	0.00	2256.39	0	00:00
TP.5-1	JUNCTION	0.01	0.03	2256.52	0	11:00
TP.6-1	JUNCTION	0.02	0.03	2256.79	0	11:00
TP.8-1	JUNCTION	0.02	0.04	2253.87	0	10:39
TP.9-1	JUNCTION	0.03	0.05	2254.69	0	11:00
TP.9-2	JUNCTION	0.02	0.04	2255.04	0	11:00
TP.9-3	JUNCTION	0.02	0.04	2256.73	0	11:00
BSTREETPS	OUTFALL	0.19	0.46	2220.16	0	11:03
OF-DS	OUTFALL	0.19	0.38	2219.98	0	11:04
OF-HW	OUTFALL	0.17	0.33	2290.83	0	10:59
OF-IPS	OUTFALL	0.17	0.33	2251.03	0	11:00

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Node Inflow Summary
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Node	Type	Maximum Lateral Inflow MGD	Maximum Total Inflow MGD	Time of Max Occurrence days	hr:min	Lateral Inflow Volume 10^6 gal
1.2.3-2	JUNCTION	0.001	0.202	0	11:00	0.000483
1.2.3-3	JUNCTION	0.002	0.201	0	11:00	0.000805
A-1	JUNCTION	0.000	0.130	0	11:00	0.000161
A-11	JUNCTION	0.000	0.028	0	11:00	0.000161
A-12	JUNCTION	0.000	0.024	0	11:00	0.000161
A-13	JUNCTION	0.000	0.024	0	11:00	0
A-14	JUNCTION	0.000	0.003	0	11:00	0.000161
A-15	JUNCTION	0.003	0.003	0	10:00	0.000966
A-2	JUNCTION	0.001	0.130	0	11:00	0.000483

A-3	JUNCTION	0.001	0.099	0	11:00	0.000483
A-4	JUNCTION	0.003	0.091	0	11:00	0.000966
A-5	JUNCTION	0.000	0.088	0	11:00	0
A-6	JUNCTION	0.000	0.088	0	11:00	0.000161
A-7	JUNCTION	0.000	0.087	0	11:00	0
A-8	JUNCTION	0.000	0.051	0	11:00	0
A-9	JUNCTION	0.001	0.051	0	11:00	0.000483
A.1-1	JUNCTION	0.006	0.288	0	11:08	0.00191
A.1-10	JUNCTION	0.001	0.023	0	11:00	0.000483
A.1-11	JUNCTION	0.001	0.011	0	11:00	0.000483
A.1-12	JUNCTION	0.001	0.009	0	11:00	0.000322
A.1-13	JUNCTION	0.003	0.008	0	11:00	0.000926
A.1-14	JUNCTION	0.002	0.005	0	10:58	0.000765
A.1-15	JUNCTION	0.003	0.003	0	10:00	0.000906
A.1-3	JUNCTION	0.003	0.283	0	11:05	0.000966
A.1-4	JUNCTION	0.000	0.281	0	11:05	0
A.1-5	JUNCTION	0.001	0.281	0	11:03	0.000302
A.1-6	JUNCTION	0.001	0.280	0	11:02	0.000483
A.1-7	JUNCTION	0.001	0.280	0	11:00	0.000483
A.1-8	JUNCTION	0.002	0.264	0	11:00	0.000805
A.1-9	JUNCTION	0.001	0.262	0	11:00	0.000322
A.1.1-1	JUNCTION	0.001	0.014	0	11:00	0.000483
A.1.1-2	JUNCTION	0.004	0.013	0	11:00	0.00145
A.1.1-3	JUNCTION	0.002	0.008	0	11:00	0.000805
A.1.1-4	JUNCTION	0.006	0.006	0	10:00	0.00191
A.1.2-1	JUNCTION	0.004	0.239	0	11:00	0.00145
A.1.2-2	JUNCTION	0.002	0.235	0	11:00	0.000805
A.1.2-3	JUNCTION	0.000	0.006	0	11:00	0
A.1.2-4	JUNCTION	0.005	0.006	0	11:00	0.00161
A.1.2-5	JUNCTION	0.000	0.001	0	08:01	0
A.1.2-6	JUNCTION	0.000	0.000	0	10:00	0.000161
A.1.2.1-1	JUNCTION	0.000	0.000	0	10:00	0.000161
A.1.2.2-1	JUNCTION	0.000	0.000	0	10:00	0.000161
A.1.3-1	JUNCTION	0.002	0.011	0	11:00	0.000644
A.1.3-2	JUNCTION	0.003	0.009	0	11:00	0.00111
A.1.3-3	JUNCTION	0.001	0.004	0	11:00	0.000483
A.1.3-4	JUNCTION	0.002	0.002	0	10:00	0.000805
A.1.3.1-1	JUNCTION	0.001	0.001	0	10:00	0.000483
A.1.4-1	JUNCTION	0.000	0.000	0	10:00	0.000161
A.10-1	JUNCTION	0.000	0.065	0	11:00	0
A.10-10	JUNCTION	0.001	0.003	0	11:00	0.000483
A.10-11	JUNCTION	0.001	0.003	0	09:32	0.000483
A.10-12	JUNCTION	0.000	0.001	0	08:01	0
A.10-13	JUNCTION	0.000	0.000	0	10:00	0.000161
A.10-2	JUNCTION	0.000	0.065	0	11:00	0
A.10-3	JUNCTION	0.000	0.065	0	11:00	0
A.10-4	JUNCTION	0.000	0.033	0	11:00	0.000161
A.10-5	JUNCTION	0.000	0.032	0	11:00	0.000161
A.10-6	JUNCTION	0.002	0.032	0	11:00	0.000644
A.10-7	JUNCTION	0.000	0.030	0	11:00	0.000161
A.10-8	JUNCTION	0.000	0.004	0	11:00	0
A.10-9	JUNCTION	0.000	0.004	0	11:00	0.000161
A.10.1-1	JUNCTION	0.002	0.033	0	11:00	0.000805
A.10.1-10	JUNCTION	0.001	0.006	0	11:00	0.000483
A.10.1-11	JUNCTION	0.001	0.003	0	11:00	0.000483
A.10.1-12	JUNCTION	0.002	0.002	0	10:00	0.000644
A.10.1-13	JUNCTION	0.000	0.000	0	00:00	0
A.10.1-14	JUNCTION	0.000	0.000	0	00:00	0
A.10.1-15	JUNCTION	0.000	0.000	0	00:00	0
A.10.1-16	JUNCTION	0.000	0.000	0	00:00	0
A.10.1-17	JUNCTION	0.000	0.000	0	00:00	0
A.10.1-18	JUNCTION	0.000	0.000	0	00:00	0
A.10.1-2	JUNCTION	0.015	0.028	0	11:00	0.00496

A.10.1-3	JUNCTION	0.002	0.013	0	11:00	0.000644
A.10.1-4	JUNCTION	0.001	0.011	0	11:00	0.000322
A.10.1-5	JUNCTION	0.001	0.010	0	11:00	0.000322
A.10.1-6	JUNCTION	0.000	0.009	0	11:00	0
A.10.1-7	JUNCTION	0.000	0.009	0	11:00	0
A.10.1-8	JUNCTION	0.001	0.009	0	11:00	0.000322
A.10.1-9	JUNCTION	0.000	0.006	0	11:00	0.000161
A.10.1.1-1	JUNCTION	0.000	0.002	0	10:59	0.000161
A.10.1.1-2	JUNCTION	0.001	0.001	0	10:00	0.000483
A.10.1.10-1	JUNCTION	0.001	0.001	0	10:00	0.000211
A.10.1.8-1	JUNCTION	0.002	0.002	0	10:00	0.000634
A.10.2-1	JUNCTION	0.006	0.025	0	10:24	0.00193
A.10.2-2	JUNCTION	0.000	0.019	0	11:00	0.000161
A.10.2-3	JUNCTION	0.001	0.019	0	10:35	0.000322
A.10.2-4	JUNCTION	0.001	0.018	0	10:05	0.000483
A.10.2-5	JUNCTION	0.016	0.016	0	10:00	0.00526
A.11-1	JUNCTION	0.002	0.030	0	11:00	0.000644
A.11-2	JUNCTION	0.004	0.028	0	11:00	0.00129
A.11-3	JUNCTION	0.001	0.024	0	11:00	0.000483
A.11-4	JUNCTION	0.001	0.015	0	11:00	0.000483
A.11-5	JUNCTION	0.002	0.014	0	11:00	0.000805
A.11.1-1	JUNCTION	0.000	0.008	0	11:05	0
A.11.1-2	JUNCTION	0.000	0.008	0	11:02	0
A.11.1-3	JUNCTION	0.000	0.008	0	11:00	0
A.11.1-4	JUNCTION	0.001	0.008	0	11:00	0.000302
A.11.1.4-1	JUNCTION	0.000	0.007	0	11:00	0
A.11.1.4-2	JUNCTION	0.000	0.007	0	11:00	0.000161
A.11.1.4-3	JUNCTION	0.000	0.006	0	11:00	0
A.11.1.4-4	JUNCTION	0.006	0.006	0	10:00	0.00205
A.12-1	JUNCTION	0.003	0.004	0	11:00	0.000966
A.12-2	JUNCTION	0.001	0.001	0	10:00	0.000322
A.13-1	JUNCTION	0.002	0.002	0	10:00	0.000785
A.14-1	JUNCTION	0.000	0.033	0	11:00	0.000161
A.14-1.1	JUNCTION	0.002	0.012	0	11:00	0.000644
A.14-1.2	JUNCTION	0.001	0.010	0	11:00	0.000483
A.14-1.3	JUNCTION	0.002	0.008	0	11:00	0.000805
A.14-1.4	JUNCTION	0.000	0.004	0	11:00	0
A.14-1.5	JUNCTION	0.001	0.002	0	10:33	0.000483
A.14-1.6	JUNCTION	0.001	0.001	0	10:00	0.000322
A.14-1.7	JUNCTION	0.001	0.001	0	10:00	0.000483
A.14-1.8	JUNCTION	0.002	0.002	0	10:00	0.000644
A.14-2	JUNCTION	0.001	0.020	0	11:00	0.000322
A.14-3	JUNCTION	0.000	0.018	0	11:00	0
A.14-4	JUNCTION	0.001	0.018	0	11:00	0.000483
A.14-5	JUNCTION	0.007	0.011	0	11:00	0.00241
A.14-6	JUNCTION	0.004	0.004	0	10:00	0.00127
A.14-7	JUNCTION	0.000	0.000	0	00:00	0
A.14-8	JUNCTION	0.000	0.000	0	00:00	0
A.14.1-1	JUNCTION	0.001	0.004	0	10:54	0.000322
A.14.1-1A	JUNCTION	0.000	0.009	0	09:05	0
A.14.1-2	JUNCTION	0.000	0.003	0	10:39	0.000161
A.14.1-3	JUNCTION	0.002	0.002	0	10:00	0.000805
A.14.2-1	JUNCTION	0.001	0.001	0	10:00	0.000483
A.14.3-1	JUNCTION	0.001	0.001	0	10:00	0.000483
A.14.4-1	JUNCTION	0.003	0.003	0	10:00	0.00113
A.14.5-1	JUNCTION	0.000	0.000	0	00:00	0
A.14.7-1	JUNCTION	0.000	0.000	0	00:00	0
A.14.7-2	JUNCTION	0.000	0.000	0	00:00	0
A.14.7-A	JUNCTION	0.000	0.000	0	00:00	0
A.15-1	JUNCTION	0.004	0.022	0	11:00	0.00129
A.15-2	JUNCTION	0.003	0.018	0	10:52	0.00111
A.15-3	JUNCTION	0.012	0.014	0	10:57	0.00382
A.15-4	JUNCTION	0.000	0.004	0	09:02	0

A.15-5	JUNCTION	0.000	0.002	0	10:51	0.000161
A.15-6	JUNCTION	0.002	0.002	0	10:00	0.000644
A.15-8	JUNCTION	0.000	0.000	0	00:00	0
A.15.5-1	JUNCTION	0.000	0.000	0	00:00	0
A.16-1	JUNCTION	0.003	0.003	0	10:00	0.000966
A.17-1	JUNCTION	0.000	0.020	0	11:00	0
A.17-2	JUNCTION	0.001	0.015	0	11:00	0.000322
A.17-3	JUNCTION	0.003	0.014	0	10:56	0.000966
A.17-4	JUNCTION	0.002	0.011	0	10:52	0.000805
A.17-4.1	JUNCTION	0.003	0.003	0	10:00	0.000966
A.17-5	JUNCTION	0.004	0.006	0	10:49	0.00145
A.17-6	JUNCTION	0.000	0.003	0	01:38	0
A.17-7	JUNCTION	0.000	0.003	0	07:38	0
A.17-8	JUNCTION	0.000	0.004	0	10:39	0
A.17-9	JUNCTION	0.001	0.001	0	10:00	0.000322
A.17.1-1	JUNCTION	0.005	0.005	0	10:00	0.00171
A.2-1	JUNCTION	0.002	0.165	0	11:00	0.000785
A.2-10	JUNCTION	0.000	0.117	0	11:00	0
A.2-11	JUNCTION	0.000	0.009	0	11:00	0.000161
A.2-12	JUNCTION	0.000	0.009	0	11:00	0
A.2-13	JUNCTION	0.002	0.009	0	11:00	0.000644
A.2-14	JUNCTION	0.000	0.007	0	11:00	0.000161
A.2-2	JUNCTION	0.000	0.162	0	11:00	0
A.2-3	JUNCTION	0.000	0.156	0	11:00	0
A.2-4	JUNCTION	0.002	0.137	0	11:00	0.000604
A.2-5	JUNCTION	0.003	0.136	0	11:00	0.000946
A.2-6	JUNCTION	0.000	0.133	0	11:00	0
A.2-7	JUNCTION	0.000	0.133	0	11:00	0.000161
A.2-8	JUNCTION	0.001	0.120	0	11:00	0.000302
A.2-9	JUNCTION	0.002	0.119	0	11:00	0.000805
A.2.1-1	JUNCTION	0.002	0.006	0	11:00	0.000805
A.2.1-2	JUNCTION	0.001	0.004	0	10:54	0.000483
A.2.1-3	JUNCTION	0.002	0.002	0	10:00	0.000765
A.2.1A-1	JUNCTION	0.001	0.019	0	11:00	0.000302
A.2.1A-2	JUNCTION	0.003	0.018	0	11:00	0.00107
A.2.1A-3	JUNCTION	0.001	0.014	0	11:00	0.000463
A.2.1A-4	JUNCTION	0.006	0.013	0	11:00	0.00208
A.2.1A-5	JUNCTION	0.000	0.006	0	10:44	0
A.2.1A-6	JUNCTION	0.002	0.002	0	10:00	0.000604
A.2.1A.1-1	JUNCTION	0.001	0.001	0	10:00	0.000322
A.2.1A.2-1	JUNCTION	0.004	0.004	0	10:00	0.00121
A.2.2-1	JUNCTION	0.001	0.012	0	10:22	0.000302
A.2.2-2	JUNCTION	0.001	0.011	0	10:56	0.000302
A.2.2-3	JUNCTION	0.000	0.009	0	10:13	0
A.2.2-4	JUNCTION	0.000	0.009	0	10:44	0.000161
A.2.2-5	JUNCTION	0.009	0.009	0	10:00	0.00282
A.2.2.1-1	JUNCTION	0.001	0.001	0	10:00	0.000302
A.2.2.2-1	JUNCTION	0.000	0.000	0	00:00	0
A.3.1-1	JUNCTION	0.000	0.000	0	10:00	0.000161
A.3A-1	JUNCTION	0.000	0.000	0	00:00	0
A.4-1	JUNCTION	0.000	0.000	0	11:00	0
A.4-10	JUNCTION	0.000	0.667	0	11:00	0
A.4-11	JUNCTION	0.001	0.533	0	11:00	0.000302
A.4-12	JUNCTION	0.001	0.532	0	11:00	0.000302
A.4-13	JUNCTION	0.000	0.053	0	11:00	0.000161
A.4-14	JUNCTION	0.001	0.053	0	11:00	0.000302
A.4-15	JUNCTION	0.001	0.052	0	11:00	0.000302
A.4-16	JUNCTION	0.023	0.051	0	10:59	0.00755
A.4-17	JUNCTION	0.001	0.028	0	10:59	0.000322
A.4-18	JUNCTION	0.027	0.027	0	10:00	0.00865
A.4-2	JUNCTION	0.000	0.000	0	11:00	0
A.4-3	JUNCTION	0.000	0.000	0	10:00	0.000161
A.4-4	JUNCTION	0.000	0.000	0	00:00	0

A.4-5	JUNCTION	0.002	0.679	0	11:00	0.000785
A.4-6	JUNCTION	0.000	0.671	0	11:00	0
A.4-7	JUNCTION	0.000	0.668	0	11:01	0
A.4-8	JUNCTION	0.000	0.668	0	11:00	0
A.4-9	JUNCTION	0.000	0.667	0	11:00	0
A.4.1-1	JUNCTION	0.001	0.005	0	00:24	0.000463
A.4.1-1A	JUNCTION	0.000	0.001	0	10:13	0
A.4.1-2	JUNCTION	0.001	0.001	0	10:00	0.000322
A.4.10-1	JUNCTION	0.000	0.134	0	11:00	0
A.4.10-1A	JUNCTION	0.000	0.134	0	11:01	0
A.4.10-2	JUNCTION	0.000	0.134	0	11:00	0
A.4.10-3	JUNCTION	0.000	0.134	0	11:00	0
A.4.10-4	JUNCTION	0.000	0.134	0	11:00	0
A.4.10-5	JUNCTION	0.000	0.134	0	11:00	0
A.4.10-6	JUNCTION	0.012	0.134	0	11:00	0.00399
A.4.10-7	JUNCTION	0.018	0.018	0	10:00	0.00596
A.4.10-8	JUNCTION	0.000	0.000	0	00:00	0
A.4.10.6-1	JUNCTION	0.000	0.103	0	11:01	0
A.4.10.6-2	JUNCTION	0.000	0.103	0	11:00	0
A.4.10.6-3	JUNCTION	0.000	0.103	0	11:00	0
A.4.16-1	JUNCTION	0.000	0.000	0	00:00	0
A.4.2-1	JUNCTION	0.000	0.001	0	09:00	0
A.4.2-2	JUNCTION	0.001	0.001	0	10:00	0.000302
A.4.5-1	JUNCTION	0.006	0.006	0	10:00	0.00181
A.4.5-2	JUNCTION	0.000	0.000	0	00:00	0
A.4.5-3	JUNCTION	0.000	0.000	0	00:00	0
A.4.8-1	JUNCTION	0.000	0.000	0	00:00	0
A.5-1	JUNCTION	0.001	0.110	0	11:00	0.000302
A.5-2	JUNCTION	0.004	0.099	0	11:00	0.00137
A.5-3	JUNCTION	0.000	0.095	0	11:00	0
A.5-4	JUNCTION	0.000	0.020	0	11:00	0.000161
A.5-5	JUNCTION	0.001	0.019	0	11:00	0.000483
A.5-6	JUNCTION	0.002	0.018	0	11:00	0.000785
A.5-7	JUNCTION	0.000	0.011	0	10:45	0.000161
A.5-8	JUNCTION	0.004	0.011	0	10:39	0.00145
A.5-9	JUNCTION	0.006	0.006	0	10:00	0.00209
A.5.1-1	JUNCTION	0.002	0.010	0	11:00	0.000604
A.5.1-2	JUNCTION	0.002	0.008	0	11:00	0.000765
A.5.1-3	JUNCTION	0.001	0.006	0	11:00	0.000322
A.5.1-4	JUNCTION	0.005	0.005	0	10:00	0.00151
A.5.2-1	JUNCTION	0.003	0.075	0	10:55	0.000906
A.5.2-2	JUNCTION	0.007	0.072	0	10:35	0.00241
A.5.2-3	JUNCTION	0.056	0.056	0	10:00	0.0181
A.5.2.1-1	JUNCTION	0.009	0.009	0	10:00	0.00296
A.5.3-1	JUNCTION	0.001	0.004	0	11:00	0.000463
A.5.3-2	JUNCTION	0.001	0.001	0	10:00	0.000483
A.5.3.1-1	JUNCTION	0.001	0.001	0	10:00	0.000322
A.6-1	JUNCTION	0.001	0.030	0	11:00	0.000302
A.6-2	JUNCTION	0.001	0.027	0	11:00	0.000483
A.6-3	JUNCTION	0.000	0.025	0	11:00	0
A.6-4	JUNCTION	0.002	0.017	0	11:00	0.000805
A.6-5	JUNCTION	0.001	0.015	0	11:00	0.000483
A.6-6	JUNCTION	0.004	0.013	0	11:00	0.00129
A.6-7	JUNCTION	0.000	0.009	0	11:00	0
A.6-8	JUNCTION	0.000	0.008	0	11:00	0
A.6-9	JUNCTION	0.001	0.001	0	10:00	0.000483
A.6.1-1	JUNCTION	0.002	0.002	0	10:00	0.000644
A.6.2-1	JUNCTION	0.000	0.008	0	11:00	0.000161
A.6.2-2	JUNCTION	0.001	0.007	0	11:00	0.000322
A.6.2-3	JUNCTION	0.005	0.006	0	10:59	0.00161
A.6.2-4	JUNCTION	0.001	0.001	0	10:00	0.000483
A.6.3-1	JUNCTION	0.001	0.001	0	10:00	0.000483
A.6.4-1	JUNCTION	0.000	0.006	0	11:00	0.000161

A.6.4-2	JUNCTION	0.000	0.000	0	10:00	0.000161
A.6.4.1-1	JUNCTION	0.005	0.005	0	10:00	0.00177
A.7-1	JUNCTION	0.002	0.003	0	10:47	0.000624
A.7-2	JUNCTION	0.000	0.001	0	10:21	0
A.7-3	JUNCTION	0.001	0.001	0	10:00	0.000463
A.8-1	JUNCTION	0.000	0.028	0	11:00	0
A.8-2	JUNCTION	0.003	0.028	0	11:00	0.00111
A.8-3	JUNCTION	0.002	0.024	0	11:00	0.000644
A.8-4	JUNCTION	0.002	0.022	0	11:00	0.000785
A.8-5	JUNCTION	0.003	0.020	0	11:00	0.00111
A.8-6	JUNCTION	0.001	0.016	0	11:00	0.000483
A.8-7	JUNCTION	0.001	0.015	0	11:00	0.000483
A.8-8	JUNCTION	0.003	0.012	0	11:00	0.00113
A.8.1-1	JUNCTION	0.001	0.001	0	10:00	0.000322
A.9-1	JUNCTION	0.003	0.027	0	11:00	0.000966
A.9-2	JUNCTION	0.005	0.024	0	11:00	0.00177
A.9-3	JUNCTION	0.004	0.019	0	11:00	0.00145
A.9-4	JUNCTION	0.004	0.014	0	10:23	0.00129
A.9-5	JUNCTION	0.003	0.010	0	10:19	0.00113
A.9-6	JUNCTION	0.002	0.007	0	10:07	0.000805
A.9-7	JUNCTION	0.004	0.004	0	10:00	0.00145
A.9A-1	JUNCTION	0.000	0.014	0	11:00	0.000161
A.9A-2	JUNCTION	0.002	0.013	0	11:00	0.000644
A.9A-3	JUNCTION	0.006	0.011	0	10:38	0.00193
A.9A-4	JUNCTION	0.005	0.005	0	10:00	0.00177
A.9A.2-1	JUNCTION	0.000	0.000	0	00:00	0
A.A5-7	JUNCTION	0.000	0.000	0	00:00	0
A1	JUNCTION	0.001	0.008	0	11:00	0.000322
A2	JUNCTION	0.004	0.007	0	11:00	0.00145
A3	JUNCTION	0.002	0.002	0	10:00	0.000805
B-1	JUNCTION	0.004	0.339	0	11:00	0.00145
B-10	JUNCTION	0.003	0.036	0	11:00	0.000966
B-11	JUNCTION	0.000	0.033	0	10:22	0.000161
B-2	JUNCTION	0.003	0.333	0	11:00	0.00113
B-3	JUNCTION	0.001	0.314	0	11:00	0.000322
B-4	JUNCTION	0.020	0.313	0	11:00	0.00654
B-5	JUNCTION	0.000	0.294	0	11:00	0
B-6	JUNCTION	0.003	0.642	0	11:00	0.000906
B-7	JUNCTION	0.000	0.515	0	11:02	0
B-8	JUNCTION	0.000	0.516	0	10:59	0
B.1-1	JUNCTION	0.002	0.002	0	10:00	0.000644
B.1A	JUNCTION	0.000	0.382	0	11:04	0
B.2-1	JUNCTION	0.016	0.016	0	10:00	0.00519
B.2A	JUNCTION	0.000	0.382	0	11:03	0
B.3-1	JUNCTION	0.000	0.005	0	10:10	0
B.3-2	JUNCTION	0.005	0.005	0	10:00	0.00177
B.3A-1	JUNCTION	0.000	0.383	0	11:01	0
B.4-1	JUNCTION	0.001	0.030	0	11:00	0.000463
B.4-2	JUNCTION	0.001	0.028	0	11:00	0.000322
B.4-3	JUNCTION	0.002	0.027	0	11:00	0.000644
B.4-4	JUNCTION	0.003	0.025	0	11:00	0.00113
B.4-5	JUNCTION	0.003	0.022	0	11:00	0.000966
B.4-6	JUNCTION	0.014	0.019	0	11:00	0.0044
B.4-7	JUNCTION	0.000	0.005	0	11:00	0
B.4-8	JUNCTION	0.000	0.005	0	11:00	0
B.4A-1	JUNCTION	0.000	0.378	0	11:00	0
B.5A	JUNCTION	0.000	0.348	0	11:00	0
B.6-1	JUNCTION	0.000	0.002	0	10:47	0
B.6-1A	JUNCTION	0.000	0.125	0	11:00	0
B.6-2	JUNCTION	0.000	0.002	0	10:46	0.000161
B.6-2A	JUNCTION	0.000	0.125	0	11:00	0
B.6-3	JUNCTION	0.001	0.001	0	10:00	0.000483
B.6-3A	JUNCTION	0.000	0.125	0	11:00	0

B.6-4A	JUNCTION	0.000	0.125	0	11:00	0
B.6-5A	JUNCTION	0.114	0.125	0	11:00	0.0369
B.6.A-1	JUNCTION	0.001	0.486	0	11:00	0.000322
B.7-1	JUNCTION	0.001	0.006	0	10:29	0.000483
B.7-2	JUNCTION	0.000	0.002	0	10:13	0
B.7-3	JUNCTION	0.002	0.002	0	10:00	0.000644
B.7.1-1	JUNCTION	0.001	0.001	0	10:00	0.000322
B.7.2-1	JUNCTION	0.000	0.000	0	10:00	0.000161
B1	JUNCTION	0.000	0.003	0	11:00	0
B2	JUNCTION	0.000	0.003	0	11:00	0
B3	JUNCTION	0.001	0.003	0	11:00	0.000322
B4	JUNCTION	0.000	0.002	0	11:00	0
B5	JUNCTION	0.002	0.002	0	10:00	0.000805
C1	JUNCTION	0.002	0.009	0	11:00	0.000644
C2	JUNCTION	0.002	0.007	0	10:51	0.000644
C3	JUNCTION	0.002	0.005	0	10:38	0.000805
C4	JUNCTION	0.002	0.002	0	10:00	0.000805
CV-01	JUNCTION	0.002	0.608	0	10:58	0.000785
CV-02	JUNCTION	0.015	0.605	0	10:57	0.00498
CV-03	JUNCTION	0.097	0.590	0	10:57	0.0314
CV-04	JUNCTION	0.000	0.493	0	10:56	0
CV-05	JUNCTION	0.000	0.493	0	10:55	0
CV-06	JUNCTION	0.064	0.493	0	10:54	0.0209
CV-07	JUNCTION	0.000	0.429	0	10:53	0
CV-08	JUNCTION	0.065	0.429	0	10:52	0.021
CV-09	JUNCTION	0.020	0.364	0	10:52	0.00664
CV-10	JUNCTION	0.000	0.343	0	10:51	0
CV-11	JUNCTION	0.000	0.343	0	10:51	0
CV-12	JUNCTION	0.000	0.343	0	10:50	0
CV-13	JUNCTION	0.015	0.342	0	10:48	0.00483
CV-14	JUNCTION	0.047	0.328	0	10:47	0.0152
CV-15	JUNCTION	0.000	0.276	0	10:52	0
CV-16	JUNCTION	0.000	0.276	0	10:51	0
CV-17	JUNCTION	0.000	0.276	0	10:44	0
CV-18	JUNCTION	0.000	0.278	0	10:38	0
CV-19	JUNCTION	0.000	0.290	0	10:44	0
CV-20	JUNCTION	0.000	0.274	0	11:00	0
CV-21	JUNCTION	0.000	0.274	0	11:00	0
CV-22	JUNCTION	0.000	0.246	0	10:17	0.000161
CV-23	JUNCTION	0.000	0.244	0	10:41	0
CV-24	JUNCTION	0.000	0.244	0	10:41	0
CV-25	JUNCTION	0.000	0.244	0	10:39	0
CV-26	JUNCTION	0.069	0.244	0	11:00	0.0223
CV-27	JUNCTION	0.000	0.175	0	10:39	0
CV-28	JUNCTION	0.000	0.175	0	10:54	0
CV-29	JUNCTION	0.000	0.175	0	10:53	0
CV-30	JUNCTION	0.000	0.175	0	10:35	0
CV-31	JUNCTION	0.175	0.175	0	10:00	0.0566
CV.10-1	JUNCTION	0.000	0.000	0	00:00	0
CV.10-2	JUNCTION	0.000	0.000	0	00:00	0
CV.10-3	JUNCTION	0.000	0.000	0	00:00	0
CV.10-4	JUNCTION	0.000	0.000	0	00:00	0
CV.10-5	JUNCTION	0.000	0.000	0	00:00	0
CV.10-6	JUNCTION	0.000	0.000	0	00:00	0
CV.10.4-1	JUNCTION	0.000	0.000	0	00:00	0
CV.12-1	JUNCTION	0.000	0.002	0	00:48	0
CV.12-10	JUNCTION	0.000	0.000	0	00:00	0
CV.12-11	JUNCTION	0.000	0.000	0	00:00	0
CV.12-2	JUNCTION	0.000	0.003	0	08:48	0
CV.12-3	JUNCTION	0.000	0.003	0	09:01	0
CV.12-4	JUNCTION	0.000	0.002	0	08:40	0
CV.12-5	JUNCTION	0.000	0.002	0	09:00	0
CV.12-6	JUNCTION	0.001	0.001	0	10:00	0.000322

CV.12-7	JUNCTION	0.000	0.000	0	00:00	0
CV.12-8	JUNCTION	0.000	0.000	0	00:00	0
CV.12-9	JUNCTION	0.000	0.000	0	00:00	0
CV.12.5-1	JUNCTION	0.000	0.000	0	00:00	0
CV.12.5-2	JUNCTION	0.000	0.000	0	00:00	0
CV.12.5-3	JUNCTION	0.000	0.000	0	00:00	0
CV.12.6-1	JUNCTION	0.000	0.000	0	00:00	0
CV.12.6-2	JUNCTION	0.000	0.000	0	00:00	0
CV.12.6-3	JUNCTION	0.000	0.000	0	00:00	0
CV.12.7-1	JUNCTION	0.000	0.000	0	00:00	0
CV.12.7-2	JUNCTION	0.000	0.000	0	00:00	0
CV.12.7-3	JUNCTION	0.000	0.000	0	00:00	0
CV.12.7-4	JUNCTION	0.000	0.000	0	00:00	0
CV.12.8-1	JUNCTION	0.000	0.000	0	00:00	0
CV.12.8-2	JUNCTION	0.000	0.000	0	00:00	0
CV.12.8-3	JUNCTION	0.000	0.000	0	00:00	0
CV.12.8-4	JUNCTION	0.000	0.000	0	00:00	0
CV.12.8-5	JUNCTION	0.000	0.000	0	00:00	0
CV.12.8-6	JUNCTION	0.000	0.000	0	00:00	0
CV.12.8-7	JUNCTION	0.000	0.000	0	00:00	0
CV.12.8-8	JUNCTION	0.000	0.000	0	00:00	0
CV.14-1	JUNCTION	0.000	0.005	0	10:51	0
CV.14-10	JUNCTION	0.000	0.000	0	00:00	0
CV.14-2	JUNCTION	0.000	0.005	0	10:50	0
CV.14-3	JUNCTION	0.000	0.005	0	10:48	0.000161
CV.14-4	JUNCTION	0.001	0.003	0	10:47	0.000322
CV.14-5	JUNCTION	0.000	0.003	0	09:04	0
CV.14-6	JUNCTION	0.000	0.003	0	05:07	0
CV.14-7	JUNCTION	0.000	0.002	0	00:20	0
CV.14-8	JUNCTION	0.000	0.003	0	10:39	0.000161
CV.14-9	JUNCTION	0.001	0.001	0	10:00	0.000322
CV.14.3-1	JUNCTION	0.000	0.002	0	09:01	0
CV.14.3-2	JUNCTION	0.001	0.001	0	10:00	0.000322
CV.14.3-3	JUNCTION	0.000	0.000	0	00:00	0
CV.14.3.2-1	JUNCTION	0.000	0.000	0	00:00	0
CV.14.5-1	JUNCTION	0.000	0.002	0	00:50	0
CV.14.5-2	JUNCTION	0.000	0.003	0	10:01	0.000161
CV.14.5-3	JUNCTION	0.000	0.000	0	10:00	0.000161
CV.14.5-4	JUNCTION	0.000	0.000	0	00:00	0
CV.14.5-5	JUNCTION	0.000	0.000	0	00:00	0
CV.14.5.2-1	JUNCTION	0.000	0.000	0	00:00	0
CV.16-1	JUNCTION	0.000	0.001	0	04:27	0
CV.16-2	JUNCTION	0.000	0.001	0	05:10	0
CV.16-3	JUNCTION	0.000	0.002	0	03:44	0
CV.16-4	JUNCTION	0.000	0.002	0	10:14	0
CV.16-5	JUNCTION	0.000	0.000	0	10:00	0.000161
CV.16-6	JUNCTION	0.000	0.000	0	00:00	0
CV.18-1	JUNCTION	0.000	0.000	0	00:00	0
CV.18-2	JUNCTION	0.000	0.000	0	00:00	0
CV.18-3	JUNCTION	0.000	0.000	0	00:00	0
CV.18-4	JUNCTION	0.000	0.000	0	00:00	0
CV.18-5	JUNCTION	0.000	0.000	0	00:00	0
CV.18-6	JUNCTION	0.000	0.000	0	00:00	0
CV.19-1	JUNCTION	0.000	0.001	0	10:32	0
CV.19-2	JUNCTION	0.000	0.004	0	18:04	0
CV.19-3	JUNCTION	0.000	0.002	0	09:04	0
CV.19-4	JUNCTION	0.000	0.002	0	10:02	0
CV.19-5	JUNCTION	0.000	0.000	0	10:00	0.000161
CV.19.2-1	JUNCTION	0.000	0.000	0	00:00	0
CV.19.2-2	JUNCTION	0.000	0.000	0	00:00	0
CV.19.2-3	JUNCTION	0.000	0.000	0	00:00	0
CV.21-1	JUNCTION	0.013	0.030	0	11:00	0.00423
CV.21-10	JUNCTION	0.000	0.000	0	00:00	0

CV.21-11	JUNCTION	0.000	0.000	0	00:00	0
CV.21-2	JUNCTION	0.015	0.017	0	11:00	0.0048
CV.21-3	JUNCTION	0.001	0.002	0	09:11	0.000302
CV.21-4	JUNCTION	0.000	0.002	0	02:00	0
CV.21-5	JUNCTION	0.000	0.001	0	05:17	0
CV.21-6	JUNCTION	0.000	0.001	0	11:00	0.000161
CV.21-7	JUNCTION	0.000	0.000	0	11:00	0
CV.21-8	JUNCTION	0.000	0.000	0	11:00	0
CV.21-9	JUNCTION	0.000	0.000	0	10:00	0.000161
CV.26-1	JUNCTION	0.000	0.005	0	03:23	0
CV.26-2	JUNCTION	0.000	0.003	0	09:22	0
CV.26-3	JUNCTION	0.000	0.000	0	11:00	0
CV.26-4	JUNCTION	0.000	0.000	0	10:00	0.000161
CV.26.3-1	JUNCTION	0.000	0.000	0	00:00	0
CV.8-1	JUNCTION	0.000	0.000	0	00:00	0
CV.8-2	JUNCTION	0.000	0.000	0	00:00	0
CV.8-3	JUNCTION	0.000	0.000	0	00:00	0
CV.8-4	JUNCTION	0.000	0.000	0	00:00	0
CV.8-5	JUNCTION	0.000	0.000	0	00:00	0
CV14-11	JUNCTION	0.000	0.000	0	00:00	0
D1	JUNCTION	0.001	0.006	0	11:00	0.000483
D2	JUNCTION	0.005	0.005	0	10:00	0.00159
E1	JUNCTION	0.002	0.107	0	11:00	0.000765
E10	JUNCTION	0.000	0.032	0	10:52	0.000161
E11	JUNCTION	0.001	0.032	0	10:54	0.000302
E11-1	JUNCTION	0.000	0.000	0	00:00	0
E12	JUNCTION	0.031	0.031	0	10:00	0.0101
E3	JUNCTION	0.000	0.105	0	11:00	0
E4	JUNCTION	0.001	0.105	0	11:00	0.000302
E4-1	JUNCTION	0.000	0.000	0	00:00	0
E4-2	JUNCTION	0.000	0.000	0	00:00	0
E5	JUNCTION	0.001	0.104	0	11:00	0.000483
E5-1	JUNCTION	0.001	0.058	0	11:00	0.000483
E5-2	JUNCTION	0.002	0.057	0	11:00	0.000644
E5-3	JUNCTION	0.001	0.055	0	11:00	0.000302
E5-3-1	JUNCTION	0.003	0.003	0	10:00	0.00113
E5-3.1	JUNCTION	0.009	0.044	0	11:00	0.00288
E5-3.1.1	JUNCTION	0.005	0.005	0	10:00	0.00161
E5-3.1.2	JUNCTION	0.000	0.000	0	00:00	0
E5-3.1.3	JUNCTION	0.000	0.000	0	00:00	0
E5-3.2	JUNCTION	0.000	0.030	0	11:00	0
E5-3.2.1	JUNCTION	0.000	0.000	0	00:00	0
E5-3.2.2	JUNCTION	0.008	0.010	0	11:00	0.00258
E5-3.2.3	JUNCTION	0.002	0.002	0	10:00	0.000805
E5-3.3	JUNCTION	0.020	0.020	0	10:00	0.00644
E5-3.3.1	JUNCTION	0.000	0.000	0	00:00	0
E5-3.3.2	JUNCTION	0.000	0.000	0	00:00	0
E5-3.3.3	JUNCTION	0.000	0.000	0	00:00	0
E5-3.4	JUNCTION	0.000	0.000	0	00:00	0
E5-3.5	JUNCTION	0.000	0.000	0	00:00	0
E5-3.6	JUNCTION	0.000	0.000	0	00:00	0
E5-4	JUNCTION	0.004	0.006	0	11:00	0.00145
E5-5	JUNCTION	0.002	0.002	0	10:00	0.000644
E5A	JUNCTION	0.001	0.044	0	11:00	0.000463
E6	JUNCTION	0.003	0.043	0	11:00	0.000946
E7	JUNCTION	0.000	0.040	0	11:00	0
E8	JUNCTION	0.003	0.040	0	10:56	0.00107
E9	JUNCTION	0.004	0.037	0	10:39	0.00137
F	JUNCTION	0.003	0.227	0	11:00	0.000966
F1	JUNCTION	0.000	0.011	0	11:00	0
F1-1	JUNCTION	0.002	0.007	0	11:00	0.000604
F1-2	JUNCTION	0.006	0.006	0	10:00	0.00181
F2	JUNCTION	0.000	0.004	0	11:00	0.000161

F3	JUNCTION	0.001	0.003	0	10:38	0.000483
F4	JUNCTION	0.002	0.002	0	10:00	0.000644
G	JUNCTION	0.001	0.198	0	11:00	0.000322
G1	JUNCTION	0.000	0.152	0	11:00	0
G1-1	JUNCTION	0.000	0.030	0	11:01	0
G1-2	JUNCTION	0.000	0.030	0	11:01	0
G1-3	JUNCTION	0.000	0.030	0	11:00	0
G1-4	JUNCTION	0.000	0.030	0	10:58	0
G1-5	JUNCTION	0.000	0.030	0	10:48	0
G1-6	JUNCTION	0.001	0.030	0	10:54	0.000463
G1-7	JUNCTION	0.029	0.029	0	10:00	0.00926
G10	JUNCTION	0.022	0.065	0	11:00	0.00724
G11	JUNCTION	0.000	0.043	0	11:00	0
G11-1	JUNCTION	0.001	0.001	0	10:00	0.000322
G12	JUNCTION	0.001	0.042	0	11:00	0.000322
G13	JUNCTION	0.000	0.041	0	11:00	0
G13-1	JUNCTION	0.000	0.041	0	11:00	0
G13-2	JUNCTION	0.004	0.041	0	11:00	0.00121
G13-3	JUNCTION	0.000	0.037	0	11:00	0
G13-4	JUNCTION	0.000	0.037	0	11:00	0
G15	JUNCTION	0.000	0.037	0	11:00	0
G16	JUNCTION	0.016	0.037	0	11:00	0.00513
G16-1	JUNCTION	0.002	0.003	0	11:00	0.000604
G16-2	JUNCTION	0.001	0.001	0	10:00	0.000302
G17	JUNCTION	0.018	0.018	0	10:00	0.00599
G2	JUNCTION	0.006	0.122	0	11:00	0.00204
G3	JUNCTION	0.001	0.115	0	11:00	0.000302
G4	JUNCTION	0.021	0.114	0	11:00	0.00677
G4A	JUNCTION	0.014	0.094	0	11:00	0.00452
G5	JUNCTION	0.000	0.080	0	11:00	0
G5-1	JUNCTION	0.001	0.006	0	11:00	0.000322
G5-1-1	JUNCTION	0.003	0.003	0	10:00	0.000966
G5-2	JUNCTION	0.001	0.002	0	11:00	0.000322
G5-3	JUNCTION	0.001	0.001	0	10:00	0.000322
G5A	JUNCTION	0.000	0.006	0	11:00	0
G5A-1	JUNCTION	0.000	0.000	0	10:00	0.000161
G6	JUNCTION	0.007	0.073	0	11:00	0.00222
G7	JUNCTION	0.000	0.066	0	11:00	0
G8	JUNCTION	0.001	0.066	0	11:00	0.000302
G9	JUNCTION	0.000	0.066	0	11:00	0
G9-1	JUNCTION	0.000	0.000	0	10:00	0.000161
H1	JUNCTION	0.004	0.007	0	11:00	0.00129
H2	JUNCTION	0.003	0.003	0	10:00	0.00113
HA	JUNCTION	0.003	0.011	0	11:00	0.00113
I	JUNCTION	0.000	0.046	0	11:00	0.000161
I-0	JUNCTION	0.000	1.615	0	11:05	0
I-1	JUNCTION	0.000	1.628	0	11:06	0
I-10	JUNCTION	0.008	0.273	0	11:00	0.0026
I-11	JUNCTION	0.000	0.237	0	11:00	0
I-12	JUNCTION	0.000	0.196	0	11:00	0.000161
I-2	JUNCTION	0.000	0.895	0	10:32	0
I-3	JUNCTION	0.023	0.608	0	11:00	0.00733
I-4	JUNCTION	0.001	0.423	0	11:05	0.000302
I-5	JUNCTION	0.000	0.422	0	11:03	0
I-6	JUNCTION	0.003	0.422	0	11:00	0.000906
I-7	JUNCTION	0.004	0.420	0	11:00	0.00137
I-8	JUNCTION	0.001	0.276	0	11:00	0.000463
I-9	JUNCTION	0.000	0.272	0	11:00	0
I-A	JUNCTION	0.000	1.777	0	11:20	0
I.1	JUNCTION	0.000	0.000	0	00:00	0
I.1A	JUNCTION	0.000	1.276	0	11:08	0
I.2	JUNCTION	0.000	0.000	0	00:00	0
I.3	JUNCTION	0.000	0.000	0	00:00	0

I.4	JUNCTION	0.000	0.000	0	00:00	0
I1	JUNCTION	0.003	0.003	0	10:00	0.000966
J	JUNCTION	0.000	0.042	0	11:00	0
J1	JUNCTION	0.006	0.007	0	11:00	0.00196
J2	JUNCTION	0.001	0.001	0	10:00	0.000322
JS-1	JUNCTION	0.000	0.478	0	11:00	0
JS-10	JUNCTION	0.000	0.008	0	10:59	0
JS-11	JUNCTION	0.004	0.008	0	09:01	0.00129
JS-12	JUNCTION	0.001	0.008	0	09:00	0.000322
JS-13	JUNCTION	0.003	0.003	0	10:00	0.000966
JS-2	JUNCTION	0.013	0.478	0	11:00	0.00421
JS-3	JUNCTION	0.003	0.465	0	11:00	0.000906
JS-4	JUNCTION	0.000	0.463	0	11:00	0
JS-5	JUNCTION	0.000	0.463	0	11:00	0
JS-6	JUNCTION	0.000	0.111	0	11:00	0
JS-7	JUNCTION	0.007	0.111	0	11:00	0.00233
JS-8	JUNCTION	0.007	0.104	0	11:00	0.00239
JS-8A	JUNCTION	0.069	0.097	0	11:00	0.0224
JS-9	JUNCTION	0.007	0.028	0	11:00	0.00239
JS.3-1	JUNCTION	0.000	0.000	0	00:00	0
JS.3-2	JUNCTION	0.000	0.000	0	00:00	0
JS.3-3	JUNCTION	0.000	0.000	0	00:00	0
JS.9-1	JUNCTION	0.002	0.012	0	11:00	0.000785
JS.9-2	JUNCTION	0.004	0.010	0	10:43	0.00145
JS.9-3	JUNCTION	0.005	0.005	0	10:00	0.00177
K1	JUNCTION	0.000	0.005	0	11:00	0
K2	JUNCTION	0.000	0.005	0	11:00	0.000161
K3	JUNCTION	0.003	0.005	0	10:44	0.000966
K4	JUNCTION	0.002	0.002	0	10:00	0.000644
L	JUNCTION	0.000	0.035	0	11:00	0
L.1-1	JUNCTION	0.031	0.032	0	11:00	0.00996
L.1-2	JUNCTION	0.000	0.001	0	11:00	0.000161
L.1-3	JUNCTION	0.000	0.000	0	10:00	0.000161
L1	JUNCTION	0.000	0.004	0	11:00	0
L2	JUNCTION	0.000	0.004	0	11:00	0
L3	JUNCTION	0.004	0.004	0	10:00	0.00123
LS-1	JUNCTION	0.002	0.680	0	11:00	0.000644
LS-10	JUNCTION	0.000	0.103	0	11:00	0
LS-11	JUNCTION	0.055	0.103	0	11:00	0.0179
LS-12	JUNCTION	0.000	0.048	0	11:00	0
LS-13	JUNCTION	0.000	0.048	0	11:00	0
LS-14	JUNCTION	0.018	0.048	0	11:00	0.00584
LS-15	JUNCTION	0.000	0.030	0	10:53	0
LS-16	JUNCTION	0.000	0.030	0	10:23	0
LS-17	JUNCTION	0.030	0.030	0	10:00	0.00985
LS-2	JUNCTION	0.000	0.679	0	11:02	0
LS-3	JUNCTION	0.000	0.679	0	11:01	0
LS-4	JUNCTION	0.000	0.679	0	11:01	0
LS-5	JUNCTION	0.000	0.679	0	11:00	0
LS-6	JUNCTION	0.000	0.679	0	11:00	0
LS-7	JUNCTION	0.000	0.679	0	11:00	0
LS-8	JUNCTION	0.000	0.103	0	11:00	0
LS-9	JUNCTION	0.000	0.103	0	11:00	0
M	JUNCTION	0.002	0.485	0	11:00	0.000644
M1	JUNCTION	0.001	0.483	0	11:00	0.000483
M10	JUNCTION	0.000	0.218	0	11:00	0
M11	JUNCTION	0.000	0.218	0	11:00	0
M12	JUNCTION	0.000	0.218	0	11:00	0
M13	JUNCTION	0.196	0.218	0	11:00	0.0636
M14	JUNCTION	0.000	0.022	0	11:00	0
M15	JUNCTION	0.000	0.022	0	11:00	0
M16	JUNCTION	0.001	0.022	0	11:00	0.000483
M16-1	JUNCTION	0.002	0.010	0	11:00	0.000805

M16-2	JUNCTION	0.003	0.008	0	11:00	0.000966
M16-3	JUNCTION	0.002	0.005	0	10:38	0.000644
M16-4	JUNCTION	0.003	0.003	0	10:00	0.000966
M17	JUNCTION	0.001	0.010	0	11:00	0.000322
M18	JUNCTION	0.003	0.009	0	11:00	0.000946
M19	JUNCTION	0.002	0.008	0	09:00	0.000644
M19-1	JUNCTION	0.002	0.002	0	10:00	0.000785
M2	JUNCTION	0.078	0.482	0	11:00	0.0252
M2-1	JUNCTION	0.000	0.003	0	10:51	0
M2-2	JUNCTION	0.003	0.003	0	10:00	0.000966
M20	JUNCTION	0.002	0.002	0	10:00	0.000644
M3	JUNCTION	0.000	0.401	0	11:00	0
M3.1	JUNCTION	0.005	0.005	0	10:00	0.00151
M4	JUNCTION	0.000	0.397	0	11:00	0
M5	JUNCTION	0.001	0.397	0	11:00	0.000322
M5-1	JUNCTION	0.000	0.122	0	11:00	0
M5-10	JUNCTION	0.003	0.032	0	10:51	0.00113
M5-11	JUNCTION	0.005	0.029	0	10:17	0.00161
M5-12	JUNCTION	0.024	0.024	0	10:00	0.00775
M5-2	JUNCTION	0.000	0.122	0	11:00	0
M5-3	JUNCTION	0.013	0.122	0	11:00	0.00413
M5-3-1	JUNCTION	0.000	0.000	0	10:00	0.000161
M5-4	JUNCTION	0.001	0.108	0	11:00	0.000322
M5-4.1	JUNCTION	0.015	0.026	0	10:39	0.00483
M5-4.2	JUNCTION	0.006	0.011	0	11:00	0.00193
M5-4.3	JUNCTION	0.002	0.009	0	10:01	0.000805
M5-4.4	JUNCTION	0.002	0.002	0	10:00	0.000644
M5-5	JUNCTION	0.039	0.081	0	10:57	0.0127
M5-6	JUNCTION	0.004	0.042	0	10:56	0.00145
M5-7	JUNCTION	0.001	0.038	0	10:58	0.000483
M5-8	JUNCTION	0.001	0.036	0	10:58	0.000322
M5-8.1	JUNCTION	0.000	0.000	0	00:00	0
M5-9	JUNCTION	0.003	0.035	0	10:59	0.000966
M6	JUNCTION	0.002	0.274	0	11:00	0.000644
M7	JUNCTION	0.001	0.272	0	11:00	0.000322
M8	JUNCTION	0.001	0.271	0	11:00	0.000463
M9	JUNCTION	0.000	0.270	0	11:00	0
M9-1	JUNCTION	0.004	0.052	0	10:43	0.00129
M9-2	JUNCTION	0.003	0.006	0	11:00	0.00113
M9-3	JUNCTION	0.002	0.002	0	10:00	0.000805
MC-1	JUNCTION	0.004	0.012	0	11:00	0.00129
MC-2	JUNCTION	0.002	0.005	0	11:00	0.000644
MC-3	JUNCTION	0.002	0.003	0	10:57	0.000644
MC-4	JUNCTION	0.000	0.000	0	00:00	0
MC-5	JUNCTION	0.000	0.000	0	00:00	0
MC-6	JUNCTION	0.000	0.000	0	00:00	0
MC-7	JUNCTION	0.000	0.000	0	00:00	0
MC-8	JUNCTION	0.000	0.000	0	00:00	0
MC-9	JUNCTION	0.000	0.000	0	00:00	0
MC.1-1	JUNCTION	0.000	0.003	0	10:57	0
MC.1-2	JUNCTION	0.001	0.003	0	10:57	0.000483
MC.1-3	JUNCTION	0.000	0.002	0	10:22	0
MC.1-4	JUNCTION	0.002	0.002	0	10:00	0.000644
MC.3-1	JUNCTION	0.000	0.001	0	09:00	0
MC.3-2	JUNCTION	0.001	0.001	0	10:00	0.000322
MH-01	JUNCTION	0.099	0.607	0	11:00	0.0321
MH-02	JUNCTION	0.065	0.508	0	11:00	0.0212
MH-02A	JUNCTION	0.000	0.443	0	11:00	0
MH-03	JUNCTION	0.000	0.420	0	11:00	0
MH-04	JUNCTION	0.000	0.420	0	11:00	0
MH-04A	JUNCTION	0.000	0.420	0	11:00	0
MH-05	JUNCTION	0.025	0.412	0	11:00	0.00805
MH-06	JUNCTION	0.045	0.059	0	11:00	0.0147

MH-07	JUNCTION	0.000	0.000	0	00:00	0
N.1	JUNCTION	0.000	0.033	0	10:02	0.000161
N.2	JUNCTION	0.032	0.032	0	10:00	0.0105
N1	JUNCTION	0.004	0.041	0	10:39	0.00145
N1-1	JUNCTION	0.004	0.006	0	10:52	0.00129
N1-2	JUNCTION	0.002	0.002	0	10:00	0.000644
N1.1	JUNCTION	0.003	0.006	0	10:14	0.000966
N1.1.1	JUNCTION	0.000	0.000	0	00:00	0
N1.2	JUNCTION	0.002	0.004	0	10:14	0.000644
N1.3	JUNCTION	0.000	0.000	0	10:00	0.000161
N2	JUNCTION	0.000	0.042	0	10:43	0.000161
N3	JUNCTION	0.003	0.031	0	11:00	0.000966
N4	JUNCTION	0.022	0.022	0	10:00	0.00724
N4-1	JUNCTION	0.000	0.000	0	00:00	0
N4-2	JUNCTION	0.000	0.000	0	00:00	0
N5	JUNCTION	0.000	0.000	0	00:00	0
N5-1	JUNCTION	0.000	0.000	0	00:00	0
N5-2	JUNCTION	0.000	0.000	0	00:00	0
N6	JUNCTION	0.000	0.000	0	00:00	0
N7	JUNCTION	0.000	0.000	0	00:00	0
N8	JUNCTION	0.000	0.000	0	00:00	0
SH-1	JUNCTION	0.000	0.328	0	11:00	0
SH-10	JUNCTION	0.005	0.214	0	11:00	0.00177
SH-11	JUNCTION	0.003	0.093	0	10:56	0.000966
SH-12	JUNCTION	0.008	0.090	0	10:43	0.00258
SH-13	JUNCTION	0.002	0.082	0	10:52	0.000644
SH-14	JUNCTION	0.003	0.080	0	10:40	0.000966
SH-15	JUNCTION	0.077	0.077	0	10:00	0.025
SH-16	JUNCTION	0.000	0.000	0	00:00	0
SH-17	JUNCTION	0.115	0.115	0	10:00	0.0374
SH-18	JUNCTION	0.001	0.009	0	10:58	0.000483
SH-19	JUNCTION	0.008	0.008	0	10:00	0.00258
SH-2	JUNCTION	0.000	0.328	0	11:00	0
SH-20	JUNCTION	0.000	0.017	0	11:00	0
SH-21	JUNCTION	0.001	0.017	0	11:00	0.000322
SH-22	JUNCTION	0.004	0.016	0	11:00	0.00145
SH-23	JUNCTION	0.002	0.009	0	11:00	0.000644
SH-24	JUNCTION	0.001	0.001	0	10:00	0.000302
SH-25	JUNCTION	0.000	0.002	0	10:57	0
SH-26	JUNCTION	0.002	0.002	0	10:00	0.000805
SH-27	JUNCTION	0.006	0.006	0	10:00	0.00209
SH-28	JUNCTION	0.000	0.000	0	00:00	0
SH-3	JUNCTION	0.073	0.328	0	11:00	0.0238
SH-4	JUNCTION	0.003	0.008	0	10:51	0.000966
SH-5	JUNCTION	0.005	0.005	0	10:00	0.00161
SH-6	JUNCTION	0.000	0.000	0	00:00	0
SH-7	JUNCTION	0.000	0.229	0	11:00	0
SH-8	JUNCTION	0.002	0.220	0	10:59	0.000805
SH-9	JUNCTION	0.004	0.217	0	10:59	0.00129
SP-1	JUNCTION	0.000	0.351	0	11:00	0
SP-10	JUNCTION	0.000	0.239	0	11:00	0
SP-11	JUNCTION	0.024	0.239	0	11:00	0.00795
SP-12	JUNCTION	0.003	0.214	0	11:00	0.000966
SP-13	JUNCTION	0.003	0.021	0	11:00	0.000966
SP-14	JUNCTION	0.003	0.016	0	11:00	0.000966
SP-15	JUNCTION	0.003	0.013	0	11:00	0.00113
SP-16	JUNCTION	0.004	0.009	0	11:00	0.00129
SP-17	JUNCTION	0.003	0.005	0	11:00	0.000966
SP-18	JUNCTION	0.002	0.002	0	10:00	0.000805
SP-2	JUNCTION	0.000	0.351	0	11:00	0
SP-3	JUNCTION	0.000	0.351	0	11:00	0
SP-4	JUNCTION	0.000	0.351	0	11:00	0
SP-4A	JUNCTION	0.000	0.351	0	11:00	0

SP-5	JUNCTION	0.109	0.351	0	11:00	0.0355
SP-6	JUNCTION	0.000	0.242	0	11:00	0
SP-7	JUNCTION	0.000	0.239	0	11:00	0
SP-8	JUNCTION	0.000	0.239	0	11:00	0
SP-9	JUNCTION	0.000	0.239	0	11:00	0
SP.12-1	JUNCTION	0.000	0.178	0	10:59	0
SP.12-2	JUNCTION	0.002	0.178	0	10:55	0.000644
SP.12-3	JUNCTION	0.176	0.176	0	10:00	0.0572
SP.13-1	JUNCTION	0.002	0.002	0	10:00	0.000644
SP.6-1	JUNCTION	0.003	0.003	0	10:00	0.000966
SP.7-1	JUNCTION	0.000	0.000	0	00:00	0
SP.7-2	JUNCTION	0.000	0.000	0	00:00	0
TP-1	JUNCTION	0.006	0.014	0	11:00	0.00193
TP-10	JUNCTION	0.003	0.012	0	11:00	0.000966
TP-11	JUNCTION	0.004	0.009	0	11:00	0.00129
TP-12	JUNCTION	0.005	0.005	0	10:00	0.00177
TP-2	JUNCTION	0.005	0.008	0	11:00	0.00161
TP-3	JUNCTION	0.000	0.003	0	11:00	0
TP-4	JUNCTION	0.003	0.003	0	10:00	0.000966
TP-5	JUNCTION	0.004	0.008	0	11:00	0.00129
TP-6	JUNCTION	0.000	0.003	0	11:00	0
TP-7	JUNCTION	0.001	0.001	0	10:00	0.000322
TP-8	JUNCTION	0.003	0.023	0	11:00	0.000966
TP-9	JUNCTION	0.000	0.017	0	11:00	0
TP.1-1	JUNCTION	0.000	0.000	0	00:00	0
TP.10.1	JUNCTION	0.000	0.000	0	00:00	0
TP.5-1	JUNCTION	0.001	0.001	0	10:00	0.000322
TP.6-1	JUNCTION	0.002	0.002	0	10:00	0.000644
TP.8-1	JUNCTION	0.003	0.003	0	10:00	0.000966
TP.9-1	JUNCTION	0.002	0.004	0	11:00	0.000644
TP.9-2	JUNCTION	0.000	0.002	0	11:00	0
TP.9-3	JUNCTION	0.002	0.002	0	10:00	0.000805
BSTREETPS	OUTFALL	0.000	2.417	0	11:03	0
OF-DS	OUTFALL	0.000	0.680	0	11:04	0
OF-HW	OUTFALL	0.000	0.608	0	10:59	0
OF-IPS	OUTFALL	0.000	0.607	0	11:00	0

****
Node Surcharge Summary
****

No nodes were surcharged.

****
Node Flooding Summary
****

No nodes were flooded.

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow MGD	Max Flow MGD	Total Volume 10^6 gal
BSTREETPS	95.17	0.567	2.417	0.517
OF-DS	90.99	0.248	0.680	0.216

OF-HW	99.30	0.205	0.608	0.195
OF-IPS	99.76	0.204	0.607	0.195
System	96.30	1.223	0.607	1.123

****
Link Flow Summary
****

Link	Type	Maximum |Run Flow| MGD	Time of Max Occurrence days	hr:min	Maximum |Output Flow| MGD	Time Occ days
1.2.3-2	CONDUIT	0.201	0	11:01	0.028	0
1.2.3-3	CONDUIT	0.201	0	11:00	0.027	0
A-1	CONDUIT	0.130	0	11:00	0.018	0
A-11	CONDUIT	0.028	0	11:00	0.004	0
A-12	CONDUIT	0.024	0	11:00	0.003	0
A-13	CONDUIT	0.024	0	11:00	0.003	0
A-14	CONDUIT	0.003	0	11:00	0.000	0
A-14.5-1	CONDUIT	0.000	0	00:00	0.000	0
A-15	CONDUIT	0.003	0	11:00	0.000	0
A-2	CONDUIT	0.130	0	11:00	0.018	0
A-3	CONDUIT	0.099	0	11:00	0.013	0
A-4	CONDUIT	0.091	0	11:00	0.012	0
A-5	CONDUIT	0.088	0	11:00	0.012	0
A-6	CONDUIT	0.088	0	11:00	0.012	0
A-7	CONDUIT	0.087	0	11:00	0.012	0
A-8	CONDUIT	0.051	0	11:00	0.007	0
A-9	CONDUIT	0.051	0	11:00	0.007	0
A.1-1	CONDUIT	0.288	0	11:10	0.045	0
A.1-10	CONDUIT	0.023	0	11:00	0.003	0
A.1-11	CONDUIT	0.011	0	11:00	0.001	0
A.1-12	CONDUIT	0.009	0	11:00	0.001	0
A.1-13	CONDUIT	0.008	0	11:00	0.001	0
A.1-14	CONDUIT	0.005	0	11:00	0.001	0
A.1-15	CONDUIT	0.003	0	10:58	0.000	0
A.1-3	CONDUIT	0.283	0	11:08	0.043	0
A.1-4	CONDUIT	0.281	0	11:05	0.042	0
A.1-5	CONDUIT	0.281	0	11:05	0.042	0
A.1-6	CONDUIT	0.280	0	11:03	0.042	0
A.1-7	CONDUIT	0.279	0	11:02	0.041	0
A.1-8	CONDUIT	0.264	0	11:01	0.039	0
A.1-9	CONDUIT	0.262	0	11:01	0.038	0
A.1.1-1	CONDUIT	0.014	0	11:00	0.002	0
A.1.1-2	CONDUIT	0.013	0	11:00	0.002	0
A.1.1-3	CONDUIT	0.008	0	11:00	0.001	0
A.1.1-4	CONDUIT	0.006	0	11:00	0.001	0
A.1.2-1	CONDUIT	0.238	0	11:00	0.034	0
A.1.2-2	CONDUIT	0.234	0	11:01	0.033	0
A.1.2-3	CONDUIT	0.006	0	11:00	0.001	0
A.1.2-4	CONDUIT	0.006	0	11:00	0.001	0
A.1.2-5	CONDUIT	0.000	0	11:00	0.000	0
A.1.2-6	CONDUIT	0.001	0	08:01	0.000	0
A.1.2.1-1	CONDUIT	0.000	0	11:00	0.000	0
A.1.2.2-1	CONDUIT	0.000	0	11:00	0.000	0
A.1.3-1	CONDUIT	0.011	0	11:00	0.001	0
A.1.3-2	CONDUIT	0.009	0	11:00	0.001	0
A.1.3-3	CONDUIT	0.004	0	11:00	0.001	0
A.1.3-4	CONDUIT	0.002	0	11:00	0.000	0
A.1.3.1-1	CONDUIT	0.001	0	10:43	0.000	0

A.1.4-1	CONDUIT	0.000	0	11:00	0.000	0
A.10-1	CONDUIT	0.065	0	11:01	0.009	0
A.10-10	CONDUIT	0.003	0	11:00	0.000	0
A.10-11	CONDUIT	0.002	0	11:00	0.000	0
A.10-12	CONDUIT	0.001	0	09:32	0.000	0
A.10-13	CONDUIT	0.001	0	08:01	0.000	0
A.10-2	CONDUIT	0.065	0	11:00	0.009	0
A.10-3	CONDUIT	0.065	0	11:00	0.009	0
A.10-4	CONDUIT	0.033	0	11:00	0.004	0
A.10-5	CONDUIT	0.032	0	11:00	0.004	0
A.10-6	CONDUIT	0.032	0	11:00	0.004	0
A.10-7	CONDUIT	0.030	0	11:00	0.004	0
A.10-8	CONDUIT	0.004	0	11:00	0.001	0
A.10-9	CONDUIT	0.004	0	11:00	0.001	0
A.10.1-1	CONDUIT	0.033	0	11:00	0.004	0
A.10.1-10	CONDUIT	0.006	0	11:00	0.001	0
A.10.1-11	CONDUIT	0.003	0	11:00	0.000	0
A.10.1-12	CONDUIT	0.002	0	11:00	0.000	0
A.10.1-13	CONDUIT	0.000	0	00:00	0.000	0
A.10.1-14	CONDUIT	0.000	0	00:00	0.000	0
A.10.1-15	CONDUIT	0.000	0	00:00	0.000	0
A.10.1-16	CONDUIT	0.000	0	00:00	0.000	0
A.10.1-17	CONDUIT	0.000	0	00:00	0.000	0
A.10.1-18	CONDUIT	0.000	0	00:00	0.000	0
A.10.1-2	CONDUIT	0.028	0	11:00	0.004	0
A.10.1-3	CONDUIT	0.013	0	11:00	0.002	0
A.10.1-4	CONDUIT	0.011	0	11:00	0.001	0
A.10.1-5	CONDUIT	0.010	0	11:00	0.001	0
A.10.1-6	CONDUIT	0.009	0	11:00	0.001	0
A.10.1-7	CONDUIT	0.009	0	11:00	0.001	0
A.10.1-8	CONDUIT	0.009	0	11:00	0.001	0
A.10.1-9	CONDUIT	0.006	0	11:00	0.001	0
A.10.1.1-1	CONDUIT	0.002	0	11:00	0.000	0
A.10.1.1-2	CONDUIT	0.001	0	10:59	0.000	0
A.10.1.10-1	CONDUIT	0.001	0	11:00	0.000	0
A.10.1.8-1	CONDUIT	0.002	0	10:54	0.000	0
A.10.2-1	CONDUIT	0.025	0	10:37	0.003	0
A.10.2-2	CONDUIT	0.019	0	10:24	0.002	0
A.10.2-3	CONDUIT	0.019	0	11:00	0.002	0
A.10.2-4	CONDUIT	0.018	0	10:35	0.002	0
A.10.2-5	CONDUIT	0.016	0	10:05	0.002	0
A.11-1	CONDUIT	0.030	0	11:00	0.004	0
A.11-2	CONDUIT	0.028	0	11:00	0.004	0
A.11-3	CONDUIT	0.024	0	11:00	0.004	0
A.11-4	CONDUIT	0.015	0	11:00	0.002	0
A.11-5	CONDUIT	0.014	0	11:00	0.002	0
A.11.1-1	CONDUIT	0.008	0	11:14	0.001	0
A.11.1-2	CONDUIT	0.008	0	11:05	0.001	0
A.11.1-3	CONDUIT	0.008	0	11:02	0.001	0
A.11.1-4	CONDUIT	0.008	0	11:00	0.001	0
A.11.1.4-1	CONDUIT	0.007	0	11:00	0.001	0
A.11.1.4-2	CONDUIT	0.007	0	11:00	0.001	0
A.11.1.4-3	CONDUIT	0.006	0	11:00	0.001	0
A.11.1.4-4	CONDUIT	0.006	0	11:00	0.001	0
A.12-1	CONDUIT	0.004	0	11:00	0.001	0
A.12-2	CONDUIT	0.001	0	11:00	0.000	0
A.13-1	CONDUIT	0.002	0	11:00	0.000	0
A.14-1	CONDUIT	0.033	0	11:00	0.004	0
A.14-1.1	CONDUIT	0.012	0	11:00	0.002	0
A.14-1.2	CONDUIT	0.010	0	11:00	0.001	0
A.14-1.3	CONDUIT	0.008	0	11:00	0.001	0
A.14-1.4	CONDUIT	0.004	0	11:00	0.001	0
A.14-1.5	CONDUIT	0.002	0	11:00	0.000	0

A.14-1.6	CONDUIT	0.001	0	10:33	0.000	0
A.14-1.7	CONDUIT	0.001	0	10:19	0.000	0
A.14-1.8	CONDUIT	0.002	0	10:47	0.000	0
A.14-2	CONDUIT	0.020	0	11:00	0.003	0
A.14-3	CONDUIT	0.018	0	11:00	0.002	0
A.14-4	CONDUIT	0.018	0	11:00	0.002	0
A.14-5	CONDUIT	0.011	0	11:00	0.001	0
A.14-6	CONDUIT	0.004	0	11:00	0.001	0
A.14-7	CONDUIT	0.000	0	00:00	0.000	0
A.14-8	CONDUIT	0.000	0	00:00	0.000	0
A.14.1-1	CONDUIT	0.009	0	09:05	0.001	0
A.14.1-1A	CONDUIT	0.004	0	10:54	0.001	0
A.14.1-2	CONDUIT	0.003	0	10:54	0.000	0
A.14.1-3	CONDUIT	0.002	0	10:39	0.000	0
A.14.2-1	CONDUIT	0.001	0	11:00	0.000	0
A.14.3-1	CONDUIT	0.001	0	11:00	0.000	0
A.14.4-1	CONDUIT	0.003	0	11:00	0.000	0
A.14.7-1	CONDUIT	0.000	0	00:00	0.000	0
A.14.7-2	CONDUIT	0.000	0	00:00	0.000	0
A.14.7-A	CONDUIT	0.000	0	00:00	0.000	0
A.15-1	CONDUIT	0.022	0	11:00	0.003	0
A.15-2	CONDUIT	0.018	0	11:00	0.002	0
A.15-3	CONDUIT	0.014	0	10:52	0.002	0
A.15-4	CONDUIT	0.002	0	10:57	0.000	0
A.15-5	CONDUIT	0.004	0	09:02	0.000	0
A.15-6	CONDUIT	0.002	0	10:51	0.000	0
A.15-8	CONDUIT	0.000	0	00:00	0.000	0
A.15.5-1	CONDUIT	0.000	0	00:00	0.000	0
A.16-1	CONDUIT	0.003	0	10:53	0.000	0
A.17-1	CONDUIT	0.020	0	11:00	0.003	0
A.17-2	CONDUIT	0.015	0	11:00	0.002	0
A.17-3	CONDUIT	0.014	0	11:00	0.002	0
A.17-4	CONDUIT	0.011	0	10:56	0.001	0
A.17-4.1	CONDUIT	0.003	0	11:00	0.000	0
A.17-5	CONDUIT	0.006	0	10:52	0.001	0
A.17-6	CONDUIT	0.001	0	10:49	0.000	0
A.17-7	CONDUIT	0.003	0	01:38	0.000	0
A.17-8	CONDUIT	0.003	0	07:38	0.000	0
A.17-9	CONDUIT	0.004	0	10:39	0.000	0
A.17.1-1	CONDUIT	0.005	0	10:26	0.001	0
A.2-1	CONDUIT	0.165	0	11:00	0.023	0
A.2-10	CONDUIT	0.117	0	11:00	0.015	0
A.2-11	CONDUIT	0.009	0	11:00	0.001	0
A.2-12	CONDUIT	0.009	0	11:00	0.001	0
A.2-13	CONDUIT	0.009	0	11:00	0.001	0
A.2-14	CONDUIT	0.007	0	11:00	0.001	0
A.2-2	CONDUIT	0.162	0	11:00	0.023	0
A.2-3	CONDUIT	0.156	0	11:00	0.022	0
A.2-4	CONDUIT	0.137	0	11:00	0.019	0
A.2-5	CONDUIT	0.136	0	11:00	0.018	0
A.2-6	CONDUIT	0.133	0	11:00	0.018	0
A.2-7	CONDUIT	0.133	0	11:00	0.018	0
A.2-8	CONDUIT	0.120	0	11:00	0.016	0
A.2-9	CONDUIT	0.119	0	11:00	0.016	0
A.2.1-1	CONDUIT	0.006	0	11:00	0.001	0
A.2.1-2	CONDUIT	0.004	0	11:00	0.000	0
A.2.1-3	CONDUIT	0.002	0	10:54	0.000	0
A.2.1A-1	CONDUIT	0.019	0	11:00	0.002	0
A.2.1A-2	CONDUIT	0.018	0	11:00	0.002	0
A.2.1A-3	CONDUIT	0.014	0	11:00	0.002	0
A.2.1A-4	CONDUIT	0.013	0	11:00	0.002	0
A.2.1A-5	CONDUIT	0.006	0	10:58	0.001	0
A.2.1A-6	CONDUIT	0.002	0	10:11	0.000	0

A.2.1A.1-1	CONDUIT	0.001	0	11:00	0.000	0
A.2.1A.2-1	CONDUIT	0.004	0	10:44	0.000	0
A.2.2-1	CONDUIT	0.012	0	10:31	0.002	0
A.2.2-2	CONDUIT	0.011	0	10:22	0.001	0
A.2.2-3	CONDUIT	0.009	0	10:42	0.001	0
A.2.2-4	CONDUIT	0.009	0	10:13	0.001	0
A.2.2-5	CONDUIT	0.009	0	10:44	0.001	0
A.2.2.1-1	CONDUIT	0.001	0	10:56	0.000	0
A.2.2.2-1	CONDUIT	0.000	0	00:00	0.000	0
A.3.1-1	CONDUIT	0.000	0	11:00	0.000	0
A.3A-1	CONDUIT	0.000	0	00:00	0.000	0
A.4-1	CONDUIT	0.000	0	11:02	0.000	0
A.4-10	CONDUIT	0.667	0	11:00	0.087	0
A.4-11	CONDUIT	0.533	0	11:00	0.070	0
A.4-12	CONDUIT	0.532	0	11:00	0.069	0
A.4-13	CONDUIT	0.053	0	11:00	0.007	0
A.4-14	CONDUIT	0.053	0	11:00	0.007	0
A.4-15	CONDUIT	0.052	0	11:00	0.007	0
A.4-16	CONDUIT	0.051	0	11:00	0.007	0
A.4-17	CONDUIT	0.028	0	10:59	0.004	0
A.4-18	CONDUIT	0.027	0	10:59	0.003	0
A.4-2	CONDUIT	0.000	0	11:00	0.000	0
A.4-3	CONDUIT	0.000	0	11:00	0.000	0
A.4-4	CONDUIT	0.000	0	00:00	0.000	0
A.4-4A	CONDUIT	0.000	0	00:00	0.000	0
A.4-5	CONDUIT	0.679	0	11:00	0.091	0
A.4-6	CONDUIT	0.671	0	11:01	0.089	0
A.4-7	CONDUIT	0.668	0	11:01	0.088	0
A.4-8	CONDUIT	0.668	0	11:01	0.088	0
A.4-9	CONDUIT	0.667	0	11:00	0.087	0
A.4.1-1	CONDUIT	0.002	0	11:00	0.000	0
A.4.1-1A	CONDUIT	0.005	0	00:24	0.000	0
A.4.1-2	CONDUIT	0.001	0	10:13	0.000	0
A.4.10-1	CONDUIT	0.134	0	11:01	0.017	0
A.4.10-1A	CONDUIT	0.134	0	11:01	0.017	0
A.4.10-2	CONDUIT	0.134	0	11:00	0.017	0
A.4.10-3	CONDUIT	0.134	0	11:00	0.017	0
A.4.10-4	CONDUIT	0.134	0	11:00	0.017	0
A.4.10-5	CONDUIT	0.134	0	11:00	0.017	0
A.4.10-6	CONDUIT	0.134	0	11:00	0.017	0
A.4.10-7	CONDUIT	0.018	0	10:30	0.002	0
A.4.10-8	CONDUIT	0.000	0	00:00	0.000	0
A.4.10.6-1	CONDUIT	0.103	0	11:01	0.013	0
A.4.10.6-2	CONDUIT	0.103	0	11:01	0.013	0
A.4.10.6-3	CONDUIT	0.103	0	11:00	0.013	0
A.4.16-1	CONDUIT	0.000	0	00:00	0.000	0
A.4.2-1	CONDUIT	0.001	0	09:00	0.000	0
A.4.2-2	CONDUIT	0.001	0	09:00	0.000	0
A.4.5-1	CONDUIT	0.006	0	10:22	0.001	0
A.4.5-2	CONDUIT	0.000	0	00:00	0.000	0
A.4.5-3	CONDUIT	0.000	0	00:00	0.000	0
A.4.8-1	CONDUIT	0.000	0	00:00	0.000	0
A.5-1	CONDUIT	0.110	0	11:00	0.014	0
A.5-2	CONDUIT	0.099	0	11:00	0.013	0
A.5-3	CONDUIT	0.095	0	11:00	0.012	0
A.5-4	CONDUIT	0.020	0	11:00	0.003	0
A.5-5	CONDUIT	0.019	0	11:00	0.002	0
A.5-6	CONDUIT	0.018	0	11:00	0.002	0
A.5-7	CONDUIT	0.011	0	10:58	0.001	0
A.5-8	CONDUIT	0.011	0	10:45	0.001	0
A.5-9	CONDUIT	0.006	0	10:39	0.001	0
A.5.1-1	CONDUIT	0.010	0	11:00	0.001	0
A.5.1-2	CONDUIT	0.008	0	11:00	0.001	0

A.5.1-3	CONDUIT	0.006	0	11:00	0.001	0
A.5.1-4	CONDUIT	0.005	0	11:00	0.001	0
A.5.2-1	CONDUIT	0.075	0	10:59	0.010	0
A.5.2-2	CONDUIT	0.072	0	10:55	0.009	0
A.5.2-3	CONDUIT	0.056	0	10:14	0.007	0
A.5.2.1-1	CONDUIT	0.009	0	10:01	0.001	0
A.5.3-1	CONDUIT	0.004	0	11:00	0.000	0
A.5.3-2	CONDUIT	0.001	0	11:00	0.000	0
A.5.3.1-1	CONDUIT	0.001	0	11:00	0.000	0
A.6-1	CONDUIT	0.030	0	11:00	0.004	0
A.6-2	CONDUIT	0.027	0	11:00	0.003	0
A.6-3	CONDUIT	0.025	0	11:00	0.003	0
A.6-4	CONDUIT	0.017	0	11:00	0.002	0
A.6-5	CONDUIT	0.015	0	11:00	0.002	0
A.6-6	CONDUIT	0.013	0	11:00	0.002	0
A.6-7	CONDUIT	0.009	0	11:00	0.001	0
A.6-8	CONDUIT	0.008	0	11:00	0.001	0
A.6-9	CONDUIT	0.001	0	10:58	0.000	0
A.6.1-1	CONDUIT	0.002	0	11:00	0.000	0
A.6.2-1	CONDUIT	0.008	0	11:00	0.001	0
A.6.2-2	CONDUIT	0.007	0	11:00	0.001	0
A.6.2-3	CONDUIT	0.006	0	11:00	0.001	0
A.6.2-4	CONDUIT	0.001	0	10:59	0.000	0
A.6.3-1	CONDUIT	0.001	0	11:00	0.000	0
A.6.4-1	CONDUIT	0.006	0	11:00	0.001	0
A.6.4-2	CONDUIT	0.000	0	11:00	0.000	0
A.6.4.1-1	CONDUIT	0.005	0	10:55	0.001	0
A.7-1	CONDUIT	0.003	0	11:00	0.000	0
A.7-2	CONDUIT	0.001	0	10:47	0.000	0
A.7-3	CONDUIT	0.001	0	10:21	0.000	0
A.8-1	CONDUIT	0.028	0	11:00	0.004	0
A.8-2	CONDUIT	0.028	0	11:00	0.004	0
A.8-3	CONDUIT	0.024	0	11:00	0.003	0
A.8-4	CONDUIT	0.022	0	11:00	0.003	0
A.8-5	CONDUIT	0.020	0	11:00	0.003	0
A.8-6	CONDUIT	0.016	0	11:00	0.002	0
A.8-7	CONDUIT	0.015	0	11:00	0.002	0
A.8-8	CONDUIT	0.012	0	11:00	0.002	0
A.8.1-1	CONDUIT	0.001	0	11:00	0.000	0
A.9-1	CONDUIT	0.027	0	11:00	0.004	0
A.9-2	CONDUIT	0.024	0	11:00	0.003	0
A.9-3	CONDUIT	0.019	0	11:00	0.002	0
A.9-4	CONDUIT	0.014	0	11:00	0.002	0
A.9-5	CONDUIT	0.010	0	10:23	0.001	0
A.9-6	CONDUIT	0.007	0	10:19	0.001	0
A.9-7	CONDUIT	0.004	0	10:07	0.001	0
A.9A-1	CONDUIT	0.014	0	11:00	0.002	0
A.9A-2	CONDUIT	0.013	0	11:00	0.002	0
A.9A-3	CONDUIT	0.011	0	11:00	0.001	0
A.9A-4	CONDUIT	0.005	0	10:38	0.001	0
A.9A.2-1	CONDUIT	0.000	0	00:00	0.000	0
A.A5-7	CONDUIT	0.000	0	00:00	0.000	0
A1	CONDUIT	0.008	0	11:00	0.001	0
A2	CONDUIT	0.007	0	11:00	0.001	0
A3	CONDUIT	0.002	0	11:00	0.000	0
B-1	CONDUIT	0.338	0	11:00	0.048	0
B-10	CONDUIT	0.025	0	11:00	0.003	0
B-11	CONDUIT	0.033	0	11:00	0.004	0
B-2	CONDUIT	0.332	0	11:00	0.047	0
B-3	CONDUIT	0.314	0	11:00	0.043	0
B-4	CONDUIT	0.313	0	11:00	0.043	0
B-5	CONDUIT	0.293	0	11:02	0.040	0
B-6	CONDUIT	0.294	0	11:00	0.040	0

B-7	CONDUIT	0.515	0	11:01	0.068	0
B-8	CONDUIT	0.513	0	11:02	0.068	0
B.1-1	CONDUIT	0.002	0	11:00	0.000	0
B.1A-1	CONDUIT	0.382	0	11:06	0.053	0
B.2-1	CONDUIT	0.016	0	10:23	0.002	0
B.2A-1	CONDUIT	0.382	0	11:04	0.053	0
B.3-1	CONDUIT	0.005	0	10:16	0.001	0
B.3-2	CONDUIT	0.005	0	10:10	0.001	0
B.3A-1	CONDUIT	0.382	0	11:03	0.052	0
B.4-1	CONDUIT	0.030	0	11:00	0.004	0
B.4-2	CONDUIT	0.028	0	11:00	0.004	0
B.4-3	CONDUIT	0.027	0	11:00	0.004	0
B.4-4	CONDUIT	0.025	0	11:00	0.003	0
B.4-5	CONDUIT	0.022	0	11:00	0.003	0
B.4-6	CONDUIT	0.019	0	11:00	0.002	0
B.4-7	CONDUIT	0.005	0	11:01	0.001	0
B.4-8	CONDUIT	0.005	0	11:00	0.001	0
B.4A-1	CONDUIT	0.377	0	11:02	0.050	0
B.5A-1	CONDUIT	0.348	0	11:01	0.046	0
B.6-1	CONDUIT	0.002	0	11:00	0.000	0
B.6-1A	CONDUIT	0.125	0	11:00	0.016	0
B.6-2	CONDUIT	0.002	0	10:47	0.000	0
B.6-2A	CONDUIT	0.125	0	11:00	0.016	0
B.6-3	CONDUIT	0.001	0	10:46	0.000	0
B.6-3A	CONDUIT	0.125	0	11:00	0.016	0
B.6-4A	CONDUIT	0.125	0	11:00	0.016	0
B.6-5A	CONDUIT	0.125	0	11:00	0.016	0
B.6-6A	CONDUIT	0.011	0	11:00	0.001	0
B.6.A-1	CONDUIT	0.486	0	11:00	0.064	0
B.6A-1	CONDUIT	0.348	0	11:00	0.046	0
B.7-1	CONDUIT	0.005	0	10:31	0.001	0
B.7-2	CONDUIT	0.002	0	10:31	0.000	0
B.7-3	CONDUIT	0.002	0	10:13	0.000	0
B.7.1-1	CONDUIT	0.001	0	10:59	0.000	0
B.7.2-1	CONDUIT	0.002	0	10:05	0.000	0
B1	CONDUIT	0.003	0	11:00	0.000	0
B2	CONDUIT	0.003	0	11:00	0.000	0
B3	CONDUIT	0.003	0	11:00	0.000	0
B4	CONDUIT	0.002	0	11:00	0.000	0
B5	CONDUIT	0.002	0	11:00	0.000	0
C1	CONDUIT	0.009	0	11:00	0.001	0
C2	CONDUIT	0.007	0	11:00	0.001	0
C3	CONDUIT	0.005	0	10:51	0.001	0
C4	CONDUIT	0.002	0	10:38	0.000	0
CDT-37	CONDUIT	1.293	0	11:08	0.190	0
CV-01	CONDUIT	0.608	0	10:59	0.079	0
CV-02	CONDUIT	0.605	0	10:58	0.079	0
CV-03	CONDUIT	0.590	0	10:57	0.077	0
CV-04	CONDUIT	0.493	0	10:57	0.064	0
CV-05	CONDUIT	0.493	0	10:56	0.064	0
CV-06	CONDUIT	0.493	0	10:55	0.064	0
CV-07	CONDUIT	0.429	0	10:54	0.056	0
CV-08	CONDUIT	0.429	0	10:53	0.056	0
CV-09	CONDUIT	0.364	0	10:52	0.047	0
CV-10	CONDUIT	0.343	0	10:52	0.044	0
CV-11	CONDUIT	0.343	0	10:51	0.044	0
CV-12	CONDUIT	0.343	0	10:51	0.044	0
CV-13	CONDUIT	0.342	0	10:50	0.044	0
CV-14	CONDUIT	0.328	0	10:48	0.042	0
CV-15	CONDUIT	0.276	0	10:47	0.036	0
CV-16	CONDUIT	0.276	0	10:52	0.036	0
CV-17	CONDUIT	0.276	0	10:51	0.036	0
CV-18	CONDUIT	0.276	0	10:44	0.036	0

CV-19	CONDUIT	0.278	0	10:38	0.036	0
CV-20	CONDUIT	0.290	0	10:44	0.035	0
CV-21	CONDUIT	0.274	0	11:00	0.035	0
CV-22	CONDUIT	0.245	0	10:45	0.032	0
CV-23	CONDUIT	0.245	0	10:17	0.032	0
CV-24	CONDUIT	0.244	0	10:41	0.032	0
CV-25	CONDUIT	0.244	0	10:41	0.031	0
CV-26	CONDUIT	0.244	0	10:39	0.031	0
CV-27	CONDUIT	0.175	0	10:51	0.023	0
CV-28	CONDUIT	0.175	0	10:39	0.023	0
CV-29	CONDUIT	0.175	0	10:54	0.023	0
CV-30	CONDUIT	0.175	0	10:53	0.023	0
CV-31	CONDUIT	0.175	0	10:35	0.023	0
CV.10-1	CONDUIT	0.000	0	00:00	0.000	0
CV.10-2	CONDUIT	0.000	0	00:00	0.000	0
CV.10-3	CONDUIT	0.000	0	00:00	0.000	0
CV.10-4	CONDUIT	0.000	0	00:00	0.000	0
CV.10-5	CONDUIT	0.000	0	00:00	0.000	0
CV.10-6	CONDUIT	0.000	0	00:00	0.000	0
CV.10.4-1	CONDUIT	0.000	0	00:00	0.000	0
CV.12-1	CONDUIT	0.001	0	11:01	0.000	0
CV.12-10	CONDUIT	0.000	0	00:00	0.000	0
CV.12-11	CONDUIT	0.000	0	00:00	0.000	0
CV.12-2	CONDUIT	0.002	0	00:48	0.000	0
CV.12-3	CONDUIT	0.003	0	08:48	0.000	0
CV.12-4	CONDUIT	0.003	0	09:01	0.000	0
CV.12-5	CONDUIT	0.002	0	08:40	0.000	0
CV.12-6	CONDUIT	0.002	0	09:00	0.000	0
CV.12-7	CONDUIT	0.000	0	00:00	0.000	0
CV.12-8	CONDUIT	0.000	0	00:00	0.000	0
CV.12-9	CONDUIT	0.000	0	00:00	0.000	0
CV.12.5-1	CONDUIT	0.000	0	00:00	0.000	0
CV.12.5-2	CONDUIT	0.000	0	00:00	0.000	0
CV.12.5-3	CONDUIT	0.000	0	00:00	0.000	0
CV.12.6-1	CONDUIT	0.000	0	00:00	0.000	0
CV.12.6-2	CONDUIT	0.000	0	00:00	0.000	0
CV.12.6-3	CONDUIT	0.000	0	00:00	0.000	0
CV.12.7-1	CONDUIT	0.000	0	00:00	0.000	0
CV.12.7-2	CONDUIT	0.000	0	00:00	0.000	0
CV.12.7-3	CONDUIT	0.000	0	00:00	0.000	0
CV.12.7-4	CONDUIT	0.000	0	00:00	0.000	0
CV.12.8-1	CONDUIT	0.000	0	00:00	0.000	0
CV.12.8-2	CONDUIT	0.000	0	00:00	0.000	0
CV.12.8-3	CONDUIT	0.000	0	00:00	0.000	0
CV.12.8-4	CONDUIT	0.000	0	00:00	0.000	0
CV.12.8-5	CONDUIT	0.000	0	00:00	0.000	0
CV.12.8-6	CONDUIT	0.000	0	00:00	0.000	0
CV.12.8-7	CONDUIT	0.000	0	00:00	0.000	0
CV.12.8-8	CONDUIT	0.000	0	00:00	0.000	0
CV.14-1	CONDUIT	0.005	0	10:53	0.001	0
CV.14-10	CONDUIT	0.000	0	00:00	0.000	0
CV.14-2	CONDUIT	0.005	0	10:51	0.001	0
CV.14-3	CONDUIT	0.005	0	10:50	0.001	0
CV.14-4	CONDUIT	0.003	0	10:48	0.000	0
CV.14-5	CONDUIT	0.003	0	03:02	0.000	0
CV.14-6	CONDUIT	0.003	0	00:40	0.000	0
CV.14-7	CONDUIT	0.003	0	05:07	0.000	0
CV.14-8	CONDUIT	0.002	0	00:20	0.000	0
CV.14-9	CONDUIT	0.003	0	10:39	0.000	0
CV.14.3-1	CONDUIT	0.001	0	10:30	0.000	0
CV.14.3-2	CONDUIT	0.002	0	09:01	0.000	0
CV.14.3-3	CONDUIT	0.000	0	00:00	0.000	0
CV.14.3.2-1	CONDUIT	0.000	0	00:00	0.000	0

CV.14.5-1	CONDUIT	0.001	0	10:14	0.000	0
CV.14.5-2	CONDUIT	0.002	0	00:50	0.000	0
CV.14.5-3	CONDUIT	0.002	0	09:23	0.000	0
CV.14.5-4	CONDUIT	0.000	0	00:00	0.000	0
CV.14.5-5	CONDUIT	0.000	0	00:00	0.000	0
CV.14.5.2-1	CONDUIT	0.000	0	00:00	0.000	0
CV.16-1	CONDUIT	0.001	0	10:47	0.000	0
CV.16-2	CONDUIT	0.001	0	04:27	0.000	0
CV.16-3	CONDUIT	0.001	0	05:10	0.000	0
CV.16-4	CONDUIT	0.002	0	03:44	0.000	0
CV.16-5	CONDUIT	0.002	0	10:14	0.000	0
CV.16-6	CONDUIT	0.000	0	00:00	0.000	0
CV.18-1	CONDUIT	0.000	0	00:00	0.000	0
CV.18-2	CONDUIT	0.000	0	00:00	0.000	0
CV.18-3	CONDUIT	0.000	0	00:00	0.000	0
CV.18-4	CONDUIT	0.000	0	00:00	0.000	0
CV.18-5	CONDUIT	0.000	0	00:00	0.000	0
CV.18-6	CONDUIT	0.000	0	00:00	0.000	0
CV.19-1	CONDUIT	0.001	0	10:42	0.000	0
CV.19-2	CONDUIT	0.001	0	10:32	0.000	0
CV.19-3	CONDUIT	0.004	0	18:04	0.000	0
CV.19-4	CONDUIT	0.002	0	09:04	0.000	0
CV.19-5	CONDUIT	0.002	0	10:02	0.000	0
CV.19.2-1	CONDUIT	0.000	0	00:00	0.000	0
CV.19.2-2	CONDUIT	0.000	0	00:00	0.000	0
CV.19.2-3	CONDUIT	0.000	0	00:00	0.000	0
CV.21-1	CONDUIT	0.030	0	11:00	0.004	0
CV.21-10	CONDUIT	0.000	0	00:00	0.000	0
CV.21-11	CONDUIT	0.000	0	00:00	0.000	0
CV.21-2	CONDUIT	0.017	0	11:00	0.002	0
CV.21-3	CONDUIT	0.002	0	11:00	0.000	0
CV.21-4	CONDUIT	0.002	0	06:06	0.000	0
CV.21-5	CONDUIT	0.002	0	02:00	0.000	0
CV.21-6	CONDUIT	0.001	0	05:17	0.000	0
CV.21-7	CONDUIT	0.000	0	11:00	0.000	0
CV.21-8	CONDUIT	0.000	0	11:00	0.000	0
CV.21-9	CONDUIT	0.000	0	11:00	0.000	0
CV.26-1	CONDUIT	0.001	0	02:21	0.000	0
CV.26-2	CONDUIT	0.005	0	03:23	0.000	0
CV.26-3	CONDUIT	0.003	0	09:22	0.000	0
CV.26-4	CONDUIT	0.000	0	11:00	0.000	0
CV.26.3-1	CONDUIT	0.000	0	00:00	0.000	0
CV.8-1	CONDUIT	0.000	0	00:00	0.000	0
CV.8-2	CONDUIT	0.000	0	00:00	0.000	0
CV.8-3	CONDUIT	0.000	0	00:00	0.000	0
CV.8-4	CONDUIT	0.000	0	00:00	0.000	0
CV.8-5	CONDUIT	0.000	0	00:00	0.000	0
CV14-11	CONDUIT	0.000	0	00:00	0.000	0
D1	CONDUIT	0.006	0	11:00	0.001	0
D2	CONDUIT	0.005	0	11:00	0.001	0
E1	CONDUIT	0.107	0	11:00	0.014	0
E10	CONDUIT	0.032	0	10:39	0.004	0
E11	CONDUIT	0.032	0	10:52	0.004	0
E11-1	CONDUIT	0.000	0	00:00	0.000	0
E12	CONDUIT	0.031	0	10:54	0.004	0
E3	CONDUIT	0.105	0	11:00	0.014	0
E4	CONDUIT	0.105	0	11:00	0.014	0
E4-1	CONDUIT	0.000	0	00:00	0.000	0
E4-2	CONDUIT	0.000	0	00:00	0.000	0
E5	CONDUIT	0.104	0	11:00	0.014	0
E5-1	CONDUIT	0.058	0	11:00	0.008	0
E5-2	CONDUIT	0.057	0	11:00	0.007	0
E5-3	CONDUIT	0.055	0	11:00	0.007	0

E5-3-1	CONDUIT	0.003	0	11:00	0.000	0
E5-3.1	CONDUIT	0.044	0	11:00	0.006	0
E5-3.1.1	CONDUIT	0.005	0	10:54	0.001	0
E5-3.1.2	CONDUIT	0.000	0	00:00	0.000	0
E5-3.1.3	CONDUIT	0.000	0	00:00	0.000	0
E5-3.2	CONDUIT	0.030	0	11:00	0.004	0
E5-3.2.1	CONDUIT	0.000	0	00:00	0.000	0
E5-3.2.2	CONDUIT	0.010	0	11:00	0.001	0
E5-3.2.3	CONDUIT	0.002	0	11:00	0.000	0
E5-3.3	CONDUIT	0.020	0	10:54	0.003	0
E5-3.3.1	CONDUIT	0.000	0	00:00	0.000	0
E5-3.3.2	CONDUIT	0.000	0	00:00	0.000	0
E5-3.3.3	CONDUIT	0.000	0	00:00	0.000	0
E5-3.4	CONDUIT	0.000	0	00:00	0.000	0
E5-3.5	CONDUIT	0.000	0	00:00	0.000	0
E5-3.6	CONDUIT	0.000	0	00:00	0.000	0
E5-4	CONDUIT	0.006	0	11:00	0.001	0
E5-5	CONDUIT	0.002	0	11:00	0.000	0
E5A	CONDUIT	0.044	0	11:00	0.006	0
E6	CONDUIT	0.043	0	11:00	0.006	0
E7	CONDUIT	0.040	0	11:00	0.005	0
E8	CONDUIT	0.040	0	11:00	0.005	0
E9	CONDUIT	0.037	0	10:56	0.005	0
F	CONDUIT	0.226	0	11:00	0.032	0
F1	CONDUIT	0.011	0	11:00	0.001	0
F1-1	CONDUIT	0.007	0	11:00	0.001	0
F1-2	CONDUIT	0.006	0	11:00	0.001	0
F2	CONDUIT	0.004	0	11:00	0.001	0
F3	CONDUIT	0.003	0	11:00	0.000	0
F4	CONDUIT	0.002	0	10:38	0.000	0
G	CONDUIT	0.198	0	11:00	0.027	0
G1	CONDUIT	0.151	0	11:00	0.020	0
G1-1	CONDUIT	0.030	0	11:02	0.004	0
G1-2	CONDUIT	0.030	0	11:01	0.004	0
G1-3	CONDUIT	0.030	0	11:01	0.004	0
G1-4	CONDUIT	0.030	0	11:00	0.004	0
G1-5	CONDUIT	0.030	0	10:58	0.004	0
G1-6	CONDUIT	0.030	0	10:48	0.004	0
G1-7	CONDUIT	0.029	0	10:54	0.004	0
G10	CONDUIT	0.065	0	11:00	0.009	0
G11	CONDUIT	0.043	0	11:00	0.006	0
G11-1	CONDUIT	0.001	0	08:01	0.000	0
G12	CONDUIT	0.042	0	11:00	0.005	0
G13	CONDUIT	0.041	0	11:00	0.005	0
G13-1	CONDUIT	0.041	0	11:00	0.005	0
G13-2	CONDUIT	0.041	0	11:00	0.005	0
G13-3	CONDUIT	0.037	0	11:00	0.005	0
G13-4	CONDUIT	0.037	0	11:00	0.005	0
G15	CONDUIT	0.037	0	11:00	0.005	0
G16	CONDUIT	0.037	0	11:00	0.005	0
G16-1	CONDUIT	0.003	0	11:00	0.000	0
G16-2	CONDUIT	0.001	0	11:00	0.000	0
G17	CONDUIT	0.018	0	11:00	0.002	0
G2	CONDUIT	0.122	0	11:00	0.016	0
G3	CONDUIT	0.115	0	11:00	0.016	0
G4	CONDUIT	0.114	0	11:00	0.015	0
G4A	CONDUIT	0.094	0	11:00	0.013	0
G5	CONDUIT	0.080	0	11:00	0.011	0
G5-1	CONDUIT	0.006	0	11:00	0.001	0
G5-1-1	CONDUIT	0.003	0	11:00	0.000	0
G5-2	CONDUIT	0.002	0	09:00	0.000	0
G5-3	CONDUIT	0.001	0	11:00	0.000	0
G5A	CONDUIT	0.006	0	11:00	0.001	0

G5A-1	CONDUIT	0.000	0	11:00	0.000	0
G6	CONDUIT	0.073	0	11:00	0.010	0
G7	CONDUIT	0.066	0	11:00	0.009	0
G8	CONDUIT	0.066	0	11:00	0.009	0
G9	CONDUIT	0.066	0	11:00	0.009	0
G9-1	CONDUIT	0.001	0	09:43	0.000	0
H1	CONDUIT	0.007	0	11:00	0.001	0
H2	CONDUIT	0.003	0	11:00	0.000	0
HA	CONDUIT	0.011	0	11:00	0.001	0
I	CONDUIT	0.046	0	11:00	0.006	0
I-0	CONDUIT	1.777	0	11:20	0.240	0
I-1	CONDUIT	1.615	0	11:05	0.239	0
I-10	CONDUIT	0.272	0	11:00	0.038	0
I-11	CONDUIT	0.237	0	11:01	0.033	0
I-12	CONDUIT	0.196	0	11:00	0.027	0
I-2	CONDUIT	0.895	0	11:10	0.135	0
I-3	CONDUIT	0.634	0	10:32	0.090	0
I-4	CONDUIT	0.423	0	11:06	0.062	0
I-5	CONDUIT	0.422	0	11:05	0.061	0
I-6	CONDUIT	0.421	0	11:03	0.061	0
I-7	CONDUIT	0.419	0	11:00	0.059	0
I-8	CONDUIT	0.276	0	11:02	0.039	0
I-9	CONDUIT	0.272	0	11:01	0.038	0
I-A	CONDUIT	2.417	0	11:03	0.240	0
I.1	CONDUIT	0.000	0	00:00	0.000	0
I.2	CONDUIT	0.000	0	00:00	0.000	0
I.3	CONDUIT	0.000	0	00:00	0.000	0
I.4	CONDUIT	0.000	0	00:00	0.000	0
I1	CONDUIT	0.003	0	11:00	0.000	0
J	CONDUIT	0.042	0	11:00	0.005	0
J1	CONDUIT	0.007	0	11:00	0.001	0
J2	CONDUIT	0.001	0	11:00	0.000	0
JS-1	CONDUIT	0.478	0	11:00	0.062	0
JS-10	CONDUIT	0.008	0	10:53	0.001	0
JS-11	CONDUIT	0.008	0	10:59	0.001	0
JS-12	CONDUIT	0.005	0	09:01	0.001	0
JS-13	CONDUIT	0.007	0	09:00	0.000	0
JS-2	CONDUIT	0.478	0	11:00	0.062	0
JS-3	CONDUIT	0.465	0	11:00	0.060	0
JS-4	CONDUIT	0.463	0	11:00	0.060	0
JS-5	CONDUIT	0.463	0	11:00	0.060	0
JS-6	CONDUIT	0.111	0	11:00	0.014	0
JS-7	CONDUIT	0.111	0	11:00	0.014	0
JS-8	CONDUIT	0.104	0	11:00	0.013	0
JS-8A	CONDUIT	0.097	0	11:00	0.012	0
JS-9	CONDUIT	0.028	0	11:00	0.004	0
JS.3-1	CONDUIT	0.000	0	00:00	0.000	0
JS.3-2	CONDUIT	0.000	0	00:00	0.000	0
JS.3-3	CONDUIT	0.000	0	00:00	0.000	0
JS.9-1	CONDUIT	0.012	0	11:00	0.002	0
JS.9-2	CONDUIT	0.010	0	11:00	0.001	0
JS.9-3	CONDUIT	0.005	0	10:43	0.001	0
K1	CONDUIT	0.005	0	11:00	0.001	0
K2	CONDUIT	0.005	0	11:00	0.001	0
K3	CONDUIT	0.005	0	11:00	0.001	0
K4	CONDUIT	0.002	0	09:00	0.000	0
L	CONDUIT	0.035	0	11:00	0.005	0
L.1-1	CONDUIT	0.032	0	11:00	0.004	0
L.1-2	CONDUIT	0.001	0	11:00	0.000	0
L.1-3	CONDUIT	0.001	0	08:03	0.000	0
L1	CONDUIT	0.004	0	11:00	0.000	0
L2	CONDUIT	0.004	0	11:00	0.000	0
L3	CONDUIT	0.004	0	11:00	0.000	0

LS-1	CONDUIT	0.680	0	11:04	0.095	0
LS-10	CONDUIT	0.103	0	11:00	0.013	0
LS-11	CONDUIT	0.103	0	11:00	0.013	0
LS-12	CONDUIT	0.048	0	11:00	0.006	0
LS-13	CONDUIT	0.048	0	11:00	0.006	0
LS-14	CONDUIT	0.048	0	11:00	0.006	0
LS-15	CONDUIT	0.030	0	11:00	0.004	0
LS-16	CONDUIT	0.030	0	10:53	0.004	0
LS-17	CONDUIT	0.030	0	10:23	0.004	0
LS-2	CONDUIT	0.678	0	11:03	0.094	0
LS-3	CONDUIT	0.679	0	11:02	0.093	0
LS-4	CONDUIT	0.679	0	11:01	0.092	0
LS-5	CONDUIT	0.679	0	11:01	0.091	0
LS-6	CONDUIT	0.679	0	11:00	0.091	0
LS-7	CONDUIT	0.679	0	11:00	0.091	0
LS-8	CONDUIT	0.103	0	11:00	0.013	0
LS-9	CONDUIT	0.103	0	11:00	0.013	0
M	CONDUIT	0.485	0	11:00	0.063	0
M1	CONDUIT	0.483	0	11:00	0.063	0
M10	CONDUIT	0.218	0	11:00	0.028	0
M11	CONDUIT	0.218	0	11:00	0.028	0
M12	CONDUIT	0.218	0	11:00	0.028	0
M13	CONDUIT	0.218	0	11:00	0.028	0
M14	CONDUIT	0.022	0	11:00	0.003	0
M15	CONDUIT	0.022	0	11:00	0.003	0
M16	CONDUIT	0.022	0	11:00	0.003	0
M16-1	CONDUIT	0.010	0	11:00	0.001	0
M16-2	CONDUIT	0.008	0	11:00	0.001	0
M16-3	CONDUIT	0.005	0	11:00	0.001	0
M16-4	CONDUIT	0.003	0	10:38	0.000	0
M17	CONDUIT	0.010	0	11:00	0.001	0
M18	CONDUIT	0.009	0	11:00	0.001	0
M19	CONDUIT	0.006	0	11:00	0.001	0
M19-1	CONDUIT	0.006	0	09:00	0.000	0
M2	CONDUIT	0.481	0	11:00	0.063	0
M2-1	CONDUIT	0.003	0	11:00	0.000	0
M2-2	CONDUIT	0.003	0	10:51	0.000	0
M20	CONDUIT	0.002	0	11:00	0.000	0
M3	CONDUIT	0.401	0	11:00	0.052	0
M3.1	CONDUIT	0.005	0	10:51	0.001	0
M4	CONDUIT	0.397	0	11:00	0.052	0
M5	CONDUIT	0.397	0	11:00	0.052	0
M5-1	CONDUIT	0.122	0	11:00	0.016	0
M5-10	CONDUIT	0.032	0	10:59	0.004	0
M5-11	CONDUIT	0.029	0	10:51	0.004	0
M5-12	CONDUIT	0.024	0	10:17	0.003	0
M5-2	CONDUIT	0.122	0	11:00	0.016	0
M5-3	CONDUIT	0.122	0	11:00	0.016	0
M5-3-1	CONDUIT	0.000	0	11:00	0.000	0
M5-4	CONDUIT	0.108	0	11:00	0.014	0
M5-4.1	CONDUIT	0.026	0	11:00	0.003	0
M5-4.2	CONDUIT	0.011	0	10:39	0.001	0
M5-4.3	CONDUIT	0.006	0	11:00	0.001	0
M5-4.4	CONDUIT	0.006	0	10:01	0.000	0
M5-5	CONDUIT	0.081	0	10:58	0.010	0
M5-6	CONDUIT	0.042	0	10:57	0.005	0
M5-7	CONDUIT	0.038	0	10:56	0.005	0
M5-8	CONDUIT	0.036	0	10:58	0.005	0
M5-8.1	CONDUIT	0.000	0	00:00	0.000	0
M5-9	CONDUIT	0.035	0	10:58	0.005	0
M6	CONDUIT	0.274	0	11:00	0.036	0
M7	CONDUIT	0.272	0	11:00	0.035	0
M8	CONDUIT	0.271	0	11:00	0.035	0

M9	CONDUIT	0.270	0	11:00	0.035	0
M9-1	CONDUIT	0.052	0	10:44	0.007	0
M9-2	CONDUIT	0.006	0	11:00	0.001	0
M9-3	CONDUIT	0.002	0	11:00	0.000	0
MC-1	CONDUIT	0.012	0	11:00	0.002	0
MC-2	CONDUIT	0.005	0	11:00	0.001	0
MC-3	CONDUIT	0.003	0	11:00	0.000	0
MC-4	CONDUIT	0.000	0	00:00	0.000	0
MC-5	CONDUIT	0.000	0	00:00	0.000	0
MC-6	CONDUIT	0.000	0	00:00	0.000	0
MC-7	CONDUIT	0.000	0	00:00	0.000	0
MC-8	CONDUIT	0.000	0	00:00	0.000	0
MC-9	CONDUIT	0.000	0	00:00	0.000	0
MC.1-1	CONDUIT	0.003	0	10:58	0.000	0
MC.1-2	CONDUIT	0.003	0	10:57	0.000	0
MC.1-3	CONDUIT	0.002	0	10:57	0.000	0
MC.1-4	CONDUIT	0.002	0	10:22	0.000	0
MC.3-1	CONDUIT	0.001	0	10:57	0.000	0
MC.3-2	CONDUIT	0.001	0	09:00	0.000	0
MH-01	CONDUIT	0.607	0	11:00	0.080	0
MH-02	CONDUIT	0.508	0	11:00	0.067	0
MH-02A	CONDUIT	0.443	0	11:00	0.057	0
MH-03	CONDUIT	0.420	0	11:00	0.054	0
MH-04	CONDUIT	0.420	0	11:00	0.054	0
MH-04A	CONDUIT	0.420	0	11:00	0.054	0
MH-05	CONDUIT	0.412	0	11:00	0.053	0
MH-06	CONDUIT	0.059	0	11:00	0.008	0
MH-07	CONDUIT	0.000	0	00:00	0.000	0
N.1	CONDUIT	0.033	0	10:22	0.004	0
N.2	CONDUIT	0.032	0	10:02	0.004	0
N1	CONDUIT	0.041	0	10:43	0.005	0
N1-1	CONDUIT	0.006	0	10:57	0.001	0
N1-2	CONDUIT	0.002	0	09:00	0.000	0
N1.1	CONDUIT	0.005	0	10:39	0.001	0
N1.1.1	CONDUIT	0.000	0	00:00	0.000	0
N1.2	CONDUIT	0.003	0	10:14	0.000	0
N1.3	CONDUIT	0.002	0	09:14	0.000	0
N2	CONDUIT	0.042	0	10:43	0.005	0
N3	CONDUIT	0.031	0	11:00	0.004	0
N4	CONDUIT	0.022	0	11:00	0.003	0
N4-1	CONDUIT	0.000	0	00:00	0.000	0
N4-2	CONDUIT	0.000	0	00:00	0.000	0
N5	CONDUIT	0.000	0	00:00	0.000	0
N5-1	CONDUIT	0.000	0	00:00	0.000	0
N5-2	CONDUIT	0.000	0	00:00	0.000	0
N6	CONDUIT	0.000	0	00:00	0.000	0
N7	CONDUIT	0.000	0	00:00	0.000	0
N8	CONDUIT	0.000	0	00:00	0.000	0
SH-1	CONDUIT	0.328	0	11:00	0.042	0
SH-10	CONDUIT	0.214	0	10:59	0.028	0
SH-11	CONDUIT	0.093	0	11:00	0.012	0
SH-12	CONDUIT	0.090	0	10:56	0.012	0
SH-13	CONDUIT	0.082	0	10:43	0.011	0
SH-14	CONDUIT	0.080	0	10:52	0.010	0
SH-15	CONDUIT	0.077	0	10:40	0.010	0
SH-16	CONDUIT	0.000	0	00:00	0.000	0
SH-17	CONDUIT	0.115	0	10:16	0.015	0
SH-18	CONDUIT	0.009	0	11:00	0.001	0
SH-19	CONDUIT	0.008	0	10:58	0.001	0
SH-2	CONDUIT	0.328	0	11:00	0.042	0
SH-20	CONDUIT	0.017	0	11:00	0.002	0
SH-21	CONDUIT	0.017	0	11:00	0.002	0
SH-22	CONDUIT	0.016	0	11:00	0.002	0

SH-23	CONDUIT	0.009	0	11:00	0.001	0
SH-24	CONDUIT	0.001	0	09:00	0.000	0
SH-25	CONDUIT	0.002	0	10:54	0.000	0
SH-26	CONDUIT	0.002	0	10:57	0.000	0
SH-27	CONDUIT	0.006	0	11:00	0.001	0
SH-28	CONDUIT	0.000	0	00:00	0.000	0
SH-3	CONDUIT	0.328	0	11:00	0.042	0
SH-4	CONDUIT	0.008	0	10:47	0.001	0
SH-5	CONDUIT	0.005	0	10:51	0.001	0
SH-6	CONDUIT	0.000	0	00:00	0.000	0
SH-7	CONDUIT	0.229	0	11:00	0.030	0
SH-8	CONDUIT	0.220	0	11:00	0.028	0
SH-9	CONDUIT	0.217	0	10:59	0.028	0
SP-1	CONDUIT	0.351	0	11:01	0.045	0
SP-10	CONDUIT	0.239	0	11:00	0.031	0
SP-11	CONDUIT	0.239	0	11:00	0.031	0
SP-12	CONDUIT	0.214	0	11:00	0.028	0
SP-13	CONDUIT	0.021	0	11:00	0.003	0
SP-14	CONDUIT	0.016	0	11:00	0.002	0
SP-15	CONDUIT	0.013	0	11:00	0.002	0
SP-16	CONDUIT	0.009	0	11:00	0.001	0
SP-17	CONDUIT	0.005	0	11:00	0.001	0
SP-18	CONDUIT	0.002	0	11:00	0.000	0
SP-2	CONDUIT	0.351	0	11:00	0.045	0
SP-3	CONDUIT	0.351	0	11:00	0.045	0
SP-4	CONDUIT	0.351	0	11:00	0.045	0
SP-4A	CONDUIT	0.351	0	11:00	0.045	0
SP-5	CONDUIT	0.351	0	11:00	0.045	0
SP-6	CONDUIT	0.242	0	11:00	0.031	0
SP-7	CONDUIT	0.239	0	11:00	0.031	0
SP-8	CONDUIT	0.239	0	11:00	0.031	0
SP-9	CONDUIT	0.239	0	11:00	0.031	0
SP.12-1	CONDUIT	0.178	0	10:59	0.023	0
SP.12-2	CONDUIT	0.178	0	10:59	0.023	0
SP.12-3	CONDUIT	0.176	0	10:55	0.023	0
SP.13-1	CONDUIT	0.002	0	11:00	0.000	0
SP.6-1	CONDUIT	0.003	0	11:00	0.000	0
SP.7-1	CONDUIT	0.000	0	00:00	0.000	0
SP.7-2	CONDUIT	0.000	0	00:00	0.000	0
TP-1	CONDUIT	0.014	0	11:00	0.002	0
TP-10	CONDUIT	0.012	0	11:00	0.002	0
TP-11	CONDUIT	0.009	0	11:00	0.001	0
TP-12	CONDUIT	0.005	0	11:00	0.001	0
TP-2	CONDUIT	0.008	0	11:00	0.001	0
TP-3	CONDUIT	0.003	0	11:00	0.000	0
TP-4	CONDUIT	0.003	0	11:00	0.000	0
TP-5	CONDUIT	0.008	0	11:00	0.001	0
TP-6	CONDUIT	0.003	0	11:00	0.000	0
TP-7	CONDUIT	0.001	0	11:00	0.000	0
TP-8	CONDUIT	0.023	0	11:00	0.003	0
TP-9	CONDUIT	0.017	0	11:00	0.002	0
TP.1-1	CONDUIT	0.000	0	00:00	0.000	0
TP.10.1	CONDUIT	0.000	0	00:00	0.000	0
TP.5-1	CONDUIT	0.001	0	11:00	0.000	0
TP.6-1	CONDUIT	0.002	0	11:00	0.000	0
TP.8-1	CONDUIT	0.003	0	10:34	0.000	0
TP.9-1	CONDUIT	0.004	0	11:00	0.001	0
TP.9-2	CONDUIT	0.002	0	11:00	0.000	0
TP.9-3	CONDUIT	0.002	0	11:00	0.000	0

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Flow Classification Summary

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Conduit	Adjusted /Actual Length	Fraction of Time in Flow Class -- Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Nor Ltd
1.2.3-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
1.2.3-3	1.00	0.00	0.00	0.00	0.23	0.48	0.00	0.29	0.7
A-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A-12	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A-13	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A-14	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A-14.5-1	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.0
A-15	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A-2	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
A-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A-4	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
A-5	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A-6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A-7	1.00	0.01	0.00	0.00	0.00	0.57	0.00	0.42	0.5
A-8	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A-9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1-10	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.1-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1-12	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1-13	1.00	0.00	0.00	0.00	0.01	0.99	0.00	0.00	0.9
A.1-14	1.00	0.00	0.00	0.00	0.06	0.94	0.00	0.00	0.9
A.1-15	1.00	0.00	0.00	0.00	0.65	0.35	0.00	0.00	0.9
A.1-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1-4	1.00	0.02	0.00	0.00	0.00	0.19	0.00	0.80	0.1
A.1-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1-6	1.00	0.00	0.00	0.00	0.03	0.97	0.00	0.00	0.0
A.1-7	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
A.1-8	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.1-9	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.2
A.1.1-1	1.00	0.00	0.00	0.00	0.68	0.03	0.00	0.29	0.7
A.1.1-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.1-3	1.00	0.00	0.00	0.00	0.75	0.25	0.00	0.00	0.9
A.1.1-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.2-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.2-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.2-3	1.00	0.00	0.00	0.00	0.70	0.01	0.00	0.29	0.7
A.1.2-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.2-5	1.00	0.04	0.00	0.00	0.00	0.00	0.00	0.96	0.0
A.1.2-6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.2.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.2.2-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.3-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.3-2	1.00	0.00	0.00	0.00	0.11	0.89	0.00	0.00	0.9
A.1.3-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.3-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.3.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.1.4-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10-1	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
A.10-10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10-12	1.00	0.05	0.00	0.00	0.00	0.00	0.00	0.95	0.0
A.10-13	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10-2	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	0.0
A.10-3	1.00	0.01	0.00	0.00	0.03	0.97	0.00	0.00	0.0

A.10-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10-6	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
A.10-7	1.00	0.00	0.00	0.00	0.19	0.81	0.00	0.00	0.4
A.10-8	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
A.10-9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10.1-10	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.10.1-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10.1-12	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10.1-13	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.0
A.10.1-14	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.10.1-15	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.10.1-16	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.10.1-17	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.10.1-18	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.10.1-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10.1-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10.1-4	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.10.1-5	1.00	0.00	0.00	0.00	0.03	0.97	0.00	0.00	0.9
A.10.1-6	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
A.10.1-7	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A.10.1-8	1.00	0.00	0.00	0.00	0.03	0.97	0.00	0.00	0.0
A.10.1-9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10.1.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10.1.1-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10.1.10-1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.10.1.8-1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.10.2-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10.2-2	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
A.10.2-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.10.2-4	1.00	0.00	0.00	0.00	0.96	0.04	0.00	0.00	0.9
A.10.2-5	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.9
A.11-1	1.00	0.00	0.00	0.00	0.93	0.00	0.00	0.07	0.9
A.11-2	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.8
A.11-3	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.11-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.11-5	1.00	0.00	0.00	0.00	0.01	0.99	0.00	0.00	0.9
A.11.1-1	1.00	0.06	0.00	0.00	0.00	0.00	0.00	0.94	0.0
A.11.1-2	1.00	0.05	0.00	0.00	0.95	0.00	0.00	0.00	0.8
A.11.1-3	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	0.0
A.11.1-4	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.8
A.11.1.4-1	1.00	0.00	0.02	0.00	0.97	0.00	0.00	0.00	0.9
A.11.1.4-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.11.1.4-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.11.1.4-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.12-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.12-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.13-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14-1.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14-1.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14-1.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14-1.4	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A.14-1.5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14-1.6	1.00	0.00	0.00	0.00	0.78	0.22	0.00	0.00	0.9
A.14-1.7	1.00	0.00	0.00	0.00	0.95	0.05	0.00	0.00	0.9
A.14-1.8	1.00	0.00	0.00	0.00	0.93	0.07	0.00	0.00	0.9
A.14-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14-3	1.00	0.04	0.00	0.00	0.00	0.00	0.00	0.96	0.0
A.14-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14-5	1.00	0.35	0.00	0.00	0.00	0.00	0.00	0.65	0.0
A.14-6	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0

A.14-7	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.14-8	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.14.1-1	1.00	0.08	0.00	0.00	0.00	0.00	0.00	0.92	0.0
A.14.1-1A	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A.14.1-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14.1-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14.2-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14.3-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14.4-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.14.7-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.14.7-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.14.7-A	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.15-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.15-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.15-3	1.00	0.00	0.00	0.00	0.97	0.03	0.00	0.00	0.9
A.15-4	1.00	0.00	0.01	0.00	0.92	0.06	0.00	0.00	0.9
A.15-5	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
A.15-6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.15-8	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.15.5-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.16-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.17-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.17-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.17-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.17-4	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0
A.17-4.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.17-5	1.00	0.00	0.00	0.00	0.99	0.01	0.00	0.00	1.0
A.17-6	1.00	0.00	0.02	0.00	0.98	0.00	0.00	0.00	0.9
A.17-7	1.00	0.02	0.00	0.00	0.11	0.87	0.00	0.00	0.9
A.17-8	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
A.17-9	1.00	0.05	0.00	0.00	0.00	0.00	0.00	0.95	0.0
A.17.1-1	1.00	0.00	0.00	0.00	0.92	0.08	0.00	0.00	0.9
A.2-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2-10	1.00	0.00	0.01	0.00	0.03	0.96	0.00	0.00	0.0
A.2-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2-12	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A.2-13	1.00	0.00	0.00	0.00	0.01	0.98	0.00	0.00	0.0
A.2-14	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2-2	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A.2-3	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A.2-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2-5	1.00	0.00	0.00	0.00	0.06	0.94	0.00	0.00	0.9
A.2-6	1.00	0.00	0.01	0.00	0.03	0.95	0.00	0.00	0.9
A.2-7	1.00	0.00	0.00	0.00	0.03	0.97	0.00	0.00	0.0
A.2-8	1.00	0.00	0.00	0.00	0.05	0.95	0.00	0.00	0.9
A.2-9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2.1-2	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.2.1-3	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.2.1A-1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.2.1A-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2.1A-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2.1A-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2.1A-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2.1A-6	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.2.1A.1-1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0
A.2.1A.2-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2.2-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2.2-2	1.00	0.00	0.00	0.00	0.17	0.83	0.00	0.00	0.0
A.2.2-3	1.00	0.00	0.01	0.00	0.58	0.41	0.00	0.00	0.9
A.2.2-4	1.00	0.00	0.00	0.00	0.03	0.96	0.00	0.00	0.0
A.2.2-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.2.2.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0

A.2.2.2-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.3.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.3A-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.4-1	1.00	0.06	0.00	0.00	0.00	0.00	0.00	0.94	0.0
A.4-10	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.9
A.4-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4-12	1.00	0.00	0.00	0.00	0.57	0.43	0.00	0.00	0.0
A.4-13	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.4-14	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4-15	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4-16	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4-17	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4-18	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4-2	1.00	0.04	0.00	0.00	0.96	0.00	0.00	0.00	0.7
A.4-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4-4	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.4-4A	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.4-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4-6	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A.4-7	1.00	0.02	0.00	0.00	0.00	0.33	0.00	0.66	0.1
A.4-8	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A.4-9	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.9
A.4.1-1	1.00	0.00	0.00	0.00	0.99	0.01	0.00	0.00	0.9
A.4.1-1A	1.00	0.00	0.03	0.00	0.16	0.81	0.00	0.00	0.9
A.4.1-2	1.00	0.00	0.00	0.00	0.22	0.78	0.00	0.00	0.1
A.4.10-1	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.0
A.4.10-1A	1.00	0.01	0.00	0.00	0.87	0.13	0.00	0.00	0.9
A.4.10-2	1.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.9
A.4.10-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4.10-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4.10-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4.10-6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4.10-7	1.00	0.06	0.00	0.00	0.00	0.00	0.00	0.94	0.0
A.4.10-8	1.00	0.06	0.94	0.00	0.00	0.00	0.00	0.00	0.0
A.4.10.6-1	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A.4.10.6-2	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A.4.10.6-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4.16-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.4.2-1	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	0.0
A.4.2-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4.5-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.4.5-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.4.5-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A.4.8-1	1.00	0.91	0.09	0.00	0.00	0.00	0.00	0.00	0.0
A.5-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.5-2	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.5-3	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.7
A.5-4	1.00	0.00	0.00	0.00	0.06	0.00	0.00	0.94	0.0
A.5-5	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.8
A.5-6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.5-7	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0
A.5-8	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.9
A.5-9	1.00	0.00	0.00	0.00	0.01	0.99	0.00	0.00	1.0
A.5.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.5.1-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.5.1-3	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.5.1-4	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.5.2-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.5.2-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.5.2-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.5.2.1-1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0
A.5.3-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.5.3-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0

A.5.3.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6-3	1.00	0.09	0.00	0.00	0.00	0.00	0.00	0.91	0.0
A.6-4	1.00	0.00	0.00	0.00	0.99	0.01	0.00	0.00	0.9
A.6-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6-6	1.00	0.00	0.00	0.00	0.01	0.99	0.00	0.00	0.9
A.6-7	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
A.6-8	1.00	0.01	0.00	0.00	0.22	0.77	0.00	0.00	0.9
A.6-9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6.2-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6.2-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6.2-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6.2-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6.3-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6.4-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6.4-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.6.4.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.7-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.7-2	1.00	0.00	0.01	0.00	0.99	0.00	0.00	0.00	0.9
A.7-3	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.3
A.8-1	1.00	0.01	0.00	0.00	0.56	0.00	0.00	0.44	0.5
A.8-2	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.5
A.8-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.8-4	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.8-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.8-6	1.00	0.00	0.00	0.00	0.02	0.97	0.00	0.00	0.9
A.8-7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.8-8	1.00	0.00	0.00	0.00	0.03	0.97	0.00	0.00	0.8
A.8.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.9-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.9-2	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.9-3	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.9-4	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
A.9-5	1.00	0.00	0.00	0.00	0.89	0.11	0.00	0.00	0.9
A.9-6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.9-7	1.00	0.00	0.00	0.00	0.04	0.96	0.00	0.00	0.0
A.9A-1	1.00	0.00	0.00	0.00	0.48	0.00	0.00	0.51	0.4
A.9A-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A.9A-3	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.9
A.9A-4	1.00	0.00	0.00	0.00	0.04	0.96	0.00	0.00	1.0
A.9A.2-1	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.0
A.A5-7	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
A1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
A3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B-10	1.00	0.00	0.00	0.00	0.77	0.03	0.00	0.21	0.7
B-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B-3	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
B-4	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
B-5	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
B-6	1.00	0.00	0.00	0.00	0.02	0.98	0.00	0.00	0.9
B-7	1.00	0.00	0.01	0.00	0.17	0.82	0.00	0.00	0.0
B-8	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.8
B.1-1	1.00	0.00	0.00	0.00	0.68	0.00	0.00	0.32	0.6
B.1A-1	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
B.2-1	1.00	0.00	0.00	0.00	0.64	0.00	0.00	0.36	0.6
B.2A-1	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
B.3-1	1.00	0.00	0.00	0.00	0.98	0.02	0.00	0.00	0.9
B.3-2	1.00	0.00	0.00	0.00	0.01	0.99	0.00	0.00	0.0

B.3A-1	1.00	0.01	0.00	0.00	0.04	0.95	0.00	0.00	0.9
B.4-1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
B.4-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B.4-3	1.00	0.00	0.00	0.00	0.02	0.98	0.00	0.00	0.0
B.4-4	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
B.4-5	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0
B.4-6	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
B.4-7	1.00	0.00	0.02	0.00	0.98	0.00	0.00	0.00	0.9
B.4-8	1.00	0.02	0.00	0.00	0.01	0.97	0.00	0.00	0.2
B.4A-1	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.0
B.5A-1	1.00	0.01	0.00	0.00	0.98	0.01	0.00	0.00	0.9
B.6-1	1.00	0.02	0.00	0.00	0.81	0.00	0.00	0.17	0.8
B.6-1A	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B.6-2	1.00	0.00	0.00	0.00	0.39	0.61	0.00	0.00	0.9
B.6-2A	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B.6-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B.6-3A	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B.6-4A	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B.6-5A	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B.6-6A	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0
B.6.A-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B.6A-1	1.00	0.00	0.00	0.00	0.01	0.99	0.00	0.00	0.2
B.7-1	1.00	0.00	0.00	0.00	0.80	0.01	0.00	0.19	0.8
B.7-2	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
B.7-3	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
B.7.1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B.7.2-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
B1	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
B2	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
B3	1.00	0.00	0.00	0.00	0.03	0.97	0.00	0.00	0.8
B4	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
B5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
C1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
C2	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
C3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
C4	1.00	0.00	0.00	0.00	0.22	0.78	0.00	0.00	0.9
CDT-37	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.1
CV-01	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.0
CV-02	1.00	0.00	0.00	0.00	0.01	0.99	0.00	0.00	0.9
CV-03	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV-04	1.00	0.00	0.00	0.00	0.02	0.98	0.00	0.00	1.0
CV-05	1.00	0.00	0.00	0.00	0.17	0.82	0.00	0.00	0.0
CV-06	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.8
CV-07	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.4
CV-08	1.00	0.00	0.00	0.00	0.58	0.42	0.00	0.00	0.9
CV-09	1.00	0.00	0.00	0.00	0.06	0.94	0.00	0.00	0.6
CV-10	1.00	0.00	0.01	0.00	0.05	0.95	0.00	0.00	0.9
CV-11	1.00	0.00	0.00	0.00	0.01	0.98	0.00	0.00	0.0
CV-12	1.00	0.00	0.00	0.00	0.29	0.71	0.00	0.00	0.0
CV-13	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.4
CV-14	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
CV-15	1.00	0.00	0.01	0.00	0.99	0.00	0.00	0.00	0.9
CV-16	1.00	0.01	0.00	0.00	0.03	0.96	0.00	0.00	0.9
CV-17	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.0
CV-18	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
CV-19	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.9
CV-20	1.00	0.00	0.00	0.00	0.01	0.98	0.00	0.00	0.0
CV-21	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV-22	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV-23	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
CV-24	1.00	0.00	0.00	0.00	0.59	0.41	0.00	0.00	0.9
CV-25	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV-26	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0

CV-27	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV-28	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV-29	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV-30	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV-31	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.10-1	1.00	0.95	0.05	0.00	0.00	0.00	0.00	0.00	0.0
CV.10-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.10-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.10-4	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.10-5	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.10-6	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.10.4-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12-1	1.00	0.04	0.00	0.00	0.30	0.00	0.00	0.66	0.2
CV.12-10	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12-11	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12-2	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	0.0
CV.12-3	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	0.0
CV.12-4	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
CV.12-5	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
CV.12-6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.12-7	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12-8	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12-9	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.5-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.5-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.5-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.6-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.6-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.6-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.7-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.7-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.7-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.7-4	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.8-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.8-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.8-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.8-4	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.8-5	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.8-6	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.8-7	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.12.8-8	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.14-1	1.00	0.00	0.02	0.00	0.98	0.00	0.00	0.00	0.9
CV.14-10	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.14-2	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
CV.14-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.14-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.14-5	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
CV.14-6	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
CV.14-7	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
CV.14-8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.14-9	1.00	0.04	0.00	0.00	0.00	0.00	0.00	0.96	0.0
CV.14.3-1	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
CV.14.3-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.14.3-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.14.3.2-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.14.5-1	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	0.0
CV.14.5-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.14.5-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.14.5-4	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.14.5-5	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.14.5.2-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.16-1	1.00	0.07	0.00	0.00	0.00	0.00	0.00	0.93	0.0
CV.16-2	1.00	0.06	0.00	0.00	0.00	0.00	0.00	0.94	0.0

CV.16-3	1.00	0.04	0.00	0.00	0.00	0.00	0.00	0.96	0.0
CV.16-4	1.00	0.04	0.00	0.00	0.00	0.00	0.00	0.96	0.0
CV.16-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.16-6	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.18-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.18-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.18-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.18-4	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.18-5	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.18-6	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.19-1	1.00	0.05	0.00	0.00	0.00	0.00	0.00	0.95	0.0
CV.19-2	1.00	0.05	0.00	0.00	0.00	0.00	0.00	0.95	0.0
CV.19-3	1.00	0.30	0.00	0.00	0.00	0.00	0.00	0.70	0.0
CV.19-4	1.00	0.43	0.00	0.00	0.00	0.00	0.00	0.57	0.0
CV.19-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.19.2-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.19.2-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.19.2-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.21-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.21-10	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.21-11	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.21-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.21-3	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0
CV.21-4	1.00	0.05	0.00	0.00	0.00	0.00	0.00	0.95	0.0
CV.21-5	1.00	0.04	0.00	0.00	0.00	0.00	0.00	0.96	0.0
CV.21-6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.21-7	1.00	0.06	0.00	0.00	0.00	0.00	0.00	0.94	0.0
CV.21-8	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	0.0
CV.21-9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.26-1	1.00	0.06	0.00	0.00	0.00	0.00	0.00	0.94	0.0
CV.26-2	1.00	0.20	0.00	0.00	0.00	0.00	0.00	0.80	0.0
CV.26-3	1.00	0.10	0.00	0.00	0.00	0.00	0.00	0.90	0.0
CV.26-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
CV.26.3-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.8-1	1.00	0.74	0.26	0.00	0.00	0.00	0.00	0.00	0.0
CV.8-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.8-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.8-4	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV.8-5	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
CV14-11	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
D1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
D2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E11-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
E12	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E3	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
E4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E4-1	1.00	0.03	0.97	0.00	0.00	0.00	0.00	0.00	0.0
E4-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
E5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E5-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E5-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E5-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E5-3-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E5-3.1	1.00	0.00	0.00	0.00	0.02	0.98	0.00	0.00	0.0
E5-3.1.1	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0
E5-3.1.2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
E5-3.1.3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
E5-3.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E5-3.2.1	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.0
E5-3.2.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0

E5-3.2.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E5-3.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E5-3.3.1	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.0
E5-3.3.2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
E5-3.3.3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
E5-3.4	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.0
E5-3.5	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
E5-3.6	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
E5-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E5-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E5A	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
E9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
F	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
F1	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
F1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
F1-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
F2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
F3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
F4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G1-1	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	0.0
G1-2	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
G1-3	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
G1-4	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
G1-5	1.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.8
G1-6	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.9
G1-7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G11	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
G11-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G12	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G13	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
G13-1	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.9
G13-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G13-3	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
G13-4	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
G15	1.00	0.00	0.00	0.00	0.08	0.92	0.00	0.00	0.9
G16	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G16-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G16-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G17	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G4A	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G5-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G5-1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G5-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G5-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G5A	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
G5A-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G7	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
G8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
G9-1	1.00	0.00	0.00	0.00	0.10	0.00	0.00	0.90	0.1
H1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
H2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0

HA	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
I	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
I-0	1.00	0.01	0.00	0.00	0.92	0.07	0.00	0.00	0.0
I-1	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
I-10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
I-11	1.00	0.01	0.00	0.00	0.10	0.00	0.00	0.89	0.0
I-12	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
I-2	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.3
I-3	1.00	0.00	0.00	0.00	0.09	0.00	0.00	0.91	0.0
I-4	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0
I-5	1.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.7
I-6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
I-7	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
I-8	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0
I-9	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.8
I-A	1.00	0.02	0.00	0.00	0.04	0.94	0.00	0.00	0.0
I.1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
I.2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
I.3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
I.4	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
I1	1.00	0.00	0.00	0.00	0.33	0.03	0.00	0.64	0.3
J	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
J1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
J2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
JS-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
JS-10	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
JS-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
JS-12	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
JS-13	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
JS-2	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.0
JS-3	1.00	0.00	0.00	0.00	0.12	0.88	0.00	0.00	0.0
JS-4	1.00	0.00	0.01	0.00	0.98	0.01	0.00	0.00	0.0
JS-5	1.00	0.01	0.00	0.00	0.98	0.02	0.00	0.00	0.6
JS-6	1.00	0.00	0.00	0.00	0.98	0.02	0.00	0.00	0.9
JS-7	1.00	0.00	0.00	0.00	0.26	0.74	0.00	0.00	0.0
JS-8	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.2
JS-8A	1.00	0.00	0.00	0.00	0.99	0.00	0.00	0.01	0.9
JS-9	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.0
JS.3-1	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.0
JS.3-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
JS.3-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
JS.9-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
JS.9-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
JS.9-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
K1	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
K2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
K3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
K4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
L	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
L.1-1	1.00	0.00	0.00	0.00	0.02	0.98	0.00	0.00	0.0
L.1-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
L.1-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
L1	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
L2	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
L3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
LS-1	1.00	0.00	0.00	0.00	0.99	0.01	0.00	0.00	0.0
LS-10	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.9
LS-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
LS-12	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
LS-13	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
LS-14	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
LS-15	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
LS-16	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0

LS-17	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
LS-2	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
LS-3	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
LS-4	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
LS-5	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.9
LS-6	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.0
LS-7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
LS-8	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.0
LS-9	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.9
M	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M10	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
M11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M12	1.00	0.00	0.00	0.00	0.99	0.01	0.00	0.00	0.0
M13	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M14	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
M15	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
M16	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M16-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M16-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M16-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M16-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M17	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M18	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M19	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M19-1	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	0.0
M2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M2-1	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
M2-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M20	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M3	1.00	0.00	0.00	0.00	0.00	0.07	0.00	0.93	0.0
M3.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M4	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
M5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-1	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
M5-10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-12	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
M5-2	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
M5-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-3-1	1.00	0.00	0.00	0.00	0.56	0.00	0.00	0.43	0.5
M5-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-4.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-4.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-4.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-4.4	1.00	0.21	0.00	0.00	0.00	0.00	0.00	0.79	0.0
M5-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M5-8.1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
M5-9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M9-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M9-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
M9-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
MC-1	1.00	0.00	0.00	0.00	0.05	0.21	0.00	0.74	0.2
MC-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
MC-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
MC-4	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

MC-5	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
MC-6	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
MC-7	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
MC-8	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
MC-9	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
MC.1-1	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
MC.1-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
MC.1-3	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
MC.1-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
MC.3-1	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.0
MC.3-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
MH-01	1.00	0.00	0.00	0.00	0.97	0.03	0.00	0.00	0.0
MH-02	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
MH-02A	1.00	0.00	0.01	0.00	0.99	0.00	0.00	0.00	0.9
MH-03	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.6
MH-04	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
MH-04A	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.9
MH-05	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.0
MH-06	1.00	0.00	0.00	0.00	0.78	0.00	0.00	0.22	0.7
MH-07	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.0
N.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
N.2	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.9
N1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
N1-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
N1-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
N1.1	1.00	0.00	0.00	0.00	0.05	0.26	0.00	0.69	0.3
N1.1.1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
N1.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
N1.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
N2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
N3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
N4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
N4-1	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.0
N4-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
N5	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.0
N5-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
N5-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
N6	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
N7	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
N8	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
SH-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-12	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-13	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-14	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-15	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-16	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
SH-17	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-18	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-19	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-20	1.00	0.00	0.00	0.00	0.93	0.02	0.00	0.05	0.9
SH-21	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-22	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-23	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-24	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-25	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
SH-26	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-27	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-28	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
SH-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-4	1.00	0.00	0.00	0.00	0.32	0.09	0.00	0.59	0.4

SH-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-6	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
SH-7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SH-9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SP-1	1.00	0.01	0.01	0.00	0.98	0.00	0.00	0.00	0.9
SP-10	1.00	0.00	0.00	0.00	0.01	0.99	0.00	0.00	0.0
SP-11	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.0
SP-12	1.00	0.00	0.00	0.00	0.01	0.99	0.00	0.00	0.9
SP-13	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SP-14	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SP-15	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SP-16	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SP-17	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SP-18	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SP-2	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.9
SP-3	1.00	0.01	0.00	0.00	0.03	0.96	0.00	0.00	0.0
SP-4	1.00	0.00	0.00	0.00	0.66	0.34	0.00	0.00	0.9
SP-4A	1.00	0.00	0.00	0.00	0.01	0.99	0.00	0.00	0.0
SP-5	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.7
SP-6	1.00	0.00	0.01	0.00	0.04	0.95	0.00	0.00	0.9
SP-7	1.00	0.01	0.01	0.00	0.01	0.97	0.00	0.00	0.0
SP-8	1.00	0.01	0.00	0.00	0.01	0.98	0.00	0.00	0.9
SP-9	1.00	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.9
SP.12-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SP.12-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SP.12-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SP.13-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
SP.6-1	1.00	0.00	0.00	0.00	0.81	0.00	0.00	0.19	0.8
SP.7-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
SP.7-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
TP-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP-10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP-12	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP-3	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
TP-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP-6	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
TP-7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP-8	1.00	0.00	0.00	0.00	0.94	0.00	0.00	0.06	0.9
TP-9	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
TP.1-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
TP.10.1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
TP.5-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP.6-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP.8-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP.9-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0
TP.9-2	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.0
TP.9-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.0

****
Conduit Surcharge Summary
****

Conduit	Hours Full: Both Ends	Hours Full: Upstream	Hours Full: Dnstream	Hours Above Full Normal Flow	Hours Capacity Limited
B-8	0.00	0.00	0.00	0.74	0.00

```
Analysis begun on:  Mon Feb 08 18:14:28 2016
Analysis ended on:  Mon Feb 08 18:14:41 2016
Total elapsed time: 00:00:13
```

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX I-2

MODELING RESULTS PRINTOUT
INDUSTRIAL PARK COLLECTION SYSTEM
FUTURE WILLOWBROOK BUILDOUT CONDITIONS

<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.0 Transitional//EN">
<!-- saved from url=(0159)file://P:\MAD (CITY OF MADRAS)\MAD-05 (WW MASTER PLAN UPDATE)\MAD05 -
<HTML><HEAD><META content="IE=5.0000" http-equiv="X-UA-Compatible">

<META content="text/html; charset=windows-1252" http-equiv=Content-Type>
<META name=GENERATOR content="MSHTML 11.00.9600.18231"></HEAD>
<BODY><PRE>
US-EPA Storm Water Management Model - Version 5.1 (Build 5.1.009)

NOTE: The summary statistics displayed in this report are
based on results found at every computational time step,
not just on results from each reporting time step.

Analysis Options

Flow Units ..... MGD
Process Models:
  Rainfall/Runoff ..... NO
  RDII ..... NO
  Snowmelt ..... NO
  Groundwater ..... NO
  Flow Routing ..... YES
  Ponding Allowed ..... YES
  Water Quality ..... NO
Flow Routing Method ..... DYNWAVE
Starting Date JAN-01-2015 00:00:00
Ending Date JAN-01-2015 23:00:00
Antecedent Dry Days 5.0
Report Time Step 23:00:00
Routing Time Step ..... 20.00 sec
Variable Time Step ..... YES
Maximum Trials 4
Head Tolerance ..... 0.005000 ft

Flow Routing Continuity	Volume acre-feet	Volume 10^6 gal
Dry Weather Inflow	0.212	0.069
Wet Weather Inflow	0.000	0.000
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	0.000	0.000
External Outflow	0.205	0.067
Internal Outflow	0.000	0.000
Evaporation Loss	0.000	0.000
Exfiltration Loss	0.000	0.000
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.006	0.002
Continuity Error (%)	0.261	

Highest Continuity Errors

Node IB-2-4	5.59%	0.0000
Node IB-3.2	4.84%	0.0000
Node IB-3	4.65%	0.0000

Node IB-3.3	3.42%	0.0000
Node IB-2.6-2	2.01%	0.0000
Node IB-2.6-1	1.77%	0.0000
Node IB-2.6-3	1.76%	0.0000
Node IB-2-3-4	1.74%	0.0000
Node IB-3.1	0.96%	0.0000
Node IA-16-1	0.88%	0.0000
Node IB-2-3-2	0.86%	0.0000
Node IA-16-2	0.74%	0.0000
Node IB-2	0.74%	0.0000
Node IB-2-3-1	0.74%	0.0000
Node IB-2-3-3	0.73%	0.0000
Node IA-16-4	0.73%	0.0000
Node IB-2-3	0.68%	0.0000
Node IA-21-1	0.64%	0.0000
Node IA-20	0.58%	0.0001
Node IB-2-6	0.56%	0.0000
		0.0003 Mgal

****
Time-Step Critical Elements
****
Node IB-2.6-3 (0.00%)
Link IB-3.3 (0.00%)
Link IB-2.6-1 (0.00%)
Link IB-2.3-4 (0.00%)
Link IB-2.3-3 (0.00%)
Node IB-2.6-4 (0.00%)
Link IB-2.6-3 (0.00%)
Link IB-3.2 (0.00%)
Link IB-2.3-5 (0.00%)
Link IB-2A (0.00%)
Link IB-2.6.2-1 (0.00%)
Link IB-2.6-4 (0.00%)
Link IB-2.6-2 (0.00%)
Link IB-3.1 (0.00%)
Link IB-3 (0.00%)
Node IB-2-3-5 (0.00%)
Node IA-16-1-1 (0.00%)
Link IB-3.4 (0.00%)
Node IB-2-6 (0.00%)
Node IB-2-5 (0.00%)

****
Highest Flow Instability Indexes
****
Link IA-1 (81)
Link IA-16-5 (3)
Link IA-12 (0)
Link IA-21 (0)
Link IB-2-12 (0)
Link IB-3.2 (0)
Link IB-2-6 (0)
Link IB-2-3-2 (0)
Link IB-2-11 (0)
Link IA-10-1 (0)
Link IB-2.6.2-1 (0)
Link IB-2-3-1 (0)
Link IA-13 (0)
Link IB-2-7 (0)
Link IB-2-3 (0)

Link IA-10 (0)
Link IA-13-1 (0)
Link IB-2-3-3 (0)
Link IB-2-8 (0)
Link IA-8 (0)

****
Routing Time Step Summary
****

Minimum Time Step	:	19.90 sec
Average Time Step	:	20.00 sec
Maximum Time Step	:	20.00 sec
Percent in Steady State	:	0.00
Average Iterations per Step	:	2.20
Percent Not Converging	:	2.85
Total Steps	:	4141
Total Iterations	:	9096

****
Node Depth Summary
****

Node	Type	Average Depth Feet	Maximum Depth Feet	Maximum Run HGL Feet	Time of Max Occurrence days hr:min	Reported Max Depth Feet	Time of Max Occurrence days hr:min
IA-1	JUNCTION	0.07	0.18	2423.68	0 11:12	0.05	0 23:00
IA-10	JUNCTION	0.15	0.30	2438.56	0 11:00	0.10	0 23:00
IA-10-1	JUNCTION	0.01	0.02	2443.97	0 11:00	0.01	0 23:0
IA-11	JUNCTION	0.17	0.35	2439.37	0 11:00	0.12	0 23:00
IA-12	JUNCTION	0.14	0.28	2440.62	0 11:00	0.10	0 23:00
IA-13	JUNCTION	0.06	0.13	2443.07	0 11:09	0.05	0 23:00
IA-13-1	JUNCTION	0.07	0.14	2445.06	0 11:04	0.05	0 23:00
IA-14	JUNCTION	0.07	0.13	2447.03	0 11:01	0.05	0 23:00
IA-15	JUNCTION	0.06	0.13	2448.11	0 11:00	0.05	0 23:00
IA-15-1	JUNCTION	0.00	0.00	2451.42	0 00:00	0.00	0 00:00
IA-15-2	JUNCTION	0.00	0.00	2453.62	0 00:00	0.00	0 00:00
IA-15-3	JUNCTION	0.00	0.00	2455.60	0 00:00	0.00	0 00:00
IA-16	JUNCTION	0.08	0.16	2448.61	0 11:03	0.06	0 23:00
IA-16-1	JUNCTION	0.04	0.07	2449.70	0 11:01	0.03	0 23:00
IA-16-1-1	JUNCTION	0.00	0.00	2452.24	0 00:00	0.00	0 00:00
IA-16-2	JUNCTION	0.04	0.07	2451.32	0 11:00	0.03	0 23:00
IA-16-3	JUNCTION	0.04	0.07	2453.06	0 11:00	0.03	0 23:00
IA-16-4	JUNCTION	0.04	0.07	2455.06	0 11:00	0.03	0 23:00
IA-16-5	JUNCTION	0.02	0.04	2460.23	0 10:32	0.02	0 23:00
IA-17	JUNCTION	0.07	0.13	2450.79	0 11:01	0.05	0 23:00
IA-18	JUNCTION	0.07	0.13	2452.88	0 11:00	0.05	0 23:00
IA-19	JUNCTION	0.08	0.15	2454.30	0 11:00	0.05	0 23:00
IA-2	JUNCTION	0.14	0.30	2427.45	0 11:17	0.11	0 23:00
IA-20	JUNCTION	0.05	0.11	2458.03	0 11:00	0.04	0 23:00
IA-20-1	JUNCTION	0.00	0.00	2458.63	0 00:00	0.00	0 00:00
IA-20-2	JUNCTION	0.00	0.00	2460.47	0 00:00	0.00	0 00:00
IA-21	JUNCTION	0.05	0.09	2460.38	0 11:00	0.03	0 23:00
IA-21-1	JUNCTION	0.01	0.02	2467.56	0 11:00	0.01	0 23:00
IA-21-2	JUNCTION	0.01	0.02	2476.91	0 11:00	0.01	0 23:00
IA-3	JUNCTION	0.15	0.32	2428.96	0 11:14	0.12	0 23:00
IA-4	JUNCTION	0.15	0.32	2430.48	0 11:11	0.12	0 23:0(
IA-5	JUNCTION	0.15	0.32	2432.04	0 11:09	0.11	0 23:00
IA-6	JUNCTION	0.16	0.33	2433.48	0 11:06	0.12	0 23:00
IA-7	JUNCTION	0.15	0.32	2435.20	0 11:04	0.11	0 23:00
IA-8	JUNCTION	0.14	0.29	2436.67	0 11:01	0.10	0 23:00

IA-9	JUNCTION	0.14	0.30	2437.93	0	11:00	0.10	0	23:00
IB-2	JUNCTION	0.05	0.09	2426.25	0	11:04	0.05	0	23:00
IB-2-1	JUNCTION	0.03	0.06	2430.26	0	11:01	0.02	0	23:00
IB-2-10	JUNCTION	0.00	0.00	2460.85	0	00:00	0.00	0	00:00
IB-2-11	JUNCTION	0.00	0.00	2462.34	0	00:00	0.00	0	00:00
IB-2-12	JUNCTION	0.00	0.00	2462.57	0	00:00	0.00	0	00:00
IB-2-2	JUNCTION	0.03	0.06	2433.29	0	11:00	0.03	0	23:00
IB-2-3	JUNCTION	0.03	0.06	2435.33	0	11:00	0.03	0	23:00
IB-2-3-1	JUNCTION	0.03	0.05	2437.29	0	11:00	0.02	0	23:00
IB-2-3-2	JUNCTION	0.02	0.04	2438.76	0	11:00	0.01	0	23:00
IB-2-3-3	JUNCTION	0.02	0.04	2439.96	0	11:00	0.02	0	23:00
IB-2-3-4	JUNCTION	0.01	0.02	2441.43	0	11:00	0.01	0	23:00
IB-2-3-5	JUNCTION	0.01	0.02	2442.96	0	11:00	0.01	0	23:00
IB-2-4	JUNCTION	0.03	0.05	2439.98	0	11:39	0.03	0	23:00
IB-2-5	JUNCTION	0.01	0.02	2444.15	0	11:00	0.01	0	23:00
IB-2-6	JUNCTION	0.01	0.01	2447.77	0	11:17	0.00	0	23:00
IB-2-7	JUNCTION	0.00	0.00	2458.53	0	00:00	0.00	0	00:00
IB-2-8	JUNCTION	0.00	0.00	2459.25	0	00:00	0.00	0	00:00
IB-2-9	JUNCTION	0.00	0.00	2459.94	0	00:00	0.00	0	00:00
IB-2.3-1	JUNCTION	0.00	0.00	2437.34	0	00:00	0.00	0	00:00
IB-2.3-2	JUNCTION	0.00	0.00	2439.18	0	00:00	0.00	0	00:00
IB-2.3-3	JUNCTION	0.00	0.00	2440.41	0	00:00	0.00	0	00:00
IB-2.3-4	JUNCTION	0.00	0.00	2442.11	0	00:00	0.00	0	00:00
IB-2.3-5	JUNCTION	0.00	0.00	2448.80	0	00:00	0.00	0	00:00
IB-2.6-1	JUNCTION	0.01	0.02	2449.10	0	11:11	0.01	0	23:00
IB-2.6-2	JUNCTION	0.01	0.02	2450.54	0	11:05	0.01	0	23:00
IB-2.6-3	JUNCTION	0.01	0.02	2451.96	0	11:00	0.01	0	23:00
IB-2.6-4	JUNCTION	0.01	0.02	2453.06	0	11:00	0.01	0	23:00
IB-2.6.2-1	JUNCTION	0.00	0.00	2457.93	0	00:00	0.00	0	00:00
IB-2A	JUNCTION	0.00	0.00	2429.61	0	00:00	0.00	0	00:00
IB-3	JUNCTION	0.01	0.02	2428.05	0	12:03	0.02	0	23:00
IB-3.1	JUNCTION	0.01	0.02	2428.51	0	12:00	0.01	0	23:00
IB-3.2	JUNCTION	0.01	0.03	2429.53	0	12:37	0.02	0	23:00
IB-3.3	JUNCTION	0.01	0.03	2430.34	0	11:58	0.01	0	23:00
IB-3.4	JUNCTION	0.02	0.03	2431.13	0	11:00	0.01	0	23:00
DEMERS_PS	OUTFALL	0.06	0.12	2423.12	0	11:11	0.05	0	23:00

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Node Inflow Summary
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Node	Type	Maximum Lateral Inflow MGD	Maximum Total Inflow MGD	Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 gal	Total Inflow Volume 10^6 gal	F Bala Er 10^6
IA-1	JUNCTION	0.018	0.227	0 11:16	0.00527	0.0669	0.
IA-10	JUNCTION	0.012	0.207	0 11:00	0.00333	0.0597	0.
IA-10-1	JUNCTION	0.001	0.001	0 10:00	0.00034	0.00034	-0.
IA-11	JUNCTION	0.000	0.195	0 11:00	0	0.0561	0.
IA-12	JUNCTION	0.143	0.195	0 11:00	0.0414	0.0562	0.
IA-13	JUNCTION	0.000	0.052	0 11:05	0	0.0148	0.
IA-13-1	JUNCTION	0.000	0.052	0 11:01	0	0.0148	0.
IA-14	JUNCTION	0.000	0.052	0 11:00	0	0.0149	0.
IA-15	JUNCTION	0.001	0.052	0 11:00	0.00017	0.0149	0.
IA-15-1	JUNCTION	0.000	0.000	0 00:00	0	0	0.
IA-15-2	JUNCTION	0.000	0.000	0 00:00	0	0	0.
IA-15-3	JUNCTION	0.000	0.000	0 00:00	0	0	0.
IA-16	JUNCTION	0.000	0.052	0 11:01	0	0.0147	0.
IA-16-1	JUNCTION	0.000	0.010	0 11:00	0	0.00289	0.
IA-16-1-1	JUNCTION	0.000	0.000	0 00:00	0	0	0.

IA-16-2	JUNCTION	0.001	0.010	0	11:00	0.00016	0.00291	0.
IA-16-3	JUNCTION	0.000	0.010	0	11:00	0	0.00277	0
IA-16-4	JUNCTION	0.000	0.010	0	10:40	0	0.00279	0
IA-16-5	JUNCTION	0.010	0.010	0	10:00	0.00279	0.00279	-0.
IA-17	JUNCTION	0.000	0.042	0	11:00	0	0.0119	0.
IA-18	JUNCTION	0.000	0.042	0	11:00	0	0.0119	0.
IA-19	JUNCTION	0.000	0.042	0	11:00	5.32e-005	0.0119	-0.
IA-2	JUNCTION	0.000	0.204	0	11:14	0	0.0586	0.
IA-20	JUNCTION	0.000	0.041	0	11:00	0	0.012	0.
IA-20-1	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IA-20-2	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IA-21	JUNCTION	0.040	0.041	0	11:00	0.0115	0.012	0.
IA-21-1	JUNCTION	0.000	0.002	0	11:00	0	0.000483	0.
IA-21-2	JUNCTION	0.002	0.002	0	10:00	0.00048	0.00048	-0.
IA-3	JUNCTION	0.000	0.205	0	11:11	0	0.0588	0.
IA-4	JUNCTION	0.000	0.205	0	11:09	0	0.059	0.
IA-5	JUNCTION	0.000	0.206	0	11:06	0	0.0591	0.
IA-6	JUNCTION	0.000	0.206	0	11:04	0	0.0593	0.
IA-7	JUNCTION	0.000	0.207	0	11:01	0	0.0596	0.
IA-8	JUNCTION	0.000	0.208	0	11:00	0	0.0597	0.
IA-9	JUNCTION	0.001	0.208	0	11:00	0.00016	0.0598	0.
IB-2	JUNCTION	0.000	0.010	0	11:01	0	0.00314	0.
IB-2-1	JUNCTION	0.000	0.010	0	11:00	0	0.00294	0.
IB-2-10	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2-11	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2-12	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2-2	JUNCTION	0.002	0.010	0	11:00	0.000681	0.00296	0.
IB-2-3	JUNCTION	0.003	0.008	0	11:00	0.000797	0.00229	0.
IB-2-3-1	JUNCTION	0.002	0.004	0	11:00	0.000613	0.00121	0.
IB-2-3-2	JUNCTION	0.000	0.002	0	11:00	0	0.000604	0
IB-2-3-3	JUNCTION	0.002	0.002	0	11:00	0.000453	0.000608	0
IB-2-3-4	JUNCTION	0.000	0.001	0	11:00	0	0.000158	1.
IB-2-3-5	JUNCTION	0.001	0.001	0	10:00	0.00016	0.00016	1.
IB-2-4	JUNCTION	0.000	0.001	0	11:00	0	0.000308	5.
IB-2-5	JUNCTION	0.001	0.001	0	11:00	0.00016	0.00031	0.
IB-2-6	JUNCTION	0.000	0.001	0	11:11	0	0.00015	0.
IB-2-7	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2-8	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2-9	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2.3-1	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2.3-2	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2.3-3	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2.3-4	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2.3-5	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2.6-1	JUNCTION	0.000	0.001	0	11:05	0	0.000153	1.
IB-2.6-2	JUNCTION	0.000	0.001	0	11:00	0	0.000156	2.
IB-2.6-3	JUNCTION	0.000	0.001	0	11:00	0	0.000159	1.
IB-2.6-4	JUNCTION	0.001	0.001	0	10:00	0.00016	0.00016	0.
IB-2.6.2-1	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-2A	JUNCTION	0.000	0.000	0	00:00	0	0	0.
IB-3	JUNCTION	0.000	0.001	0	12:00	0	0.000223	4.
IB-3.1	JUNCTION	0.000	0.001	0	12:00	8.17e-005	0.000226	0.
IB-3.2	JUNCTION	0.000	0.000	0	11:58	0	0.000151	5.
IB-3.3	JUNCTION	0.000	0.000	0	11:00	0	0.000157	3.
IB-3.4	JUNCTION	0.001	0.001	0	10:00	0.00016	0.00016	2.
DEMERS_PS	OUTFALL	0.000	0.244	0	11:11	0	0.0669	0.

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Node Surcharge Summary
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No nodes were surcharged.

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Node Flooding Summary
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No nodes were flooded.

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Outfall Loading Summary
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Outfall Node	Flow Freq Pcnt	Avg Flow MGD	Max Flow MGD	Total Volume 10^6 gal
DEMERS_PS	90.80	0.077	0.244	0.067
System	90.80	0.077	0.244	0.067

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Link Flow Summary
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Link	Type	Maximum |Run Flow| MGD	Time of Max Occurrence days hr:min	Maximum |Output Flow| MGD	Time of Max Occurrence days hr:min	Max/ Full Flow
IA-1	CONDUIT	0.244	0 11:11	0.032	0 23:00	0.01
IA-10	CONDUIT	0.207	0 11:00	0.025	0 23:00	0.24
IA-10-1	CONDUIT	0.001	0 11:00	0.000	0 23:00	0.00
IA-11	CONDUIT	0.195	0 11:00	0.023	0 23:00	0.29
IA-12	CONDUIT	0.195	0 11:00	0.023	0 23:00	0.22
IA-13	CONDUIT	0.052	0 11:09	0.007	0 23:00	0.08
IA-13-1	CONDUIT	0.052	0 11:05	0.006	0 23:00	0.09
IA-14	CONDUIT	0.052	0 11:01	0.006	0 23:00	0.09
IA-15	CONDUIT	0.052	0 11:00	0.006	0 23:00	0.08
IA-15-1	CONDUIT	0.000	0 00:00	0.000	0 00:00	0.00
IA-15-2	CONDUIT	0.000	0 00:00	0.000	0 00:00	0.00
IA-15-3	CONDUIT	0.000	0 00:00	0.000	0 00:00	0.00
IA-16	CONDUIT	0.052	0 11:03	0.006	0 23:00	0.07
IA-16-1	CONDUIT	0.010	0 11:01	0.001	0 23:00	0.01
IA-16-1-1	CONDUIT	0.000	0 00:00	0.000	0 00:00	0.00
IA-16-2	CONDUIT	0.010	0 11:00	0.001	0 23:00	0.01
IA-16-3	CONDUIT	0.010	0 11:00	0.001	0 23:00	0.02
IA-16-4	CONDUIT	0.010	0 11:00	0.001	0 23:00	0.02
IA-16-5	CONDUIT	0.010	0 10:40	0.001	0 23:00	0.01
IA-17	CONDUIT	0.042	0 11:01	0.005	0 23:00	0.08
IA-18	CONDUIT	0.042	0 11:00	0.005	0 23:00	0.08
IA-19	CONDUIT	0.042	0 11:00	0.005	0 23:00	0.09
IA-2	CONDUIT	0.204	0 11:16	0.028	0 23:00	0.25
IA-20	CONDUIT	0.041	0 11:00	0.005	0 23:00	0.06
IA-20-1	CONDUIT	0.000	0 00:00	0.000	0 00:00	0.00
IA-20-2	CONDUIT	0.000	0 00:00	0.000	0 00:00	0.00
IA-21	CONDUIT	0.041	0 11:00	0.005	0 23:00	0.04
IA-21-1	CONDUIT	0.002	0 11:00	0.000	0 23:00	0.00
IA-21-2	CONDUIT	0.002	0 11:00	0.000	0 23:00	0.00
IA-3	CONDUIT	0.204	0 11:14	0.027	0 23:00	0.26
IA-4	CONDUIT	0.205	0 11:11	0.027	0 23:00	0.26

IA-5	CONDUIT	0.205	0	11:09	0.026	0	23:00	0.26
IA-6	CONDUIT	0.206	0	11:06	0.026	0	23:00	0.27
IA-7	CONDUIT	0.206	0	11:04	0.025	0	23:00	0.27
IA-8	CONDUIT	0.207	0	11:01	0.025	0	23:00	0.27
IA-9	CONDUIT	0.208	0	11:00	0.025	0	23:00	0.27
IB-2	CONDUIT	0.010	0	11:04	0.002	0	23:00	0.02
IB-2-1	CONDUIT	0.010	0	11:01	0.001	0	23:00	0.01
IB-2-10	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2-11	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2-12	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2-2	CONDUIT	0.010	0	11:00	0.001	0	23:00	0.02
IB-2-3	CONDUIT	0.008	0	11:00	0.001	0	23:00	0.02
IB-2-3-1	CONDUIT	0.004	0	11:00	0.001	0	23:00	0.01
IB-2-3-2	CONDUIT	0.002	0	11:00	0.000	0	23:00	0.00
IB-2-3-3	CONDUIT	0.002	0	11:00	0.000	0	23:00	0.00
IB-2-3-4	CONDUIT	0.001	0	11:00	0.000	0	23:00	0.00
IB-2-3-5	CONDUIT	0.001	0	11:00	0.000	0	23:00	0.00
IB-2-4	CONDUIT	0.001	0	11:40	0.000	0	23:00	0.00
IB-2-5	CONDUIT	0.001	0	11:00	0.000	0	23:00	0.00
IB-2-6	CONDUIT	0.001	0	11:17	0.000	0	23:00	0.00
IB-2-7	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2-8	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2-9	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2.3-1	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2.3-2	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2.3-3	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2.3-4	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2.3-5	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2.6-1	CONDUIT	0.001	0	11:11	0.000	0	23:00	0.00
IB-2.6-2	CONDUIT	0.001	0	11:05	0.000	0	23:00	0.00
IB-2.6-3	CONDUIT	0.001	0	11:00	0.000	0	23:00	0.00
IB-2.6-4	CONDUIT	0.001	0	11:00	0.000	0	23:00	0.00
IB-2.6.2-1	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-2A	CONDUIT	0.000	0	00:00	0.000	0	00:00	0.00
IB-3	CONDUIT	0.001	0	12:04	0.000	0	23:00	0.00
IB-3.1	CONDUIT	0.001	0	12:00	0.000	0	23:00	0.00
IB-3.2	CONDUIT	0.000	0	12:37	0.000	0	23:00	0.00
IB-3.3	CONDUIT	0.000	0	11:58	0.000	0	23:00	0.00
IB-3.4	CONDUIT	0.000	0	11:00	0.000	0	23:00	0.00

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Flow Classification Summary
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	Adjusted	Fraction of Time in Flow Class								
Conduit	/Actual Length	Dry	Up Dry	Down Dry	Sub Crit	Sup Crit	Up Crit	Down Crit	Norm Ltd	Inlet Ctrl
IA-1	1.00	0.06	0.00	0.00	0.09	0.86	0.00	0.00	0.06	0.00
IA-10	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IA-10-1	1.00	0.00	0.00	0.00	0.82	0.00	0.00	0.17	0.83	0.00
IA-11	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IA-12	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IA-13	1.00	0.06	0.00	0.00	0.06	0.00	0.00	0.87	0.06	0.00
IA-13-1	1.00	0.06	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00
IA-14	1.00	0.04	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00
IA-15	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IA-15-1	1.00	0.08	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IA-15-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IA-15-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IA-16	1.00	0.04	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00

IA-16-1	1.00	0.03	0.00	0.00	0.41	0.00	0.00	0.56	0.41	0.00
IA-16-1-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IA-16-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IA-16-3	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00
IA-16-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IA-16-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IA-17	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00
IA-18	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00
IA-19	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IA-2	1.00	0.09	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.00
IA-20	1.00	0.00	0.00	0.00	0.02	0.15	0.00	0.82	0.14	0.00
IA-20-1	1.00	0.51	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IA-20-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IA-21	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IA-21-1	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00
IA-21-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IA-3	1.00	0.08	0.00	0.00	0.00	0.00	0.00	0.92	0.00	0.00
IA-4	1.00	0.06	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00
IA-5	1.00	0.05	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.00
IA-6	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.00
IA-7	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00
IA-8	1.00	0.01	0.00	0.00	0.99	0.00	0.00	0.00	0.91	0.00
IA-9	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.12	0.00
IB-2	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00
IB-2-1	1.00	0.01	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00
IB-2-10	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2-11	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2-12	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2-2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IB-2-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IB-2-3-1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IB-2-3-2	1.00	0.02	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00
IB-2-3-3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IB-2-3-4	1.00	0.05	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.00
IB-2-3-5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IB-2-4	1.00	0.05	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.00
IB-2-5	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.95	0.00
IB-2-6	1.00	0.00	0.12	0.00	0.88	0.00	0.00	0.00	0.87	0.00
IB-2-7	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2-8	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2-9	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2.3-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2.3-2	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2.3-3	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2.3-4	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2.3-5	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2.6-1	1.00	0.10	0.00	0.00	0.00	0.00	0.00	0.90	0.00	0.00
IB-2.6-2	1.00	0.07	0.00	0.00	0.00	0.00	0.00	0.93	0.00	0.00
IB-2.6-3	1.00	0.04	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00
IB-2.6-4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
IB-2.6.2-1	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-2A	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IB-3	1.00	0.09	0.00	0.00	0.00	0.00	0.00	0.91	0.00	0.00
IB-3.1	1.00	0.08	0.00	0.00	0.92	0.00	0.00	0.00	0.75	0.00
IB-3.2	1.00	0.06	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00
IB-3.3	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.00
IB-3.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00

****
Conduit Surcharge Summary
****

No conduits were surcharged.

Analysis begun on: Fri Apr 08 11:43:02 2016
Analysis ended on: Fri Apr 08 11:43:03 2016
Total elapsed time: 00:00:01</PRE></BODY></HTML>

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX J

REGULATORY CONSIDERATIONS FOR SURFACE-WATER DISCHARGE EMAIL CORRESPONDENCE W/DEQ

- **J-1 FEBRUARY 2, 2017 EMAIL CORRESPONDENCE – DEQ RESPONSE TO FIRST REQUEST FOR INPUT**
- **J-2 FEBRUARY 7, 2017 EMAIL CORRESPONDENCE – DEQ RESPONSE TO FOLLOW-UP QUESTIONS**

Ken Condit

From: WEST Jayne <jayne.west@state.or.us>
Sent: Thursday, February 02, 2017 3:18 PM
To: Ken Condit
Cc: WEST Jayne
Subject: RE: City of Madras Wastewater Master Plan - Effluent Handling Alternatives

Ken-please see my responses below. In general recycling via irrigation is almost always preferred over surface water discharge, especially for a community like Madras with ag fields so available. It is usually cheaper to maintain a WPCF permit over the long term. The limitations in NPDES permits will always tend to become more restrictive over the years. The monitoring in NPDES permits is always more expensive. Willow Creek is on the 303(d) list for temperature which would require Madras to meet the temperature criteria at the end of pipe (no mixing zone) which would be very difficult to achieve.

Hope this helps.

From: Ken Condit [mailto:kenc@hhpr.com]
Sent: Wednesday, February 01, 2017 12:30 PM
To: WEST Jayne
Cc: Wen Jou
Subject: City of Madras Wastewater Master Plan - Effluent Handling Alternatives

Good morning Jayne,

We briefly talked last April about the update to the wastewater master plan (WWMP) we have been preparing for the City of Madras. The plan update has been prepared based on the presumption that effluent storage and reuse/recycling by farmland irrigation is still the most cost effective method for effluent handling, as was the conclusion of the 1996 WWMP. That original plan evaluated a surface-water discharge to Willow Creek as an alternative using assumptions about discharge limitations based Deschutes River WQ stds, since no NPDES permit has ever been issued. That plan also considered wetlands as an alternative treatment method.

Because of the publicity the Prineville project has generated and the relatively-high (above avg) sewer rates in Madras, the City has been asking about potential alternatives to their current effluent handling. More particularly, the City is asking whether the approach being implemented in Prineville could work for Madras. We have offered input regarding the different circumstances with a surface discharge to a seasonal stream that can have no flow in the winter, but we need some input from DEQ regarding the issues below.

1. Seasonal discharge vs seasonal storage. Please provide some guidance regarding the procedure the City must follow to apply for an NPDES permit to discharge to Willow Creek or the Deschutes River. I am only finding the USEPA Form 2A. Yes that's the form and also a Land Use Compatibility form (LUCS)

    - Would the City be required to perform a WQ analysis for a Willow Cr discharge? Yes
    - Are WQ standards/TMDLs going to be forthcoming for the Deschutes R below ? We already have WQ standards for the Deschutes. A TMDL is planned but no date yet.
    - Would DEQ potentially deny a permit for Willow Cr because of technological constraints or based on an antidegradation policy? Yes, potentially.
    - Would DEQ issue preliminary effluent limits for either Willow Cr or Deschutes R that the City could use for planning purposes to compare alternatives? The WQ standards for the Deschutes Basin are in OAR 340-041.

2. Recycling in Wetlands.

    - Would discharge to wetlands in Madras be considered a beneficial reuse? I'd have to know more about the wetlands. If they are next to the river it would be considered an indirect discharge not beneficial reuse. The Prineville wetland project was extremely difficult to get through EPA. They will be watching now to see how it works. Our guidance on indirect discharges is currently in flux.

- What quality effluent is discharged to the wetlands in Prineville & do those wetlands discharge to the river? I noticed the current Prineville NPDES permit expired in Dec 2016 and that permit was written around a lagoon system with no effluent polishing (40/60 TSS limits). Is there a new draft permit with new limits being proposed? Yes, the wetlands discharge to the river so the effluent must meet WQ standards for the Crooked River under OAR 340-041. There is a permit modification that should be on our permit repository. Let me know if you can't retrieve it.

3. Recycling by moderate rate infiltration.

    - Can you provide some guidance regarding the procedure for gaining approval for recycling effluent through infiltration and evaporation? Effluent disposal via infiltration would not be recycling. For starters we would require a hydrogeologic characterization to look at groundwater. We would also require monitoring wells so a Groundwater Monitoring Plan would be required. Then we would also potentially ask for a wastewater management plan. You could look at Redmond's permit for an example.
    - Would the City need to submit a groundwater analysis to obtain effluent limits? Yes
    - Would DEQ issue preliminary effluent limits that the City could use for planning purposes to compare alternatives? It would depend on the results of the characterization but as I mention above you could look at Redmond.

Since the City does not need to implement major WWTP improvements within the next 8 years or more, these questions are all aimed at guiding long term planning. I understand at this stage, the information you can provide may be rather general. But some input regarding the effort required to pursue alternatives for effluent handling would be very helpful in getting the draft WWMP completed and submitted to DEQ for review.

We appreciate your attention to our inquiries and look forward to your response.

Thank you,

Ken Condit, P.E.
Project Engineer

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Ken Condit

From: WEST Jayne <jayne.west@state.or.us>
Sent: Tuesday, February 07, 2017 4:27 PM
To: Ken Condit
Cc: WEST Jayne
Subject: RE: City of Madras Wastewater Master Plan - Effluent Handling Alternatives

Ken-some answers below. A little like what came first, the chicken or the egg...

From: Ken Condit [mailto:kenc@hhpr.com]
Sent: Saturday, February 04, 2017 1:00 PM
To: WEST Jayne
Cc: Wen Jou
Subject: RE: City of Madras Wastewater Master Plan - Effluent Handling Alternatives

Jayne,

We appreciate your quick reply to my questions and the useful information. Unfortunately, I'm forced to bug you again in the hope of providing a helpful summary to the City – maybe a few paragraphs in the master plan.

Given the high cost of effluent storage capacity, it appears the implementation of a seasonal discharge could be cost effective. Since the City has effluent storage capacity, the seasonal discharge might allow the continued recycling practices without expanding storage capacity. But we understand a summer discharge instead of recycling would be quite costly and would also seem less likely to be permitted.

If you have an opportunity to respond to the following questions regarding a winter-time discharge (11/1 – 3/31), we'd appreciate it.

1. If I am understanding the rules properly a discharge to Willow Cr. would be regulated based on the WQS for the Deschutes between the Bend Diversion Dam and Pelton Dam. The attached table lists what I understand the winter standards to be for this reach. Can you or one of your colleagues either confirm or correct my understanding? That looks correct but there are other things that could come into play. Let's just say those are the best case scenario.

2. You mention a TMDL is planned for the Deschutes and that Willow Cr is on the 303(d) list of impaired waters for temperature. Is temperature the only parameter for which a TMDL is planned or is there any other parameter (such as oxygen, N or P) that is known to impair WQ? I talked to Bonnie Lamb who is the TMDL coordinator for the Deschutes. Her answer: It might be a stretch to say that a TMDL is "planned" for Willow Creek since it is so far out there. But Willow Creek is on the 303d list for temperature, so a TMDL is required for temperature. Willow Creek enters the Deschutes in Lake Simtustus. The Deschutes River in the reservoir is listed as impaired for pH and chlorophyll-a (summer) and dissolved oxygen (year round). And the Deschutes River below the Pelton Round Butte Project is listed for temperature, pH (year round), and D.O. (spawning and year round). So we will need to develop TMDLs for these parameters as well.
   While Willow Creek may not have a huge impact on the Deschutes River (especially up in Madras), I suspect we will be evaluating nutrient inputs from tributaries as part of this TMDL work. And Willow Creek has been documented as having relatively high nitrate levels – at least at the mouth.

3. Narrative Criterion – there is a prohibition for new discharge to reservoirs, unless an exemption to the antidegradation rule is obtained. Since Willow Cr meets the Deschutes above Pelton Dam, is a discharge to Willow Cr also considered a discharge to a reservoir? This is one reason I thought nutrient limits might be an issue. I don't think we would consider it a reservoir.

4. Antidegradation – To obtain a winter discharge permit, it seems an exception to the antidegradation standard under OAR 340-41-0004(9) would likely need to be requested.

- Would such a request need to be accompanied by an analysis showing the discharge would not further degrade water-quality-limited waters? I don't think we would allow an exception. You would have to meet limits at end of pipe and would not be allowed a mixing zone for Category 5 parameters needing a TMDL. And since Willow Creek dries up all parameters may have end of pipe limits.
- The potential exemption for a riparian-zone restoration would seem to bring constructed wetlands option into the mix. Was the Prineville project categorized as a proposed riparian-zone restoration project? No, they did do some restoration work but it wasn't associated with the discharge for permitting purposes. I'm just wondering whether the City might need to compare the cost for winter storage vs wetlands plus more reporting for a Nov 1-Mar 31 discharge permit?

5. Are you able to comment on the steps for a permit application process?

- Would the City want to request an initial meeting to discuss options w/DEQ? Not really. Ultimately it's up to the City to decide. Once you've decided you really want to go another route and have chosen an option we can discuss more then.
- Would the City be able to first submit USEPA Form 2A w/ an LUCS and available supporting data, then wait for an initial reply from DEQ before requesting an antidegradation exemption and performing the associated WQ analysis? Before you go through the trouble of applying we should be sure that what you are proposing can be permitted. Honestly I've never be involved in an antidegradation exemption so if more is needed on this topic I'll have to bring in someone who knows more about it.
- Or would the City need to do an analysis upfront prior to submitting the application? It's hard to say, you'll need to figure out what you want to do and then we can see what upfront analysis we need.
- Would the submission of an application potentially expedite TMDL publication? No
- Does USEPA need to approve new TMDLs? Yes This seems a daunting possibility under current political climates (OK, you may not want to comment on that).

Thanks again for your input on these issues.

Ken Condit, P.E.
Project Engineer

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From: WEST Jayne [mailto:jayne.west@state.or.us]
Sent: Thursday, February 02, 2017 3:18 PM
To: Ken Condit <kenc@hhpr.com>
Cc: WEST Jayne <jayne.west@state.or.us>
Subject: RE: City of Madras Wastewater Master Plan - Effluent Handling Alternatives

Ken-please see my responses below. In general recycling via irrigation is almost always preferred over surface water discharge, especially for a community like Madras with ag fields so available. It is usually cheaper to maintain a WPCF permit over the long term. The limitations in NPDES permits will always tend to become more restrictive over the years. The monitoring in NPDES permits is always more expensive. Willow Creek is on the 303(d) list for temperature which would require Madras to meet the temperature criteria at the end of pipe (no mixing zone) which would be very difficult to achieve.

Hope this helps.

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Sent: Wednesday, February 01, 2017 12:30 PM
To: WEST Jayne
Cc: Wen Jou
Subject: City of Madras Wastewater Master Plan - Effluent Handling Alternatives

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX K

DESCRIPTIONS OF ALTERNATIVE TREATMENT PROCESSES W/SUMMARIES OF KEY ADVANTAGES AND DISADVANTAGES

APPENDIX K
DESCRIPTIONS OF ALTERNATIVE TREATMENT PROCESSES

INTRODUCTION

This appendix provides brief descriptions of the alternative treatment processes we considered for inclusion in the cost-effectiveness analysis and summarizes key advantages and disadvantages for each. Chapter 5 of this WWMP presents the results of the screening effort we conducted to eliminate alternatives that are not a good fit for this application. Chapter 6 presents the results of the cost-effectiveness analysis we performed on the remaining alternatives to identify recommended processes for expansions and upgrades to the North Wastewater Treatment Plant (NWWTP).

ALTERNATIVE LIQUID-STREAM PROCESSES

A Preliminary Treatment Alternatives

General. Untreated (raw) sewage entering a wastewater treatment plant (WWTP) carries floating or suspended debris and other coarse materials that can clog or foul equipment. Raw sewage also contains grit particles, such as coffee grounds, eggshells, and fine sand that are abrasive and can cause accelerated wear to equipment. These grit particles are also relatively heavy and can accumulate in tanks or lagoons, thereby reducing effective treatment volume.

To prevent the damage and operational problems these materials can cause, WWTPs commonly include preliminary treatment processes at the head end of the plant (headworks). Preliminary treatment processes designed to handle coarse materials consist of either screening or cutting equipment. Headworks also commonly include grit chambers or channels with associated equipment to settle out grit particles. The following paragraphs describe the alternative processes we considered for preliminary treatment.

Screening Processes

Coarse Screening Equipment. Coarse screens are mounted in an influent channel and consist of either manually-cleaned bar racks or mechanically-cleaned equipment openings of 0.25 inch or more. Manual bar racks have no moving parts and eliminate the need for power. However, they require maintenance personnel to rake trapped materials up and out of the screening channel and load the screenings into a trash bin on a regular basis. Bars on manual screens typically have a wider spacing than bars on mechanical screens to reduce the risk of the screen blinding with debris and overflowing between cleanings.

Mechanically-cleaned units are typically installed at WWTPs with capacities similar to those in Madras because the automated screens provide safer work conditions and better debris removals. The automatic cleaning devices allow the screens to be provided with smaller openings to capture more material than bar racks. Although mechanical screens are more complex than manual devices, a variety of equipment types with proven records are available.

We eliminated manually-cleaned bar racks as an alternative influent screening process because of the following disadvantages:

- their lower removal efficiencies;
- the need for greater O&M staff attention; and
- increased safety and health hazards associated with raking the screens and handling the screenings.

Mechanical screening is included in each alternative treatment train we evaluated for the following reasons:

- the protection it provides for downstream processes;
- the significant advantages it offers over manual devices; and
- the common use and proven reliability of the technology at small WWTPs.

A bar rack is included in each alternative only as an emergency bypass screen that would be available in case of equipment failure.

Fine Screening Equipment. Screens with openings less than 0.25 inch are used in WWTPs where downstream processes are highly vulnerable to fouling from solids. Fine screens consist either of static screens with no cleaning mechanism or mechanically-cleaned equipment similar to the coarse screening devices described above. Since fine screens remove more material than coarse screens, they need to be cleaned more frequently and the cost of handling the screenings is higher.

There is no need to consider downstream processes for the NWWTP that are highly vulnerable to fouling and require fine screens. Therefore, the higher operating costs of fine screens are not justified and we did not evaluate them for this study.

Cutting Equipment. Equipment designed to cut or grind up coarse materials in the raw sewage is sometimes used at small WWTPs as an alternative to devices that screen out materials. We do not recommend the use of these devices in Madras because they leave cut or ground material in the flow stream. Despite being cut or ground, the material can still become tangled on or clog downstream components, which can impact performance and increase O&M costs.

Grit Removal

Vortex-type chambers are circular in shape and create a rotating flow pattern that keeps lighter solids in suspension and allows the heavier grit to settle into a bottom hopper. The rotational energy in a chamber can be low, medium or high based on the unit design and configuration. The Pista grit system at the existing South WWTP (SWWTP) uses a low-energy vortex-type chamber.

Low-energy vortex chambers are commonly used, effective at removing grit, and reliable. Medium- to high-energy chambers are also effective and reliable, but the higher headlosses make them less compatible for the NWWTP site because of the shallow depth to rock. The headworks at the NWWTP will need to be constructed aboveground to allow gravity flow to the secondary process. Grit chambers with higher head losses would need to be constructed at a higher level resulting in higher costs for a taller support structure.

Aerated grit chambers are rectangular, concrete tanks with coarse-bubble diffusers and bottom hoppers. An air blower forces air through the diffusers to impart a rolling, flow pattern in the chamber and keep lighter solids suspended while the grit settles to the bottom.

Aerated grit chambers are a proven technology, but removal efficiencies are less consistent than vortex chambers. The aeration system results in higher O&M requirements and power costs than the other grit-removal alternatives.

Horizontal-Flow Grit Channels consist of a long, shallow concrete channel with a velocity control device at the downstream end. The channel is designed to maintain a velocity that allows grit to settle, but keeps lighter solids in suspension. A conveyor with scrapers, buckets, or plows collects settled grit and transports it out of the channel.

Grit channels are a relatively simple technology, but they provide less reliable grit removal over a range of flow rates. The grit conveyor/collector equipment can also experience rapid wear, has the potential for jamming, and can require regular repairs.

Grit Handling. All the alternatives described above would also include a grit separator/classifier unit to wash and dewater the grit for hauling as solid waste.

Based on the screening criteria (Table 5-8) and the City's experience at the SWWTP, only low-energy vortex grit chambers are recommended for inclusion at a NWWTP headworks. The other alternatives do not rate well based on the screening criteria due to site compatibility issues, lower reliability, and/or greater O&M requirements.

Preliminary Treatment Summary. All secondary treatment alternatives for the NWWTP will include a headworks structure with a mechanically-cleaned screen and low-energy, vortex grit chamber.

B Secondary Treatment Alternatives

Descriptions. Secondary treatment consists of a biological process that oxidizes and stabilizes the WW. Biological processes promote the growth of microorganisms that consume organic matter and, as a byproduct, generate biosolids primarily made up of these microorganisms. These processes require some type of solids separation to clarify secondary effluent prior to further treatment. As a result, all secondary alternatives evaluated in this study include solids separation as part of the overall process. The secondary alternatives we evaluated include natural and mechanical processes commonly used in similar municipal applications.

1. **Lagoon Systems.** Communities that produce WW flows of about 1.0 MGD or less often use lagoon systems for secondary treatment because of the low O&M requirements. Lagoons are constructed with earthen dikes to reduce construction costs. The bottom and perimeter dikes of lagoons are typically lined with plastic. A key consideration with lagoons is the growth of algae because gravity settling is ineffective in removing the algae.

   The lagoon systems we considered for this application are described below. A wide variety of configurations and components can be used for lagoon systems, particularly aerated lagoons. Therefore, these processes offer significant flexibility in tailoring a design to fit a specific application.

   a. **Facultative Lagoons** are large, shallow ponds that provide natural treatment with little or no mechanical equipment. The NWWTP lagoon system was originally a facultative process before being upgraded. The original process relied on a polishing lagoon for solids removal, but the plant was retrofitted with a DAF clarifier/filter unit to remove algae and other solids.

      Polishing lagoons are not reliable for this application due to the local climate, disinfection requirements, and spray irrigation practices. Therefore, this alternative would include DAF clarification equipment with chemical addition or a comparable solids-removal technology.

   b. **Partially-Aerated/Facultative Lagoons** are similar to facultative lagoons, except that aeration equipment and, potentially, other components are added to allow for higher influent loading. The result is that less lagoon volume is required relative to the facultative system.

      The two primary cells at the NWWTP have been converted to partially aerated lagoons, but these existing lagoons are shallower than would typically be recommended for partially-aerated cells. Solids-removal considerations are basically the same for partially-aerated lagoons as they are for facultative lagoons.

   c. **Aerated /Partially Mixed Lagoons.** Aerated lagoons are the next step up in treatment rate relative to the other lagoon alternatives. This higher treatment rate is provided by designing the aeration system to add more oxygen for microbial activity and more mixing to bring the microbes into contact with organic wastes.

Aerated lagoons are deeper than the other lagoon alternatives to promote oxygen transfer. The higher-rate treatment process also results in reduced lagoon volume, so the required area would be significantly less than for the other lagoon systems.

Clarifiers for aerated lagoons can be internal to the last lagoon cell or external to the lagoons. The higher loading and improved mixing of an aerated lagoon can prevent or reduce algae growth. But due to the warm, summertime climate in Madras, algae production could still be a concern. Therefore, the clarifier would be designed with chemical addition for algae removal.

2. **Extended Aeration Systems.** The extended aeration process is widely employed as a proven technology for small to medium-sized municipalities. It is a low-rate version of the activated sludge process and typically includes an aeration basin with an aeration system, a clarifier, a return activated sludge (RAS) system, and a sludge wasting system. Any extended aeration process will require a stabilization process for waste sludge (biosolids).

   The aeration system is designed to provide complete mixing of the aeration basin, as well as enough oxygen to support aerobic treatment. The RAS equipment recycles settled solids from the clarifier back to the aeration basin and the wasting system pumps sludge to a thickener or a stabilization process. There are options that exclude an RAS system because no separate clarifier is used.

   The extended-aeration processes being considered for this application are described below.

   a. **Earthen Aeration Basins.** This process uses lined, earthen basins similar to aerated lagoons except that a concrete, partition wall is located at one end of the aeration basin to separate the adjacent clarifiers. The aeration basins are also usually constructed deeper than aerated lagoons to improve oxygen transfer.

      The main drawback to using earthen basins in an extended aeration system is the need for sloped sides to provide stability. As a result, they require significantly more area than basins with concrete or steel walls.

   b. **Oxidation Ditch.** This alternative includes a concrete aeration basin laid out in a race-track configuration. The aeration basin can have sloped or vertical perimeter walls. Oxidation ditches are usually designed with a separate, external clarifier. The oxygen and mixing needed in the oxidation ditch can be provided with either or both mechanical aerators and/or air diffusers with blowers. Oxidation ditches and the external clarifiers can be constructed of concrete or steel.

   c. **Compact Extended Aeration Process Configuration.** This alternative combines the aeration basin, clarifier and aerobic digester in a concentric configuration using common-wall construction. The aeration basin and digester are oriented in an outer ring that encircles a clarifier at the center. These compact, extended aeration plants can be constructed of concrete or steel.

   d. **SBR Process.** A SBR process is currently in operation at the SWWTP. As a variation of the activated sludge process, it is configured as a batch process with time-based cycles and the same tank serving as both the aeration basin and clarifier. Because the SBR process has no separate clarifier, no RAS system is needed. The SBR basins can be constructed of concrete or steel.

      During an aeration phase of each timed batch, the tank receives air and tank contents are completely mixed. Then a settling phase occurs with no aeration or mixing to allow solids to settle by gravity. Clarified water is then withdrawn from near the surface by a floating decanter.

3. **Secondary Processes Not Evaluated.** The following biological processes were discarded prior to the alternatives screening.

   a. **Conventional activated sludge and trickling filters.** These processes are commonly used at larger WWTPs, but are not considered suitable for the WWTP capacity required in Madras due to their need for primary treatment, higher biosolids production, and higher O&M costs.

   b. **Multi-stage activated sludge and membrane bioreactors.** The advanced levels of treatment these technologies can provide are not required in Madras. Therefore, their relatively high costs and complexities cannot be justified.

Secondary Treatment Screening Summary. Key advantages and disadvantages and the results of our screening effort for the secondary processes are described in the following paragraphs.

1. **Lagoons Systems**

   a. **Facultative Lagoons**

   Advantages:

   - simple to operate with limited maintenance requirements;
   - no upstream grit removal required; and
   - no separate stabilization process needed.

   Disadvantages:

   - requires the most land;
   - may be considered incompatible with airport site due to wildlife attraction;
   - DAF clarifier is a more complex technology with significant O&M requirements; and
   - can experience high algae production that may affect clarifier performance.

   Screening Result: This alternative rates well with most of the screening criteria. But due to large area requirements and compatibility concerns with the adjacent airport site there would be significant limitations on future expansions. Given this lack of flexibility in addressing industrial site readiness, we have eliminated facultative lagoons from further consideration in this study.

   b. **Partially-Aerated/Facultative lagoons**

   Advantages:

   - simpler to operate relative to mechanical plants; no upstream grit removal required;
   - no separate stabilization process needed;
   - requires less land than facultative lagoons;
   - uses shallower cells than other alternatives besides facultative lagoons; and
   - offers a lot of options for lagoon configuration and system components.

   Disadvantages:

   - requires more land than aerated lagoons and mechanical processes;
   - may be considered incompatible with airport site due to wildlife attraction;
   - DAF clarifier is a more complex technology with significant O&M requirements; and
   - Partially-aerated lagoons use deeper cells than facultative lagoons.

Screening Result: Similar to facultative lagoons, this alternative rates well with most of the screening criteria. But due to large area requirements and compatibility concerns with the adjacent airport site there may be significant limitations on future expansions. Given this lack of flexibility in addressing industrial site readiness, the construction of new partially-aerated, facultative lagoons were not evaluated in this study.

c. **Aerated Lagoons**

Advantages:

- requires less land relative to other lagoon systems;
- more likely to be compatible with airport site than other lagoon systems;
- simpler to operate relative to mechanical processes;
- smaller stabilization process capacity relative to mechanical processes;
- produces less algae than other lagoons systems; and
- offers a lot of options for lagoon configuration and system components.

Disadvantages:

- requires more land than mechanical processes;
- may require more efforts to mitigate wildlife attraction than mechanical processes;
- upstream grit removal recommended; and
- uses deeper lagoon cells than other lagoon systems.

Screening Result: This alternative generally rates favorably with the screening criteria and is recommended for inclusion in the cost effectiveness analysis. It should be feasible to address site compatibility issues, if this is the selected secondary process alternative.

2. **Extended Aeration Systems**

a. **General Comparison to Lagoon Systems**

Advantages Relative to Lagoon Systems:

- requires less land;
- less difficult to mitigate wildlife attractions;
- insignificant algae growth;
- fewer suspended solids in the secondary effluent; and
- no chemical addition required.

Disadvantage Relative to Lagoon Systems:

- requires deeper basins;
- more heavily dependent on mechanical equipment than lagoon systems;
- higher O&M requirements;
- higher energy use for aeration and mixing;
- higher biosolids production;
- requires upstream grit removal; and
- requires separate biosolids stabilization process.

General Screening Result: Extended aeration systems are commonly used in WWTPs of similar size as this application due to their reliability, moderate O&M requirements, and cost competitiveness. Other key reasons to consider extended aeration processes are the smaller area requirement than lagoon systems.

b. Extended Aeration Process with Earthen Aeration Basins

Advantages Relative to Other Extended Aeration Processes:

- no SBR automated valves or decanter required;
- less automation than SBR process; and
- produces thicker waste activated sludge (lower volume) than an SBR.

Disadvantages Relative to Other Extended Aeration Processes:

- requires more land and earthwork for earthen aeration basin with sloped sides; and
- requires a separate clarifier and RAS equipment.

Screening Result: Earthen aeration basins are not well suited to the NWWTP site because the depth of the basins combined with the shallow depth to rock would require relatively tall dikes to be constructed above grade. This practice would be costly and would not provide the same structural integrity as concrete walls. Given this site compatibility issue, we eliminated the extended aeration process using earthen basins from further evaluation.

c. Oxidation Ditch

Advantages Relative to Other Extended Aeration Processes:

- no SBR automated valves or decanter required;
- less automation than SBR process;
- produces thicker waste activated sludge (lower volume) than an SBR.

Disadvantages Relative to Other Extended Aeration Processes:

- requires more land for an external clarifier; and
- requires a separate clarifier and RAS equipment.

Screening Result: The oxidation ditch process rates reasonably well with the screening criteria and is recommended for inclusion in the cost effectiveness analysis.

d. Compact Extended Aeration Process Configuration.

Advantages Relative to Other Extended Aeration Processes:

- no SBR automated valves or decanter required;
- less automation than SBR process;
- produces thicker waste activated sludge (lower volume) than an SBR; and
- requires less land than other extended aeration processes besides SBR.

Disadvantages Relative to Other Extended Aeration Processes:

- requires more land than SBR; and
- requires a separate clarifier and RAS equipment.

Screening Result: The compact extended aeration process rates reasonably well with the screening criteria and is recommended for inclusion in the cost effectiveness analysis.

e. SBR

Advantages Relative to Other Extended Aeration Processes:

- no separate clarifier or RAS equipment required;
- requires less land than other extended aeration processes; and
- City personnel are familiar with the process.

Disadvantages Relative to Other Extended Aeration Processes:

- requires deeper tanks than other extended aeration processes.
- produces more dilute waste activated sludge than other extended aeration processes;
- requires separate mixer, automated valves or decanter; and
- involves more dependence on sophisticated automation.

Screening Result: The SBR process rates reasonably well with the screening criteria and is recommended for inclusion in the cost effectiveness analysis.

C Disinfection Alternatives

Descriptions. Disinfection is provided to destroy or inactivate a high proportion of the microorganisms present in the treated WW, particularly pathogens (disease-causing organisms). The disinfection requirements for Class B effluent are established by the limitations on total-coliform levels published in the DEQ regulations for water recycling (see Table 1-1).

Descriptions of the disinfection alternatives being considered for this application are provided in the following paragraphs.

1. **Sodium Hypochlorite (NaOCl) Bulk Storage and Feed.** NaOCl is commonly referred to as chlorine bleach and is delivered as a solution in bulk containers at a strength of about 12%. NaOCl solution is currently used as the disinfectant at both existing WWTPs. NaOCl solution is stored in plastic tanks and fed into the treated effluent by a chemical feed pump. The chlorinated effluent passes through a concrete contact tank to provide enough contact time for disinfection.

   The solution is stable and breaks down very slowly. Therefore, a loss of strength only becomes a significant concern if it is stored for a matter of months. Outside storage or proper ventilation can prevent the accumulation of vapors released during any gradual solution decay.

   The solution can burn workers if it is spilled. But there are no concerns about the release of a hazardous, compressed gas. The only required containment is a secondary tub under the storage tank to capture a leak or spill.

2. **Onsite Sodium Hypochlorite Generation.** NaOCl is commonly generated onsite from a salt solution using electrodes. The salt solution is delivered by tank truck and stored in an outdoor tank. The NaOCl solution is generated at about a 1% concentration and stored in a day tank. Since the generated solution is far more dilute than the bulk NaOCl solution, it is less irritating if workers come in contact with it. But the feed pumps need to have a higher capacity to pump the more dilute solution. The contact tank would be the same volume as that required for the bulk delivery and feed alternative.

3. **Tablet Chlorination Equipment.** A tablet chlorinator system prepares and mixes a hypochlorite solution from dry, calcium hypochlorite (CaOCl) tablets and injects the solution into the treated effluent.

   The chlorinator assembly primarily consists of the chamber where tablets are dissolved and mixed into solution, a chlorine-solution feed pump, valves, piping, a support frame and a control module. A static mixer is typically provided at the injection point upstream of the chlorine contact tank. The contact tank would be the same volume as that required for the NaOCl alternatives.

4. **UV Light.** The UV disinfection process passes the treated effluent through UV light that either destroys the microorganisms or prevents them from reproducing (dividing). In this application the UV light would be supplied by low pressure/high output lamps in quartz sleeves mounted on racks in a concrete channel. UV systems have safeguards that prevent illuminated lamps from being removed from the channel. Therefore, UV light is generally a safe process.

UV light is a highly effective microbiocide and requires only a short exposure time in the UV channels to destroy the microorganisms. The design UV dose and required number of lamps are established by the total-coliform limitations and the anticipated quality of the effluent. No disinfectant residual is provided by UV as it is with the alternatives using chlorine.

5. **Chlorine Dioxide (ClO2).** This alternative involves the onsite generation of ClO2 gas from precursor chemicals. A package generator unit produces ClO2 as the chlorine is required for disinfection and the gas is immediately mixed with water to form a dilute ClO2 solution. The precursor chemicals are typically dilute solutions of hydrochloric acid and sodium chlorite. These weak solutions pose similar containment requirements and handling considerations as the industrial-grade NaOCl the City currently uses.

   ClO2 is a stronger microbiocide than bleach and can be fed at a lower dose. As with the NaOCl options, a contact tank is needed to allow time for disinfection, but less contact time is required.

6. **Disinfection Processes Not Evaluated.** The following disinfection processes were discarded prior to the alternatives screening because they are generally not suitable for this application.

   a. **Chlorine Gas.** The storage of compressed chlorine gas and injection of the gas into solution was traditionally the most common method of disinfection at WWTPs because of the strong germicidal effects and affordability. However, chlorine gas is hazardous and new installations are now uncommon due to safety concerns and stricter regulations requiring costly containment and scrubbing facilities. For these reasons, we have not evaluated the use of chlorine gas.

   b. **Ozone** and **medium-pressure, UV lamps.** These technologies can be suitable for disinfection at large WWTPs. However, they are too costly and complex for smaller applications.

Disinfection Summary. Key advantages and disadvantages to the disinfection processes and the results of our screening effort are described in the following paragraphs.

1. **NaOCl Bulk Storage and Feed**

   Advantages:

   - simple to operate with limited equipment maintenance requirements;
   - no precursor chemicals required;
   - requires less power for operation than UV system; and
   - City personnel are familiar with its use.

   Disadvantages:

   - requires truck deliveries of solution that is over 85% water;
   - requires some handling of harsh chemical;
   - requires chlorine contact tank; and
   - requires higher dose than ClO2.

   Screening Result: This alternative rates very well with the screening criteria and is recommended for inclusion in the cost effectiveness analysis.

2. **Onsite NaOCl Generation**

   Advantages:

   - no hazardous precursor chemicals required; and
   - requires less power for operation than UV system.

Disadvantages:

- requires truck deliveries of brine solution;
- relies heavily on automation;
- relatively more complex process than NaOCl bulk delivery and feed;
- requires chlorine contact tank; and
- requires higher dose than ClO2.

Screening Result: This alternative rates well enough with the screening criteria and is recommended for inclusion in the cost effectiveness analysis.

3. **Tablet Chlorination Equipment**

Advantages:

- simple to operate with limited equipment maintenance requirements;
- no precursor chemicals required;
- requires less power for operation than UV system; and
- CaOCl tablets are safe and simple to use.

Disadvantages:

- requires chlorine contact tank; and
- requires higher dose than ClO2.

Screening Result: This alternative rates very well with the screening criteria and is recommended for inclusion in the cost effectiveness analysis.

4. **UV Light**

Advantages:

- simple to operate with limited equipment maintenance requirements;
- no chemical deliveries or handling required; and
- no chlorine contact tank required.

Disadvantages:

- relies heavily on sophisticated automation;
- requires more power than other alternatives;
- better suited for WWTPs with advanced treatment that provide higher effluent quality; and
- has relatively higher O&M requirements for lamp cleaning and replacement.

Screening Result: Due to O&M considerations, we have eliminated this alternative from further evaluation.

5. **Onsite ClO2 Generation and Feed**

Advantages:

- requires less power for operation than UV light;
- system operation is relatively simpler than UV light; and
- relatively stronger disinfectant requiring less chlorine contact time than NaOCl or CaOCl.

Disadvantages:

- has not been commonly used for WWTP effluent disinfection;
- relies heavily on automation;
- relatively more complex process than the other disinfection alternatives;
- requires truck deliveries of dilute chemical solutions;
- requires some handling of harsh chemicals;
- requires contact tank; and
- requires more power than NaOCl storage and feed.

Screening Result: This alternative does not rate well with the screening criteria due to process complexity, chemical requirements and less common use in the WW industry. Therefore, we have eliminated this alternative from further evaluation.

ALTERNATIVE BIOSOLIDS-HANDLING PROCESSES

A General

Biosolids handling alternatives must be evaluated in conjunction with options for expanding the NWWTP. The biosolids handling alternatives that were considered in the screening effort are addressed in the following paragraphs.

B Stabilization Alternatives

Biosolids from a biological process must be stabilized to meet current requirements for Class B land application. Therefore, a stabilization process must be included with each secondary treatment alternative that produces waste sludge. Descriptions of the biosolids stabilization alternatives are provided in the following paragraphs.

1. **Aerobic Digestion.** An aerobic digester stabilizes waste activated sludge (WAS) similar to the way WW is oxidized and stabilized in the extended aeration process. Liquid WAS is pumped to the digester where aeration and mixing support the growth of microorganisms that consume part of the volatile organic matter. Aeration equipment used in the digester can be of the same type as that used in the secondary process to simplify maintenance management efforts.

   The average solids retention time in the digester must be sufficient to meet stabilization criteria identified in the regulations for Class B biosolids. A digester is generally operated as a partial batch process in which part of the biosolids are removed from the bottom of the tank after a settling period. A decanting device is usually provided to remove a batch of supernatant from near the liquid surface at the end of the settling period. The supernatant is returned to the WWTP influent for treatment.

2. **Sludge Lagoon.** A sludge lagoon is similar to a facultative lagoon except the sludge lagoon is usually deeper. WAS is pumped to the lagoon and allowed to remain for an extended period. Since no aeration and mixing are provided the biological stabilization process is much slower than in the digester process and solids retention time is often a period of years. As a result, a large amount of area is needed for the sludge lagoon. Supernatant is drawn from the surface when the addition of WAS raises the liquid surface to the maximum operating level of the lagoon.

3. **Composting.** The types of composting processes used at WWTPs of the size being considered in this study include the aerated static pile or windrow system. Both these configurations require the WAS to be thickened and mixed with a bulking agent such as wood chips. Cured compost is often also added to make it easier to handle and reduce clumping. The composting process would occur on a paved, outdoor surface with drainage containment.

The static pile process involves forming long, narrow rows of material over perforated, plastic aeration piping. The pile is left in place while an air blower forces air through the pipe and up through the material to promote aerobic stabilization. The windrow process also involves forming long, narrow rows of material, but no air is introduced. Instead the pile is periodically turned over and mixed to reaerate the material.

In both processes, the material is composted for about 2 months before being removed and stockpiled until it is used as soil amendment. Typically, the compost is left in a stockpile to cure for a period of months for further stabilization.

4. **Lime Stabilization.** This process involves mixing sufficient amounts of dry, hydrated lime with the biosolids to raise the pH to 12 throughout the mixture. The high pH level is maintained long enough to destroy or inactivate the microorganisms and produce stable biosolids. Lime stabilization would take place in an outdoor containment area similar to a sludge drying bed. The process would require a lime storage vessel, a lime feeder and a mixing device.

5. **Stabilization Processes Not Evaluated – Anaerobic digestion and Thermal Drying.** These alternatives are complex, labor-intensive processes with a variety of mechanical equipment needing regular attention. Because of this complexity and the associated O&M costs, these technologies are generally not suitable for smaller WWTPs and were discarded prior to alternatives screening.

Stabilization Summary. Key advantages and disadvantages to the stabilization processes and the results of our screening effort are described in the following paragraphs.

1. **Aerobic Digestion**

Advantages:

- no chemical deliveries or handling required;
- requires less space than sludge lagoon and composting processes; and
- City personnel are familiar with the process.

Disadvantages:

- energy-intensive process requiring more power than other alternatives;
- more O&M requirements than other stabilization alternatives; and
- produces sludge that is more difficult to dewater.

Screening Result: This alternative rates well with the screening criteria and is recommended for inclusion in the cost effectiveness analysis.

2. **Sludge Lagoon**

Advantages:

- simple to operate with limited equipment maintenance requirements;
- low power requirements; and
- no chemical deliveries or handling required.

Disadvantages:

- requires more land than other stabilization alternatives;
- may be considered incompatible with airport site due to wildlife attraction;
- more-likely to produce nuisance odors than aerobic digesters or lime stabilization; and
- stabilized biosolids must be dredged and can be difficult to convey to drying beds.

Screening Result: This alternative rates well with most of the screening criteria. But due to area requirements and compatibility concerns with the adjacent land uses, we have eliminated a sludge lagoon from further consideration in this study.

3. Composting (Static Pile or Windrow)

Advantages:

- simple to operate with moderate equipment maintenance requirements;
- requires less land than sludge lagoon;
- windrow process has low power requirements;
- no chemical deliveries or handling required; and
- can readily produce Class A biosolids with fewer restrictions of use.

Disadvantages:

- requires slightly more land than aerobic digester and lime stabilization alternatives;
- requires reliable supply of bulking agent; and
- would need to be located in a building to mitigate wildlife attraction and odors.

Screening Result: This alternative rates well with some of the screening criteria. But the process would be made more complicated by the need for an enclosure with heating, ventilating and odor treatment equipment. Therefore, we have eliminated composting from further consideration in this study.

4. Lime Stabilization

Advantages:

- low power requirements; and
- requires less space than sludge lagoon and composting processes.

Disadvantages:

- requires chemical deliveries and handling of hazardous chemical; and
- has relatively higher O&M requirements than other stabilization alternatives.

Screening Result: This alternative does not rate well when compared to other alternative due to the chemical handling and O&M requirements. Therefore, we have eliminated lime stabilization from further consideration in this study.

C Thickening Alternatives

Thickening equipment separates water from the biosolids (WAS or stabilized biosolids) to reduce the volume. The thickened biosolids are still handled as a liquid because the material can be pumped as long as the solids content is limited to 6.0%.

A thickener can be installed upstream of a digester to reduce the required capacity or downstream of the digester to reduce the volume that must be hauled offsite. In the case of the SWWTP, installing a thickener ahead of the existing aerobic digesters could effectively increase existing capacity without expanding tank volume. A thickener would also reduce the volume that must be hauled to the drying beds, thereby reducing transportation costs and effectively increasing available drying-bed capacity.

A feature common to thickeners is the use of polymer and a flocculation tank to condition the biosolids and promote flocculation before thickening. Proper polymer dose is required to maintain solids capture. An improper dose results in more solids being recycled back to the headworks with the separated water.

Another common feature is a thickened sludge storage bin and a pump downstream of the thickener. The pump would transfer the solids to a subsequent process or into a tank truck for hauling. The storage bin would receive biosolids discharged from the thickener while the truck is in route or unloading.

Descriptions of the biosolids thickening alternatives are provided in the following paragraphs.

1. **Gravity Belt Thickener.** A gravity belt thickener allows water to separate and drain from the solids through a horizontal, filtering belt. Liquid sludge is introduced to and spread across the belt while a drive system slowly moves the belt over rollers attached to a support frame. The filtering belt is held taught over the rollers as it progresses and plows are suspended over the belt to turn the solids and promote water drainage.

   Gravity belt thickeners are commonly used on and well suited for WAS from extended aeration systems such as those being evaluated here. The degree of thickening provided can be adjusted by changing belt speed and changing the number and positions of the plow elements. The main maintenance considerations with this type of thickener are keeping the proper belt tensioning and alignment.

2. **Rotating Screen or Drum Thickener.** This device involves feeding liquid sludge into one end of a perforated stainless steel drum that is slowly rotated. Water drains out as the solids gradually progress along the interior of the drum to the discharge end. Water is sprayed through the top of the rotating drum to clean off solids residue.

   Rotating drum thickeners are also commonly used with WAS and have proven to be reliable units with limited O&M requirements. The rotating speed of the drum can be adjusted, but typically it is left unchanged after equipment startup.

3. **DAF Thickener.** A DAF thickener uses a process similar to the existing DAF clarifier at the NWWTP. Compressed air is dissolved into the WAS in a pressure tank before the WAS is fed into a larger tank with a free liquid surface. As the air bubbles rise they carry conditioned solids to the surface where a skimming system pushes the floating solids to one end. A collection system is also provided to remove any solids that settle to the bottom of the tank.

   The DAF thickener is more complex than the other alternatives because of the need for an air injection system with an air compressor, control valves and accessories. Due to this need for more equipment, DAF thickeners are less common at small WWTPs.

Thickening Summary. Key advantages and disadvantages to the thickening processes and the results of our screening effort are described in the following paragraphs.

1. **Gravity Belt Thickener**

   Advantages:

   - more operating flexibility;
   - less complex than DAF thickener; and
   - requires slightly less space than DAF thickener process.

   Disadvantages:

   - more O&M requirements than rotating drum thickener; and
   - filtering belt not as durable and long lasting as rotating drum.

   Screening Result: This alternative rates sufficiently well with the screening criteria and is recommended for inclusion in the cost effectiveness analysis.

2. **Rotating Drum/Screen Thickener**

Advantages:

- least complex to operate with limited equipment maintenance requirements;
- long service life of stainless steel drum; and
- requires slightly less space than DAF thickener process.

Disadvantages:

- less operating flexibility than gravity belt thickener.

Screening Result: This alternative rates well with the screening criteria and is recommended for inclusion in the cost effectiveness analysis.

3. **DAF Thickener**

Advantages:

- City personnel are familiar with the DAF process.

Disadvantages:

- less operating flexibility than gravity belt thickener;
- requires slightly more space than other alternatives;
- requires more energy for air injection system; and
- more complex with more O&M requirements than other thickening alternatives.

Screening Result: This alternative does not rate well with regard to process complexity and appropriateness for small installations. Therefore, we have eliminated this alternative from further evaluation.

D Dewatering and/or Drying Alternatives

Dewatering Process. Mechanical dewatering goes a step further than thickening by further separating water from the biosolids to produce sludge cake that is handled as a solid material. In the case of the SWWTP, a dewatering unit would produce material that could be hauled to the drying beds in a large dump truck. The material would be spread on the beds for further drying to facilitate land application.

Dewatering equipment would need to be housed in a building for freeze protection. The process would also require polymer addition equipment and a discharge bin for storage. Since the material is handled as a solid, a screw conveyor would be needed to load the material into the dump truck for hauling.

Mechanical dewatering units include technologies such as centrifuges and belt filter presses that are relatively expensive and complex devices. These technologies require significant operator attention and can become difficult to maintain as they age. Due to these considerations, we generally do not recommend their use at smaller WWTPs.

By contrast, a mechanical screw press for dewatering is relatively little less complex than a belt filter press and operates at lower speeds relative to a centrifuge. Therefore, it would have greater potential for being suitable for use in Madras. Therefore, a screw press is worth consideration.

Drying Process. Drying biosolids facilitates application on farmland with conventional spreaders. Biosolids can be dried on conventional drying beds similar to those at the NWWTP, in vacuum-assisted drying beds, or in mechanical dryers. The existing drying beds in Madras have proven effective both in producing material that can be readily land applied and in providing seasonal storage, as long as sufficient storage capacity is available.

Vacuum-assisted sludge drying beds housed in an enclosure may be a suitable drying technology to consider for Madras in the future, if future drying-bed expansions are not acceptable to the FAA. However, at this time, there is no need to evaluate the technology.

We do not recommend the use of a mechanical dryer in a community the size of Madras due to the relative complexity of the equipment and the associated O&M requirements.

SUMMARY OF ALTERNATIVES SCREENING RESULTS

NWWTP. Table K-1 lists the treatment processes that we have identified through initial review and screening efforts as potentially cost-effective alternatives that should be further evaluated for expansions to the NWWTP.

Table K-1
NWWTP Expansions – Alternatives Recommended for Further Evaluation

1. **Preliminary Treatment at Headworks:** Mechanically-Cleaned Screen and Low-Energy, Vortex Grit Chamber
2. **Secondary Treatment** a. Aerated/Partially Mixed Lagoon System – retrofit and expansion (no stabilization) b. Oxidation Ditch Extended Aeration c. Compact Extended Aeration Process Configuration d. SBR Extended Aeration
3. **Disinfection** a. Sodium Hypochlorite Bulk Storage and Feed b. Tablet Chlorination Equipment
4. **Biosolids Stabilization:** Aerobic Digestion
5. **Biosolids Thickening:** None
6. **Biosolids Dewatering:** Sludge Drying Beds

As described in Chapter 5, this study has not evaluated alternative biosolids thickening or dewatering processes for the NWWTP, since the use of such additional equipment is not justified at this time. The City may want to evaluate the cost effectiveness of thickening and dewatering in future studies as conditions change.

Similarly, this study has not evaluated any alternative biosolids drying processes at the NWWTP other than expansions to the existing sludge drying beds. If land-use compatibility conflicts prevent drying-bed expansions adjacent to the airport, the City will need to evaluate other processes at that time.

SWWTP. We have identified mechanical thickening equipment such as a rotary screen or gravity belt thickener as suitable processes for further consideration at the SWWTP expansion. We have also identified a screw press for mechanical dewatering as a potentially cost-effective alternative for the SWWTP.

An evaluation of the specific types of mechanical thickening and dewatering equipment is beyond the scope of a planning-level alternatives analysis. Such detailed evaluations of thickening and dewatering equipment should be conducted during the preliminary design stage of project development.

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX L

PRELIMINARY ESTIMATES OF PROBABLE COSTS FOR WWTP IMPROVEMENTS

City of Madras
Wastewater Master Plan Update

Planning-Level Estimates of Probable Construction Costs
Secondary Alternatives for North WWTP Expansion
Aerated, Partially-mixed Lagoons - 0.5 MGD Module

A. Basis of Estimate

1. Scope of Estimate:

a. Estimates based on using 3-equally sized lagoon cells with 3:1 side slopes.

b. Lagoon estimates include internal equipment, HDPE liner, sand base under liner and Cl. 50 rip rap slope protection at inlets only.

c. Estimates include external clarifiers w/same area as clarifiers for extended aeration alternatives.

d. Estimates include separate digester tank w/33% of total volume for extended aeration alternatives.

e. Estimates include CMU bldg. for pumps, MCCs & Control Systems.

f. Estimates include earthwork, yard piping, site work & buried electrical conduits.

2. Lagoon Size & Configuration:

a.	Max. Lagoon SWD	=	8.0	feet
b.	Freeboard to top of lagoon	=	2.0	feet
c.	Lagoon Dike Depth	=	10.0	feet
d.	Base of Lagoon Length	=	430	feet
e.	Base of Lagoon Width	=	170	feet
f.	Top of Lagoon Length	=	490	feet
g.	Top of Lagoon Width	=	230	feet
h.	Perimeter Gravel Road Width	=	20	feet

B. Summary of Probable Costs

1	Excavation, Backfill & Dike Embankments	$1,200,000
2	Cast in Place Concrete	$650,000
3	CMU Blower Bldg. w/HVAC & Lighting	$90,000
4	Equipment, Valves & Piping	$1,240,000
5	Yard Piping	$230,000
6	Process Electrical	$170,000
7	Lagoon Liners	$300,000
8	Miscellaneous Items	$55,000
	Total for Construction (w/Contractor Markup)	**$3,935,000**
	Construction Contingencies (25%)	$985,000
	Total Probable Construction Cost	**$4,920,000**

City of Madras
Wastewater Master Plan Update

Planning-Level Estimates of Probable Construction Costs
Secondary Alternatives for North WWTP Expansion
Oxidation Ditch Extended Aeration Process - 0.5 MGD Module

A. Basis of Estimate

1. Scope of Estimate:

a. Estimates based on two oxidation ditches with mechanical aeration, two clarifiers & two aerobic digesters.

b. Estimates include oxidation ditch basins, circular clarifiers, digesters, RAS & WAS systems, internal components, & associated equipment.

c. Assume aerobic digester volume same as 0.5-MGD module at SWWTP.

d. Estimates include CMU bldg. for pumps, MCCs & Control Systems.

e. Estimates include earthwork, yard piping, site work & buried electrical conduits.

2. Oxidation Ditch Size & Configuration:

a.	Approx. Vol., Each Basin	=	0.38	MG
b.	Basin SWD	=	12.0	feet
c.	Basin Channel Width	=	14.0	feet
d.	Straight Wall Length	=	54.0	feet
e.	Overall Basin Width	=	32.5	feet
f.	Radius of Basin Ends	=	15.8	feet
g.	Maximum Length	=	85.7	feet

3. Clarifier Size and Configuration

a.	Clarifier SWD	=	10.0	feet
b.	Inside Clarifier Dia.	=	32.0	feet
c.	Inside Clarifier Area	=	707	feet

4. Aerobic Digester Size and Configuration

a.	Approx. Vol., Each Basin	=	0.15	MG
b.	Basin SWD	=	12.0	feet
c.	Basin Width	=	41.0	feet
d.	Basin Length	=	41.0	feet

B. Summary of Probable Costs

1	Excavation & Backfill	$115,000
2	Cast in Place Concrete	$1,620,000
3	CMU Equipment Bldg. w/HVAC & Lighting	$190,000
4	Equipment, Valves & Piping	$1,630,000
5	Process Electrical	$195,000
6	Miscellaneous Items	$170,000
	Total for Construction (w/Contractor Markup)	**$3,920,000**
	Construction Contingencies (25%)	$980,000
	Total Probable Construction Cost	**$4,900,000**

City of Madras
Wastewater Master Plan Update

Planning-Level Estimates of Probable Construction Costs
Secondary Alternatives for North WWTP Expansion
Compact Extended Aeration Configuration - 0.5 MGD Module

A. Basis of Estimate

1. Scope of Estimate:

a. Estimates based on two, concrete reactor units, each w/aeration basin, clarifier and aerobic digester
b. Estimates include aeration basins, concentric clarifiers, digesters, RAS & WAS systems, internal components & associated equipment.
c. Assume aerobic digester volume same as 0.5 mgd module at SWWTP
d. Estimates include CMU bldg. for pumps, MCCs & Control Systems.
e. Estimates include earthwork, yard piping, site work & buried electrical conduits.

2. Compact Aeration Size & Configuration:

a.	Approx. Vol., Each Aeration Basin	=	0.19	MG
b.	Number of Basins	=	2	
c.	Aeration Basin & Digester SWD	=	12.0	feet
d.	Clarifier SWD	=	10.0	feet
e.	Inside Clarifier Dia.	=	32.0	feet
f.	Inside Clarifier Area	=	707	sq. ft.
g.	Aerobic Digester Volume	=	0.15	MG
h.	Outside Reactor Volume	=	45,455	cf
i.	Outer Basin Area	=	3,788	sq. ft.
j.	Outer Diameter, Each Compact Reactor Unit	=	80.0	feet

B. Summary of Probable Costs

1	Excavation & Backfill	$97,000
2	Cast in Place Concrete	$1,510,000
3	CMU Equipment Bldg. w/HVAC & Lighting	$216,000
4	Equipment, Valves & Piping	$1,605,000
5	Process Electrical	$193,000
6	Miscellaneous Items	$170,000
	Total for Construction (w/Contractor Markup)	**$3,791,000**
	Construction Contingencies (25%)	$949,000
	Total Probable Construction Cost	**$4,740,000**

City of Madras
Wastewater Master Plan Update
Planning-Level Estimates of Probable Construction Costs
Secondary Alternatives for North WWTP Expansion
Sequencing Batch Reactor Process - 0.5 MGD Module

A. Basis of Estimate

1. Scope of Estimate:

a. Estimates based on two concrete SBR reactors w/ post equalization.
b. Estimates include SBR basins, digesters, WAS pumps, internal components & associated equipment.
c. Estimates include CMU bldg. for pumps, MCCs & Control Systems.
d. Estimates include earthwork, yard piping, site work & buried electrical
e. Assume aerobic digester volume same as 0.5 mgd module at SWWTP.

2. SBR/Digester Size & Configuration:

a.	Approx. SBR Vol. @ Avg. Depth	=	0.56	MG
b.	Approx. Vol., Each Basin @ Avg. Depth	=	0.28	MG
c.	Avg. Basin SWD	=	16.0	feet
d.	Max. Basin SWD	=	18.0	feet
e.	Inside Basin Area	=	2,340	sq. ft.
f.	Inside Basin Length	=	48.0	feet
g.	Inside Basin Width	=	48.0	feet
h.	Aerobic Digester Volume	=	0.15	MG
i.	Inside Basin Length	=	48.0	feet
j.	Inside Basin Width	=	14.0	feet

3. Post Equalization Basin Size and Confiiguration:

a.	Basin Length	=	48.0	feet
b.	Basin Width	=	48.0	feet
c.	Max. Basin SWD	=	12.5	feet

B. Summary of Probable Costs

1	Excavation & Backfill	$97,000
2	Cast in Place Concrete	$1,820,000
3	CMU Equipment Bldg. w/HVAC & Lighting	$90,000
4	Equipment, Valves & Piping	$1,315,000
5	Process Electrical	$158,000
6	Miscellaneous Items	$170,000
	Total for Construction (w/Contractor Markup)	**$3,650,000**
	Construction Contingencies (25%)	$913,000
	Total Probable Construction Cost	**$4,563,000**

City of Madras
Wastewater Master Plan Update

Planning-Level Estimates of Probable Construction Costs
Disinfection Alternatives for North WWTP Expansion

I. Sodium Hypochlorite Bulk Storage & Feed

A. Basis/Scope of Estimate

a. Estimates include bulk NaOCl storage tank, two metering pumps, valves, piping, instrumentation and controls.

b. Estimates based on outdoor storage tank with heat jacket and insulation mounted on concrete pad and sheltered by bldg. overhang.

c. Estimates based on all equipment being housed in a separate CMU bldg. with concrete slab on grade and metal roof.

B. Summary of Probable Costs

1	Excavation, Backfill & Sitework	$3,000
2	Cast in Place Concrete	$12,000
3	CMU Equipment Bldg.	$35,000
4	NaOCl Storage Tank & Accessories	$18,000
5	Equipment, Valves, Piping & Accessories	$30,000
6	Process Electrical & Controls	$10,000
7	Miscellaneous Items	$5,000
Total for Construction (w/Contractor Markup)		**$113,000**
	Construction Contingencies (25%)	$28,000
Total Probable Construction Cost		**$141,000**

City of Madras
Wastewater Master Plan Update

Planning-Level Estimates of Probable Construction Costs
Disinfection Alternatives for North WWTP Expansion

II. Onsite Sodium Hypochlorite Generation & Feed

A. Basis/Scope of Estimate

a. Estimates include bulk brine tank, two brine pumps, generator, day tank, metering pumps, valves, piping, instrumentation and controls.

b. Estimates based on outdoor brine tank with heat jacket and insulation mounted on concrete pad and sheltered by bldg. overhang.

c. Estimates based on all equipment being housed in a separate CMU bldg. with concrete slab on grade and metal roof.

B. Summary of Probable Costs

1	Excavation, Backfill & Sitework	$5,000
2	Cast in Place Concrete	$23,000
3	CMU Equipment Bldg.	$63,000
4	Hypochlorite Generator Unit	$175,000
5	Brine Tank & Accessories	$15,000
6	Other Equipment, Valves, Piping & Accessories	$24,000
7	Process Electrical & Controls	$24,000
8	Miscellaneous Items	$8,000
Total for Construction (w/Contractor Markup)		**$337,000**
Construction Contingencies (25%)		$84,000
Total Probable Construction Cost		**$421,000**

City of Madras
Wastewater Master Plan Update

Planning-Level Estimates of Probable Construction Costs
Disinfection Alternatives for North WWTP Expansion

III. Tablet Chlorination (CaOCl) Equipment

A. Basis/Scope of Estimate

a. Estimates include tablet chlorination unit, two metering pumps, day tank, valves, piping, instrumentation and controls.

b. Estimates based on all equipment being housed in a separate CMU bldg. with concrete slab on grade and metal roof.

c. Estimates based on bldg. sized to provide indoor tablet storage space.

B. Summary of Probable Costs

1	Excavation, Backfill & Sitework	$4,000
2	Cast in Place Concrete	$16,000
3	CMU Equipment Bldg.	$45,000
4	Tablet Chlorinator Unit	$75,000
5	Other Equipment, Valves, Piping & Accessories	$21,000
6	Process Electrical & Controls	$12,000
7	Miscellaneous Items	$6,000
Total for Construction (w/Contractor Markup)		**$179,000**
Construction Contingencies (25%)		$45,000
Total Probable Construction Cost		**$224,000**

City of Madras
Wastewater Master Plan Update

Summary of Planning-Level Estimates for Probable Annual O&M Costs

A. Secondary Treatment Alternatives

1 Aerated/Partially-Mixed Lagoons

a	Labor Costs	$48,000
b	Power Costs	$64,000
c	Materials	$4,000
	Annual O&M Cost	**$116,000**
	Present Worth	**$1,990,000** (20 yrs @ 1.5%)

2 Oxidation Ditches

a	Labor Costs	$65,000
b	Power Costs	$82,000
c	Materials	$5,000
	Annual O&M Cost	**$152,000**
	Present Worth	**$2,610,000** (20 yrs @ 1.5%)

3 Compact Extended Aeration

a	Labor Costs	$70,000
b	Power Costs	$79,000
c	Materials	$5,000
	Annual O&M Cost	**$154,000**
	Present Worth	**$2,640,000** (20 yrs @ 1.5%)

4 Sequencing Batch Reactors

a	Labor Costs	$66,000
b	Power Costs	$78,000
c	Materials	$4,000
	Annual O&M Cost	**$148,000**
	Present Worth	**$2,540,000** (20 yrs @ 1.5%)

B. Disinfection Alternatives

1 NaOCl Bulk Storage& Feed

a	Labor Costs	$9,800
b	Power Costs	$500
c	Materials	$43,645
	Annual O&M Cost	**$53,945**
	Present Worth	**$926,000** (20 yrs @ 1.5%)

2 Onsite NaOCl Generation & Feed

a	Labor Costs	$20,400
b	Power Costs	$4,600
c	Materials	$10,000
	Annual O&M Cost	**$35,000**
	Present Worth	**$601,000** (20 yrs @ 1.5%)

3 Tablet Chlorination Equipment

a	Labor Costs	$15,100
b	Power Costs	$1,700
c	Materials	$26,000
	Annual O&M Cost	**$42,800**
	Present Worth	**$735,000** (20 yrs @ 1.5%)

Planning-Level Estimates of Probable Construction Costs - Dec 2016
Alternative Upgrades for Existing NWWTP

Option 1: Full Renovation and Future Expansion on Adjacent Site
(Renovate entire NWWTP in phases for 0.5 MGD capacity; Construct 0.5-MGD expansion when needed)

A. Full Lagoon Renovation (in Phases) - Maintain 0.5 MGD Capacity

	Item Description	Itemized Cost	Total Cost
1	Mobilization/Demobilization	$80,000	
2	Drain Lagoon & Demolish Exist. Lagoon Components	$50,000	
3	Replace Bedding & Liner in Cells A-D	$2,010,000	
4	Replace Mechanical Aerators in Lagoon Cells A & B	$450,000	
5	Replace Lagoon Transfer Structures & Access Walkways	$40,000	
6	Replace Inlet, Transfer & Outlet Piping for Cells A-D	$64,000	
7	Replace Electrical and Control Equipment for Lagoons	$54,000	
8	Construct Bldg. for Single DAF Unit incl. Sitework/Earthwork	$290,000	
9	Replace Existing DAF Unit in New Bldg.	$575,000	
10	Phase 1A - Disinfection and Pumping System Improvements	$295,000	
11	Phase 1B - Headworks and Related Improvements	$1,460,000	
	Subtotal - Renovate Existing Lagoons		$5,369,000
	Construction Contingencies (25%)		$1,342,000
	Total - Renovate Existing Lagoons		**$6,711,000**

B. NWWTP Expansion on Adjacent Site - New 0.5 MGD Facility

	Item Description	Itemized Cost	Total Cost
1	Mobilization/Demobilization	$106,000	
2	General Sitework	$175,000	
3	Expand Headworks Structure for 0.5-MGD Expansion	$330,000	
4	Headworks Equipment, Controls & Piping	$620,000	
5	Influent Flow Meter & Vault	$20,000	
6	Aerated Lagoons, Clarifiers & Digesters	$3,934,000	
7	Disinfection System and Chlorine Contact Tank	$350,000	
8	Effluent PS & Recycle PS	$210,000	
9	Process Building	$324,000	
10	Electrical and SCADA System	$240,000	
11	Sludge Drying Beds	$600,000	
12	Yard Piping	$260,000	
	Subtotal - Complete 0.5 MGD Treatment Module		$7,169,000
	Construction Contingencies (25%)		$1,792,000
	Total - Ajacent 0.5 MGD Expansion		**$8,961,000**

C. Option 1 - Estimated Total Probable Construction Cost **$15,672,000**

Planning-Level Estimates of Probable Construction Costs - Dec 2016
Alternative Upgrades for Existing NWWTP

Option 2: Partial Renovation and Future Expansion on Adjacent Site
(Renovate half of existing lagoons for 0.25-MGD capacity; Construct 0.75-MGD expansion when needed)

A. Partial Lagoon Renovation - Provide 0.25 MGD Capacity

	Item Description	Itemized Cost	Total Cost
1	Mobilization/Demobilization	$55,000	
2	Demolish Exist. Lagoon Components	$25,000	
3	Drain, Replace Liner, & Restore Earth Cover in Cells A & C	$1,005,000	
4	Replace Mechanical Aerators in Lagoon Cell A	$235,000	
5	Replace Lagoon Transfer Structures & Access Walkways	$20,000	
6	Replace Inlet, Transfer & Outlet Piping for Cells A & C	$32,000	
7	Replace Electrical and Control Equipment for Lagoons	$28,000	
8	Construct Bldg. for Single DAF Unit incl. Sitework/Earthwork	$261,000	
9	Replace Existing DAF Unit w/Smaller Unit	$340,000	
10	Phase 1A - Disinfection and Pumping System Improvements	$230,000	
11	Phase 1B - Headworks and Related Improvements	$1,460,000	
	Subtotal - Partial Renovation of Existing Lagoons		$3,691,000
	Construction Contingencies (25%)		$923,000
	Total - Partial Renovation of Existing Lagoons		**$4,614,000**

B. NWWTP Expansion on Adjacent Site - New 0.75 MGD Facility

	Item Description	Itemized Cost	Total Cost
1	Mobilization/Demobilization	$150,000	
2	General Sitework	$210,000	
3	Expand Headworks Structure for 0.5-MGD Expansion	$500,000	
4	Headworks Equipment, Controls & Piping	$930,000	
5	Influent Flow Meter & Vault	$20,000	
6	Aerated Lagoons, Clarifiers & Digesters	$5,232,000	
7	Disinfection System and Chlorine Contact Tank	$440,000	
8	Effluent PS & Recycle PS	$225,000	
9	Process Building	$375,000	
10	Electrical and SCADA System	$300,000	
11	Sludge Drying Beds	$900,000	
12	Yard Piping	$390,000	
	Subtotal - Complete 0.5 MGD Treatment Module		$9,672,000
	Construction Contingencies (25%)		$2,418,000
	Total - Ajacent 0.75 MGD Expansion		**$12,090,000**

C. Option 2 - Estimated Total Probable Construction Cost **$16,704,000**

Planning-Level Estimates of Probable Construction Costs - Dec 2016
Alternative Upgrades for Existing NWWTP

Option 3: Lagoon Retrofit and Future Expansion on Adjacent Site
(Retrofit half of existing lagoons w/0.5-MGD aerated lagoon system; Expand by 0.5-MGD when needed)

A. Retrofit to Maintain 0.5-MGD Capacity

	Item Description	Itemized Cost	Total Cost
1	Mobilization/Demobilization	$88,000	
2	Demolish Exist. Lagoon Components	$25,000	
3	Earthwork - Convert Cell A to 3-Cell Aerated Lagoons	$881,000	
4	Liner for 3-cell Aerated Lagoons	$304,000	
5	Equipment and Piping	$1,466,000	
6	Transfer Structures & Miscellaneous	$85,000	
7	Replace Electrical and Control Equipment for Lagoons	$150,000	
8	Construct Digester Tank	$270,000	
9	Construct Bldg. for Single DAF Unit incl. Sitework/Earthwork	$290,000	
10	Replace Existing DAF Unit in New Bldg.	$575,000	
11	Phase 1A - Disinfection and Pumping System Improvements	$295,000	
12	Phase 1B - Headworks and Related Improvements	$1,460,000	
	Subtotal - Retrofit Existing Lagoons to Maintain Capacity		$5,889,000
	Construction Contingencies (25%)		$1,472,000
	Total - Retrofit Half of Exist. Lagoons & Maintain Capacity		**$7,361,000**

B. NWWTP Expansion on Adjacent Site - New 0.5 MGD Facility

	Item Description	Itemized Cost	Total Cost
1	Mobilization/Demobilization	$106,000	
2	General Sitework	$175,000	
3	Expand Headworks Structure for 0.5-MGD Expansion	$330,000	
4	Headworks Equipment, Controls & Piping	$620,000	
5	Influent Flow Meter & Vault	$20,000	
6	Aerated Lagoons, Clarifiers & Digesters	$3,934,000	
7	Disinfection System and Chlorine Contact Tank	$350,000	
8	Effluent PS & Recycle PS	$210,000	
9	Process Building	$324,000	
10	Electrical and SCADA System	$240,000	
11	Sludge Drying Beds	$600,000	
12	Yard Piping	$260,000	
	Subtotal - Complete 0.5 MGD Treatment Module		$7,169,000
	Construction Contingencies (25%)		$1,792,000
	Total - Ajacent 0.5 MGD Expansion		**$8,961,000**

C. Option 3 - Estimated Total Probable Construction Cost **$16,322,000**

Planning-Level Estimates of Probable Construction Costs - Dec 2016
Alternative Upgrades for Existing NWWTP

Option 4: Two-Phase Lagoon Retrofit on Existing Lagoon Site
(Retrofit each half of existing lagoons w/aerated lagoons for 0.5-MGD upgrade and 0.5-MGD expansion)

A. Retrofit to Maintain 0.5-MGD Capacity

	Item Description	Itemized Cost	Total Cost
1	Mobilization/Demobilization	$97,000	
2	Demolish Exist. Lagoon Components (Ph 1)	$25,000	
3	Earthwork - Convert Cells A & B to Aerated Lagoon System	$881,000	
4	Liner for Ph 1 3-cell Aerated Lagoons	$304,000	
5	Equipment and Piping (Ph 1)	$1,466,000	
6	Transfer Structures & Miscellaneous (Ph 1)	$85,000	
7	Replace Electrical and Control Equipment for Lagoons	$150,000	
8	Construct Digester Tank	$270,000	
9	Phase 1A - Bldg. for Two DAF Units incl. Sitework/Earthwork	$490,000	
10	Phase 1A - Replace Existing DAF Unit in New Bldg.	$555,000	
11	Phase 1A - Disinfection and Pumping System Improvements	$295,000	
12	Phase 1B - Headworks and Related Improvements	$1,460,000	
	Subtotal - Phase Retrofit to Maintain Capacity		$6,078,000
	Construction Contingencies (25%)		$1,520,000
	Total - Retrofit Half of Exist. Lagoons & Maintain Capacity		**$7,598,000**

B. Retrofit to Expand Capacity to 1.0-MGD

	Item Description	Itemized Cost	Total Cost
1	Mobilization/Demobilization	$91,000	
2	General Sitework	$20,000	
3	Demolish Exist. Lagoon Components (Ph 2)	$25,000	
4	Earthwork - Convert Cells C & D to Aerated Lagoon System	$881,000	
5	Liner for second 3-cell Aerated Lagoons	$304,000	
6	Equipment and Piping (Ph 2)	$1,416,000	
7	Transfer Structures & Miscellaneous (Ph 2)	$85,000	
8	Replace Electrical and Control Equipment - Ph 2 Lagoons	$120,000	
9	Second DAF Unit	$510,000	
10	Expand Disinfection Capacity	$350,000	
11	Elect. & SCADA for Expansion	$106,400	
12	Headworks for Expansion to 1.0 MGD	$950,000	
13	Expand Effluent PS & Recycle PS (Ph 2)	$210,000	
14	Construct Digester Tank	$270,000	
15	Yard Piping for Expansion	$195,000	
16	Sludge Drying Beds for Expansion	$600,000	
	Subtotal - Retrofit Existing Lagoons to Expand Capacity		$6,133,000
	Construction Contingencies (25%)		$1,533,000
	Total - Retrofit Other Half of Exist. Lagoons for 0.5-MGD Expansion		**$7,666,000**

C. Option 4 - Estimated Total Probable Construction Cost **$15,264,000**

Planning-Level Estimates of Probable Construction Costs - Dec 2016
Alternative Upgrades for Existing NWWTP

Option 5: Replace and Expand NWWTP on Adjacent Site
(Construct new 0.5-MGD facility and abandon existing; Construct 0.5-MGD expansion when needed)

A. Replace w/New 0.5 MGD Facility on Adjacent Site

	Item Description	Itemized Cost	Total Cost
1	Mobilization/Demobilization	$103,000	
2	General Sitework	$175,000	
3	Headworks Structure for 0.5-MGD NWWTP Upgrade	$650,000	
4	Headworks Equipment (Screening & Grit Removal)	$620,000	
5	Influent Flow Meter & Vault	$20,000	
6	Aerated Lagoons, Clarifiers, Digesters, Yard Piping	$3,934,000	
7	Disinfection System and Chlorine Contact Tank	$350,000	
8	Effluent PS & Recycle PS	$210,000	
9	Process Building	$324,000	
10	Electrical and SCADA System	$240,000	
11	Yard Piping	$260,000	
12	Demolish Exist. Lagoon Components	$50,000	
	Subtotal -Replace w/New 0.5 MGD		$6,936,000
	Construction Contingencies (25%)		$1,734,000
	Total - Replace Existing NWWTP on Adjacent Site		**$8,670,000**

B. NWWTP Expansion on Adjacent Site - New 0.5 MGD Facility

	Item Description	Itemized Cost	Total Cost
1	Mobilization/Demobilization	$106,000	
2	General Sitework	$175,000	
3	Expand Headworks Structure for 0.5-MGD Expansion	$330,000	
4	Headworks Equipment, Controls & Piping	$620,000	
5	Influent Flow Meter & Vault	$20,000	
6	Aerated Lagoons, Clarifiers & Digesters	$3,934,000	
7	Disinfection System and Chlorine Contact Tank	$350,000	
8	Effluent PS & Recycle PS	$210,000	
9	Process Building	$324,000	
10	Electrical and SCADA System	$240,000	
11	Sludge Drying Beds	$600,000	
12	Yard Piping	$260,000	
	Subtotal - Complete 0.5 MGD Treatment Module		$7,169,000
	Construction Contingencies (25%)		$1,792,000
	Total - Ajacent 0.5 MGD Expansion		**$8,961,000**

C. Option 5 - Estimated Total Probable Construction Cost **$17,631,000**

City of Madras
Wastewater Master Plan

Planning-Level Estimates of Probable Construction Costs
South WWTP Phase 1 and Phase 2 Improvements

I. Phase 1 Expansion and Renovation (0.65 MGD Capacity)

A. Basis/Scope of Estimate

1 Estimates based on upgrading existing grit removal, SBR, filter, & disinfection processes, plus influent & effluent PS.

2 Estimates include expansions to Influent & Effluent PS.

B. Summary of Probable Costs

1 Equipment, Piping, Valves & Accessories	$534,000
2 Process Electrical	$52,000
3 Yard Piping & Sitework	$75,000
4 Miscellaneous Items	$52,000
Total for Construction (w/Contractor Markup)	**$713,000**
Construction Contingencies (25%)	$179,000
Total Phase 1 Probable Construction Cost	**$892,000**

II. Phase 2 Expansion and Renovation (1.15 MGD Capacity)

A. Basis of Estimate

1. Scope of Estimate:

a. Estimates include SBR process, digesters, post-eq, related components, yard piping modifications, & earthwork.

b. Estimates include expansions to Influent & Effluent PS, headworks, & disinfection process.

2. SBR Size & Configuration:

a. Approx. Vol., Each Basin	=	0.81	MG
b. Max. Basin SWD	=	20.0	feet
c. Inside Basin Area	=	5,184	sq. ft.
d. Inside Basin Length	=	72.0	feet
e. Inside Basin Width	=	72.0	feet
f. Aerobic Digester Volume	=	0.15	MG
g. Digester Length	=	72.0	feet
h. Digester Width	=	20.0	feet

B. Summary of Probable Costs

1 Excavation & Backfill	$345,000
2 Cast in Place Concrete	$1,600,000
3 Equipment, Valves & Piping	$2,520,000
4 Process Electrical	$197,000
5 Miscellaneous Items	$170,000
6 Headworks Expansion & Renovation	$920,000
Total for Construction (w/Contractor Markup)	**$5,752,000**
Construction Contingencies (25%)	$1,440,000
Total Phase 2 Probable Construction Cost	**$7,192,000**

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX M

EFFLUENT RECYCLING – WATER BALANCE CALCULATION AND ESTIMATED FARMLAND REQUIREMENTS

City of Madras
Wastewater Master Plan Update

Table M-1
Requirements for Effluent Storage Capacity
Annual Water Balance for 0.5-MGD WWTP Treatment Module
Pond Surface Area = 24 Acres (when full)

Month	Avg. Sewage Flow (See Note 1)		Precipitation (Maximum Year - See Note 2)		Evaporation (Minimum Year - See Note 2)		Net Effluent Flow from Storage or WWTP		Discharge to Recycling			Estimate of Stored Volume		
										Volumes		Monthly Change	Accumulated Volume	
	MG	AF	In.	AF	In.	AF	MG	AF	Days	MG	AF	(+/- AF)	AF	MG
January	14.73	45.19	1.46	2.86	0.00	0.00	15.66	48.05	0	0.00	0.00	48.05	151.66	49.42
February	13.05	40.05	2.43	4.76	0.00	0.00	14.60	44.81	0	0.00	0.00	44.81	196.48	64.02
March	13.18	40.44	2.24	4.39	0.00	0.00	14.61	44.83	0	0.00	0.00	44.83	241.30	78.62
April	12.73	39.05	1.02	2.00	0.84	1.65	12.84	39.40	15	12.65	38.82	0.58	241.88	78.81
May	13.18	40.44	0.95	1.86	5.03	9.85	10.57	32.45	31	26.14	80.23	-47.78	194.10	63.24
June	13.50	41.43	0.59	1.16	7.38	14.45	9.17	28.14	30	25.30	77.64	-49.50	144.60	47.12
July	15.50	47.57	1.63	3.19	8.68	17.00	11.00	33.76	31	26.14	80.23	-46.47	98.13	31.98
August	14.73	45.19	1.86	3.64	9.06	17.74	10.13	31.09	31	26.14	80.23	-49.14	49.00	15.97
September	13.50	41.43	0.45	0.88	6.98	13.67	9.33	28.64	30	25.30	77.64	-49.00	0.00	0.00
October	12.40	38.06	1.06	2.08	2.10	4.11	11.74	36.03	10	8.43	25.88	10.15	10.15	3.31
November	13.50	41.43	1.66	3.25	0.00	0.00	14.56	44.68	0	0.00	0.00	44.68	54.83	17.86
December	14.73	45.19	2.69	3.59	0.00	0.00	15.89	48.78	0	0.00	0.00	48.78	103.61	33.76
Annual	164.70	505.48	18.04	33.66	40.07	78.47	150.10	460.67	178	150.10	460.67	0.00		79.0

Conversion Factor (Ac-Ft/MG) = 3.069
Average Pond Surface Area = 23.5 Acres
Average Effluent Discharge Rate to Irrigation = 0.843 MGD
Notes:

1. WWTP Average Design Flow based on the peak monthly flow (Peak Monthly Flow = 0.50 MGD)
   Average Annual Flow = 90% of peak month
   Average Annual Flow = 0.45 MGD
   Assume peak monthly flow occurs in July and above average flows occur in December and January due to infiltration and inflow.
2. Water balance calculations assume maximum annual precipitation (1983-NOAA Madras Station) and minimum annual evaporation (1993-NUID Data). Evaporation data for 1993 includes assumed value for April based on lowest April data from 1987 - 2002

City of Madras
Wastewater Master Plan Update
Table M-2
Recycling Acreage Requirements for NWWTP
Based on Average Gross Irrigation Requirements for Common Crops

Crop Description	Gross Irrigation Potential (Inches) (Note 1)	Net Crop Irrigation Demand (Inches) (Note 2)	Estimated Golf Course Effl. Recycling (MG) (Note 3)		Estimated Net Remaining NWWTP Effl. for Recycling (MG) (Note 4)			Total Required Farmland for Recycling (Acres)			Current Gross Available Farmland (Acres)	Projected Net Available Farmland in Airport Area (Acres) (Note 5)			Estimated Net Farmland Surplus or Deficit for Each Phase (Acres)		
			Current	Future Expansion	Phase 1 Capacity (0.5-MGD)	Phase 2 Capacity (1.0-MGD)	Phase 3 Capacity (1.5-MGD)	Phase 1 Capacity (0.5-MGD)	Phase 2 Capacity (1.0-MGD)	Phase 3 Capacity (1.5-MGD)		Phase 1 Capacity (0.5-MGD)	Phase 2 Capacity (1.0-MGD)	Phase 3 Capacity (1.5-MGD)	Phase 1 Capacity (0.5-MGD)	Phase 2 Capacity (1.0-MGD)	Phase 3 Capacity (1.5-MGD)
Turf Grass	38.11	30.49	18.0	29.0	131.6	284.9	449.1	159.0	344.1	542.6	246	174	160	111	15	-184	-432
Grass Seed (Fall)	35.11	28.08	18.0	29.0	131.6	284.9	449.1	172.6	373.6	589.0	246	174	160	111	1	-214	-478
Pasture Grass	32.28	25.83	18.0	29.0	131.6	284.9	449.1	187.7	406.3	640.5	246	174	160	111	-14	-246	-530
Alfalfa (Reference)	28.67	22.94	18.0	29.0	131.6	284.9	449.1	211.4	457.5	721.2	246	174	160	111	-37	-297	-610
Winter Grains	23.71	18.96	18.0	29.0	131.6	284.9	449.1	255.7	553.3	872.2	246	174	160	111	-82	-393	-761
Spring Grains	22.64	18.11	18.0	29.0	131.6	284.9	449.1	267.8	579.4	913.5	246	174	160	111	-94	-419	-802
Average	**30.09**	**24.07**	**18.0**	**29.0**	**131.6**	**284.9**	**449.1**	**209.0**	**452.4**	**713.2**	**246**	**174**	**160**	**111**	**-35**	**-292**	**-602**

Volume Conversion Factor = 3.069 Ac-ft/MG
Average Design Capacity:
Current Capacity = 0.50 MGD
Phase 1 Expansion = 1.00 MGD
Phase 2 Expansion = 1.50 MGD

NOTES:

(1) Gross Irrigation Potential = Avg. Irrigation Requirement (5 out of 10 yr.) divided by Irrigation Efficiency
Turf Grass Assumed Irrigation Efficiency = 90%
Field Crop Assumed Irrigation Efficiency = 85%

(2) Basis for Calculating Net Farmland Irrigation Demand
Net irrigation demand = 80% of gross irrigation potential (Remainder of water obtained from NUID or not needed)

(3) Basis for Calculating Effluent Recycling at Golf Course
Gross Irrigation Potential based on Turf Grass
Net irrigation demand = 25% of gross irrigation potential (Remainder of water obtained from NUID or not needed)
Available Golf Course Land:
Current Usable Land = 71 Acres
Future Usable Land = 114 Acres (after expansion)
Future Golf Course expansion projected to occur before NWWTP flows reach Phase 2 capacity (1.0 MGD)

(4) Basis for Calculating Net Volume of Available Treated Effluent
WWTP Design Capacity = Projected Peak Monthly Flow
Average Annual Flow = 90% of Peak Month
Avg. Annual Flow at Capacity for each Phase:
Current Capacity = 0.45 MGD (Avg Annual)
Phase 1 Expansion = 0.90 MGD (Avg Annual)
Phase 2 Expansion = 1.35 MGD (Avg Annual)
Net volume loss in ponds = 14.60 MG (Min. Evaporation less Max. Precipitation)

(5) Basis for Calculating Net Available Farmland
Assume proportion of fields in production & taking effluent = 90% (Remainder of fields left fallow or grow food crops)
Phase 1 - Assume development of airport area. Net Available Farmland Subtracted = 47 Acres (Field 14)
Phase 2 - Construct effl. storage pond on farmland. Net Available Farmland Subtracted = 16 Acres (part of Field 9)
Phase 3 - Expand NWWTP & effl. Storage ponds. Net Available Farmland subtracted = 54 Acres (part of Fields 8, 9 & 11)

City of Madras
Wastewater Master Plan Update

Table M-3
Recycling Acreage Requirements for SWWTP
Based on Average Gross Irrigation Requirements for Common Crops

Crop Description	Gross Irrigation Potential (Inches) (Note 1)	Net Crop Irrigation Demand (Inches) (Note 2)	Estimated Net SWWTP Effl. Available for Recycling (MG) (Note 3)			Total Required Farmland for Recycling (Acres)			Gross Area of SWWTP Sites (Acres)	Projected Net Available Farmland (Acres) (Note 4)		Estimated Net Farmland Surplus or Deficit for Each Phase (Acres)		
			Current Capacity (0.54 MGD	Phase 1 Capacity (0.65 MGD	Phase 2 Capacity (1.15 MGD	Current Capacity (0.54 MGD	Phase 1 Capacity (0.65 MGD	Phase 2 Capacity (1.15 MGD		Currently Available Land	Planned Future Total	Current Capacity (0.54 MGD	Phase 1 Capacity (0.65 MGD	Phase 2 Capacity (1.15 MGD
Turf Grass	40.35	36.32	150	183	335	152	186	340	304	100	274	122	88	-66
Grass Seed (Fall)	37.30	33.57	150	183	335	164	201	368	304	100	274	110	73	-94
Pasture Grass	34.30	30.87	150	183	335	179	218	400	304	100	274	95	56	-126
Alfalfa (Reference)	30.46	27.42	150	183	335	201	246	450	304	100	274	73	28	-176
Winter Grains	25.19	22.67	150	183	335	243	297	545	304	100	274	31	-23	-271
Spring Grains	24.05	21.65	150	183	335	255	312	570	304	100	274	19	-38	-296
Average	**31.94**	**28.75**	**150**	**183**	**335**	**199**	**243**	**445**	**304**	**100**	**274**	**75**	**31**	**-171**

Volume Conversion Factor = 3.069 Ac-ft/MG
Average Design Capacity:
Current Capacity = 0.54 MGD
Phase 1 Expansion = 0.65 MGD
Phase 2 Expansion = 1.15 MGD

NOTES:

(1) Gross Irrigation Potential = Avg. Irrigation Requirement (5 out of 10 yr.)/Irrigation Efficiency
Turf Grass Assumed Irrigation Efficiency = 85%
Field Crop Assumed Irrigation Efficiency = 80%

(2) Basis for Calculating Net Irrigation Potential
Net irrigation demand = 90% of gross irrigation potential (Remainder of water obtained from NUID or not needed)

(3) Basis for Calculating Volume of Available Treated Effluent
WWTP Design Capacity = Projected Peak Monthly Flow
Average Annual Flow = 90% of Peak Month
Avg. Annual Flow at Capacity for each Phase:
Current Capacity = 0.45 MGD (Avg Annual)
Phase 1 Expansion = 0.54 MGD (Avg Annual)
Phase 2 Expansion = 0.96 MGD (Avg Annual)
Net volume loss in ponds = 14.60 MG (Min. Evaporation less Max. Precipitation)

(4) Basis for Calculating Net Available Farmland
Assume proportion of fields in production & taking effluent = 90% (Remainder of fields left fallow or grow food crops)
Current net available land includes 90% of Woodworth lease (76 Gross AC) and McTaggart-Deschutes Basin Lot (35 Gross AC).
Future lands include proposed golf course land (193 Gross AC), plus Woodworth and McTaggart-Deschutes Basin Lots.
Calculations of Net Farmland Surplus or Deficit based on using proposed golf course land as farmland.

City of Madras
Wastewater Master Plan Update

Table M-4
Average Water Uses, Net Irrigation Requirements and Gross Application Rates for Various Crops in Madras Area (See Note 1)
Used as Basis for Estimating Farmland Area Requirements

Month	Turf Grass Irrigation (In.) (Note 2)	Pasture Grass		Alfalfa / Hay		Grass Seed (Fall)		Spring Grains		Winter Grains	
		ETcrop (In.)	NIRR (In.)	ETcrop (In.)	NIRR (In.)	ETcrop (In.)	NIRR (In.)	ETcrop (In.)	NIRR (In.)	ETcrop (In.)	NIRR (In.)
January	--	--	--	--	--	0.16	0.00	--	--	--	--
February	--	--	--	--	--	0.55	0.04	--	--	--	--
March	--	--	--	--	--	1.57	0.91	--	--	0.67	0.35
April	2.26	2.13	1.81	2.20	1.85	3.43	2.91	2.17	1.65	2.80	2.28
May	4.83	4.72	3.86	4.49	3.58	5.47	4.53	5.12	4.21	5.43	4.53
June	5.90	5.67	4.72	5.35	4.37	6.50	5.47	6.50	5.39	6.50	5.39
July	8.31	7.01	6.65	6.57	6.26	8.03	7.64	7.17	6.81	7.24	6.89
August	6.60	5.55	5.28	5.16	5.00	5.63	5.43	1.26	1.18	0.71	0.71
September	4.48	4.06	3.58	3.82	3.31	2.09	1.65	--	--	--	--
October	1.93	2.05	1.54	--	--	1.85	1.22	--	--	--	--
November	--	--	--	--	--	0.59	0.04	--	--	--	--
December	--	--	--	--	--	0.08	0.00	--	--	--	--
Total Annual	**34.30**	**31.19**	**27.44**	**27.59**	**24.37**	**35.95**	**29.84**	**22.22**	**19.24**	**23.35**	**20.15**
Gross Appl. Rates (Note 3):											
North WWTP	**38.11**		**32.28**		**28.67**		**35.11**		**22.64**		**23.71**
South WWTP	**40.35**		**34.30**		**30.46**		**37.30**		**24.05**		**25.19**

(1) The average crop water requirements (ETcrop) and the Net Irrigation Requirements are based on meeting the requirements for 5 out of 10 years in the Madras-Redmond region. Source: Oregon Crop Water Use and Irrigation Requirements, Reprinted March 1999.

(2) Based on Historical Usage. Frequent harvesting and intense cultivation allow for higher water and nutrient use. High value on appearance stresses the need for proper watering (25 percent increase over pasture grass requirement).

(3) Gross Application Rate (i.e. Irrigation Potential) = $\frac{\text{Net Irrigation Required (NIRR)}}{\text{Assumed Irrigation Efficiency}}$

1. North WWTP - Assumed Irrigation Efficiencies:

Turf grass = 90%
All Other Crops = 85%

2. South WWTP - Assumed Irrigation Efficiencies:

Turf grass = 85%
All Other Crops = 80%

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX N

MINUTES OF PUBLIC MEETINGS
HELD 01/26/2017 AND 11/29/2017
(PREPARED BY MADRAS PUBLIC WORKS)

THE CITY OF MADRAS

WASTEWATER SYSTEM DRAFT 2016 MASTER PLAN UPDATE JANUARY 26, 2017

REASONS FOR PLAN UPDATE

1. Previous WW Master Plan completed in 1996
2. Support Asset Management – Inventory, Condition, & Maintenance Plan
3. Updated Population Projections – 2015 forecasts from PSU (State Program)
4. Evaluate System Capacity– Identify service needs inside UGB for next 20 years based on projections
5. Capital Improvements Plan – Identify WW projects & estimate probable costs
6. Financial Plan – identify rates & other charges needed to sustain facilities
7. Industrial Site Readiness – Plan for infrastructure needs to serve potential development

EXISTING WASTEWATER FACILITIES

1. Two Collection Systems – Main (most of City) & Industrial Park (North Area)
2. Five Sewage Pump Stations – B Street N & S (two largest); Demers serves Industrial Park; Golf Course & South 97 are small
3. Two WASTEWATER TREATMENT PLANTS
   - North (near airport): Lagoon system constructed in mid 1970s; plant upgraded twice in 1990s
   - South (at J St. & Grizzly): Mechanical system; built in 2001; designed for 2 expansions - 1st completed in 2008 for DRCI (prison)

INVENTORY & CONDITION ASSESSMENTS

1. Sewers –Condition adequate; original lines near end of projected service life in 20 years; should institute cleaning/inspection program
2. Pump Stations – Age and Condition are issues at Demers & Golf Course. Age a consideration for B Street North.
3. North Wastewater Treatment Plant –Age an issue for many components
4. South Wastewater Treatment Plant – Plant generally in adequate to good condition

INVENTORY & CONDITION ASSESSMENTS

1. Sewers –Condition adequate; original lines near end of projected service life in 20 years; should institute cleaning/inspection program
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3. North Wastewater Treatment Plant –Age an issue for many components
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Basis of Planning – Forecasts for Population and DUs inside UGB

Year	Population (1)	Occupied DUs (2)	AAGR (3)
2015	7,484	2,880	---
2020	8,070	3,105	1.52%
2025	8,700	3,345	1.51%
2030	9,268	3,565	1.27%
2035	9,815	3,775	1.15%
2065	12,749	4,905	0.88%

(1) PSU 2015 forecast for entire area within UBG (under State Population Forecast Program).
(2) Forecasts for occupied DUs based on an average unit occupancy of 2.6 PPH.
(3) AAGR calculated for each incremental 5-year period to 2035 and 30-year period 2035-65.

Basis of Planning–Forecast WW Treatment Capacity Requirements (in MGD)

Year	Total Forecast WW Flows (1)		Net Available ADF Capacity (2)
	Maximum Monthly	Peak Hourly	
2020	0.91	2.43	0.13
2025	1.03	2.75	0.01
2030	1.09	2.91	– 0.05
2035	1.14	3.04	– 0.10
2065 (build-out)	1.41	3.76	

(1) Includes projected flows based on population forecasts plus full contribution of allotted capacity for prison. No allowance for additional major industrial development.

(2) Based on the existing total ADF capacity of 1.04 MGD.

MGD – Million Gallons per Day

ADF – Average Design Flow

COLLECTION SYSTEM ANALYSIS

1. Modeled Sewer Systems under current & projected flows

Industrial Park projections incl. addition of 1.0 MGD average flow at three alternative sites to plan for potential major developments

Projected Main System flows distributed using proposed developments

2. Flow records show sewers not subject to excessive infiltration & inflow (runoff, snow melt, or perched groundwater)
3. Capacities of existing sewers & pump stations adequate for current conditions
4. Modeling identified capacity shortfalls under projected flows & evaluated alternative improvements

RECOMMENDED INDUSTRIAL PARK SEWER IMPROVEMENTS

1. Sewer extensions within existing developed areas – address infill
   - Mill & Hess Streets – 8"Gravity Sewers
2. Potential parallel sewer to increase capacity
   - Address site readiness for major industrial users (assume 1.0 MGD average flow)
   - Three alternative sites evaluated – north, south & east areas of Industrial Peak
   - Initial sewer alignment & sizing identified for each alternative site

Estimates of Probable Costs for Sewer Improvements
Industrial Park Collection System (Current to Dec 2016)
All Project dollars are based on current dollars

Project Description	Time Frame (Years)	Pipe Size (inches)	Approximat e Length (ft.)	Probable Project Cost (1)
Industrial Park Sewer Extensions				
1. Hess Street Sewer	6-10	8	1,670	$339,000
2. Mill Street Sewer	6-10	8	1,430	$290,000
Subtotal for Sewer Extensions				**$629,000**
Potential Sewers for Major Industrial Park Users				
1. East Area Parallel Sewer – Cherry Ln.	(2)	15	4,800	$1,620,000
2. South Area Parallel Sewer – Demers Dr.	(2)	18	2,400	$972,000
3. North Area Parallel Sewer – Airport Way	(2)	18	2,240	$907,000

(1) Probable project cost includes a 25% construction contingency and 35% allowance for non-construction costs (engineering and administrative).

(2) Potential improvements shown for planning industrial site readiness. Timing this is dependent on developments for major users. Required sewer projects for major user(s) must be reevaluated based on actual development proposal(s).

RECOMMENDED MAIN COLLECTION SYSTEM SEWER IMPROVEMENTS

1. Capacity Upgrades for Projected Flows
   - North Y Sewer (replacement)

- Culver Hwy Sewer (parallel pipe)

2. Sewer extensions in un-sewered areas
   - Mostly North side tributary to North Wye Sewer
   - Juniper Heights tributary to Culver Hwy Sewer
3. Sewer extensions needed for proposed developments

Estimates of Probable Costs for Sewer Improvements
Main Collection System (Current to Dec 2016) All Project dollars are based on current dollars

Project Description	Time Frame (Years)	Pipe Size (inches)	Approximate Length (ft.)	Probable Project Cost (1)
1. North Y Sewer Replacement (By Pipe Bursting)	0-5	12	2,060	$852,000
2. Culver Hwy. Parallel Sewer	11-15	10	3,100	$733,000
3. Mountain View/Sky Ridge Sewer Extensions (2)	0-5	8	4,500	$1,139,000
4. Jefferson Street/North Unit (2)	0-5	8	2,900	$539,000
5. Bel Air/Herzberg Heights (2)	0-5	8	5,100	$1,120,000
6. Juniper Heights Sewer Extension (2)	16-20	8	5,350	$1,354,000
7. Willow Creek North Sewer Extension (3)	16-20	8	2,500	$548,000
8. Madras South Town Center Sewer Extension (3)	>20 Yrs	8	2,420	$613,000
9. Eldorado Estates/The Ridge Sewer Extension (3)	>20 Yrs	8	1,800	$456,000
Subtotal for Main Collection System Sewers				**$7,353,000**

(1) Probable project cost includes a 25% construction contingency and 35% allowance for non-construction costs.
(2) Un-sewered areas with current developments.
(3) Sewer extension required for future developments

RECOMMENDED IMPROVEMENTS PUMP STATIONS

1. North Area:
   - Replace Demers PS - design for future expansions to handle industrial growth (3-5 Years)
   - Replace Demers Force Main–future 8"Force Main when Demers PS is expanded
   - Replace Golf Course PS–expand to accommodate Willowbrook (6-10 Years)
2. Main Collection System:

- Renovate B Street North Pump Station & Add Screening Equipment (11-15 Years)
- Replace standby power generator serving B St North & South Pump Station (11-15 Years)
- Renovate South 97 Pump Station (11-15 Years)
- Expand B Street South Pump Station along w/South WWTP expansion (16-20 Years)

Estimates of Probable Costs for Pump Station Improvements (Current to Dec 2016)
All Project dollars are based on current dollars

Project Description	Time Frame (Years)	Current Capacity (MGD)	Planned Capacity (MGD)	Probable Project Cost (1)
A. Industrial Park Collection System (North Area)				
1. Golf Course PS Replacement – Expanded Capacity	6-10	N/A	0.21	$475,000
2. Demers PS Replacement – Expanded Capacity	3-5	0.42	1.33	$1,735,000
3. Demers Force Main Replacement – 8" Pipe	(2)	0.56	1.33	$1,535,000
Subtotal – Pump Stations & Force Mains in North Area				**$3,745,000**
B. Main Collection System Pump Stations				
1. "B" Street North PS Renovation – No expansion	11-15	1.11	1.11	$805,000
2. "B" Street South PS Expansion & Renovation	16-20	1.33	2.66	$710,000
3. "B" Street North & South Generator Set Replacement	11-15	N/A	N/A	$235,000
4. South U.S. 97 PS Renovation – No expansion	11-15	0.06	0.06	$60,000
Subtotal – Pump Stations in Main Collection System				**$1,810,000**
Total – Pump Stations & Force Mains				**$5,555,000**

(1) Probable project cost includes a 25% construction contingency and 35% allowance for non-construction costs (engineering and administrative).

(2) Potential improvement shown for planning industrial site readiness. Timing is dependent on developments for major users. Required projects for major user(s) must be reevaluated based on actual development proposal(s).

WASTEWATER TREATMENT PLANT ALTERNATIVES EVALUATION

1. Evaluate alternative treatment scenarios to meet 20-yr needs & address industrial site readiness
   - Address small, projected capacity deficit from population growth
   - Address WW distribution for best use of existing WWTPs
   - Provide flexibility for serving proposed developments & potential Industrial-Park development
   -

2. Evaluate North WWTP alternatives:
    - Alternative capacity expansions to for industrial development
    - Upgrade of existing facilities to address age & condition issues (renovation, retrofit or replacement)

RECOMMENDED APPROACH FOR WW TREATMENT

1. Phase 1 South WWTP Upgrade–retrofit to provide small incremental expansion (8-10 years)
2. Phase 2 South WWTP Upgrade–0.5 MGD expansion to free-up capacity at North WWTP for development (15+ years – timing depends on development pace)
3. Retrofit North WWTP to maintain 0.5-MGD capacity (10-12 years)
4. Expand North WWTP as needed to serve Industrial Park developments
5. Identify additional irrigation sites for North WWTP effluent recycling (South WWTP expansion – use proposed Golf Course site)

ALTERNATIVES EVALUATION - NORTH WWTP

1. Recommended Treatment Processes for Future Expansions
    - Preliminary Treatment w/Mechanical Screening & Grit Removal
    - Secondary Treatment w/Aerated Lagoon System & Clarification
    - Disinfection Using Tablet Chlorination System
    - Aerobic Digesters & Sludge Drying Beds (same as existing)
2. Recommended Future Upgrade for Existing North WWTP
    - Retrofit Existing Lagoons in Phases to Convert to Aerated Lagoon System
    - Replace Clarification & Disinfection Equipment
    - Add Aerobic Digesters & Continue Use of Existing Sludge Drying Beds

Estimates of Probable Costs for WWTP Improvements (Current to Dec 2016)
All Project dollars are based on current dollars

Project Description	Time Frame (Years)	Current Capacity (MGD)	Planned Capacity (MGD)	Probable Project Cost (1)
A. South WWTP Upgrades				
1. Phase 1 Expansion/Renovation (Retrofit Existing Plant)	8-10	0.54	0.65	$1,202,000
2. Phase 2 Expansion and Renovation	15-20	0.65	1.15	$9,642,000
3. Phase 2 Effluent Storage Expansion	15-20	0.65	1.15	$8,910,000
Subtotal for South WWTP Improvements				**$19,754,000**
B. North WWTP Upgrades				
1. Phase 1 Retrofit to Maintain 0.5 MGD Capacity	10-12	0.50	0.50	$10,180,000
2. Phase 2 Retrofit for 0.5 MGD Expansion (to 1.0 MGD)	(2)	0.50	1.00	$10,740,000

3. Construct Effluent Storage for 0.5 MGD Expansion	(2)	0.50	1.00	$12,137,000
4. Phase 3 – Construct 0.5-MGD Module (Expand to 1.5 MGD)	(2)	--	1.5	$12,333,000
5. Effluent Storage Ponds for Expansion to 1.5 MGD	(2)	--	1.5	$12,137,000
Subtotal for North WWTP Improvements				**$57,527,000**

(1) Probable project cost includes a 25% construction contingency and 35% allowance for non-construction costs (engineering and administrative).

(2) Potential improvement shown for planning industrial site readiness. Timing is dependent on developments for major users. Required projects for major user(s) must be reevaluated based on actual development proposal(s).

All Project dollars are based on current dollars

The following topics were discussed:

Do these numbers include the golf course?

What about a wetland option like Prineville is doing?

Why can't we discharge into Willow creek?

Prineville is discharging into the Crooked River through a wet land?

How many acres will be supported on the 57 million dollar improvement?

Can our system handle the temporary influx with the Solar Eclipse?

THE CITY OF MADRAS

WASTEWATER MASTER PLAN UPDATE PUBLIC MEETING NOVEMBER 29, 2017

Engineer Ken Condit presented a power point presentation that covered the following information .

REASONS FOR PLAN UPDATE

1. Previous WW Master Plan completed in 1996
2. Support Asset Management – Inventory, Condition, & Maintenance Plan
3. Updated Population Projections – 2015 forecasts from PSU (State Program)
4. Evaluate System Capacity– Identify service needs inside UGB for next 20 years based on projections
5. Capital Improvements Plan – Identify WW projects & estimate probable costs
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   Industrial Park projections incl. addition of 1.0 MGD average flow at three alternative sites to plan for potential major developments

Projected Main System flows distributed using proposed developments

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3. Capacities of existing sewers & pump stations adequate for current conditions
4. Modeling identified capacity shortfalls under projected flows & evaluated alternative improvements

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2. Sewer extensions in un-sewered areas
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    - Address WW distribution for best use of existing WWTPs
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2. Recommended Future Upgrade for Existing North WWTP
    - Retrofit Existing Lagoons in Phases to Convert to Aerated Lagoon System
    - Replace Clarification & Disinfection Equipment
    - Add Aerobic Digesters & Continue Use of Existing Sludge Drying Beds

Citizen comments included questions about sewer rates being raised, the use of treated effluent water on farm land, and the possibility of an expansion at the North Plant. For a copy of the power point presentation please contact the City of Madras at 541-475-2344 or email mquinn@ci.madras.or.us

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX O

CMOM PROGRAM SELF-ASSESSMENT CHECKLIST
(U.S. ENVIRONMENTAL PROTECTION AGENCY, 2003)

About the CMOM Program Self Assessment Checklist

Introduction

A sanitary sewer collection system is a vital element of any community's infrastructure and a critical component of the wastewater treatment process. The nation's sanitary sewer infrastructure has been built over the last 100 years or more using a variety of materials, design standards, installation techniques, and maintenance practices. As this valuable infrastructure ages, the importance of preventive and predictive maintenance increases.

What is CMOM?

CMOM stands for "capacity, management, operations, and maintenance." It is a flexible, dynamic framework for municipalities to identify and incorporate widely-accepted wastewater industry practices to:

- Better manage, operate, and maintain collection systems
- Investigate capacity constrained areas of the collection system
- Respond to sanitary sewer overflow (SSO) events

The CMOM approach helps municipal wastewater utility operators provide a high level of service to customers and reduce regulatory noncompliance. CMOM can help utilities optimize use of human and material resources by shifting maintenance activities from "reactive" to "predictive"–often leading to cost savings through avoided overtime, emergency construction costs, increased insurance premiums, and the possibility of lawsuits. CMOM information and documentation can also help improve communications with the public, other municipal works and regional planning organizations, and regulators.

In CMOM planning, the utility selects performance goal targets, and designs CMOM activities to meet the goals. The CMOM planning framework covers operation and maintenance (O&M) planning, capacity assessment and assurance, capital improvement planning, and financial management planning. Information collection and management practices are used to track how well each CMOM activity is meeting the performance goals, and whether overall system efficiency is improving. On an ongoing basis, activities are reviewed and adjusted to better meet the performance goals. As the CMOM program progresses, performance goals can change. For instance, an initial goal may be to develop a geographic information system (GIS) of the system. Once the GIS is complete, a new goal might be to use the GIS to track emergency calls and use the information to improve maintenance planning.

An important component of a successful CMOM program is to periodically collect information on current systems and activities and develop a "snapshot-in-time" analysis. From this analysis, the utility establishes its performance goals and plans its CMOM program activities.

Additional information describing CMOM can be found at: www.epa.gov/npdes/sso or www.epa.gov/region4/water/wpeb/pdfs/self-audit_review2-3.pdf.

What is the purpose of the CMOM program checklist?

This document is a screening-level tool that can help utilities evaluate CMOM programs and identify general areas of strength and weakness. Completing this CMOM assessment will allow the utility to flag CMOM program areas that need improvement and establish priorities for additional, more detailed assessments. In addition, the checklist will allow the utility to compare annual performance (e.g., percent of employees meeting training standards).

This document is not intended to be all-inclusive. It addresses the types of practices EPA believes should be considered by most utilities when implementing a CMOM program. However, the ways in which utilities use the information gathered through the checklist will depend on the complexity and site-specific issues facing individual collection systems. When reviewing the questions, utilities should use their judgment to determine if the question is reasonable for their collection system size and design.

How do I use this checklist?

The questions on the checklist will request answers in three different formats:

- Check yes, no, or not applicable (NA),
- Fill in the blank, and
- Check all that apply.

At the end of each section, additional space is provided to allow for comments on or explanations of the answers recorded (information that will be useful to the utility in follow-on planning). Each utility should make an effort to answer all the questions that are applicable to its system. If a particular question takes a significant amount of time to answer, this could be an indication of an area of weakness. Utilities should plan to invest approximately one day to complete the checklist.

This document is designed to help utilities perform an initial evaluation of CMOM activities. **It is not intended to serve as an absolute indicator of a successful CMOM program, nor will all of the questions apply to every utility.** By working through these questions, utilities will be able to identify strengths and areas for improvements in their CMOM programs. If a utility has a significant number of "no" answers or very few items selected in the checklist, this could indicate an area of weakness. The utility manager then can make a more detailed evaluation, including identifying specific actions needed to address areas for improvement.

General Information

CHECKLIST COMPLETED BY:

Name _____ Date _____

Daytime Telephone Number _____

UTILITY CONTACT INFORMATION

Utility Name _____

LOCATION

Street Address _____

Street Address (continued) _____

City _____ State _____ Zip _____

STAFF

Name _____

Title _____

Email _____

Phone ( ) - Fax ( ) -

PERMITTED TREATMENT & COLLECTION FACILITES

NPDES or STATE PERMIT #	PERMITTEE/CO-PERMITTEE/JURISDICTIONS	PERMIT COVERAGE WWTP Effluent	Collection System	Wet-Weather Facility
		☐	☐	☐
		☐	☐	☐
		☐	☐	☐
		☐	☐	☐
		☐	☐	☐

Collection System Description

SYSTEM INVENTORY

[ ] NUMBER # of Treatment facilities

Treatment Facilities

WWTP design capacity [ ] MGD

Average daily flow [ ] MGD

Average dry weather fow [ ] MGD

Access & Maintenance

Manholes [ ] NUMBER

Number of air vacuum relief valves [ ] NUMBER

Conveyance & Pumping

	Gravity Sewers	Force Mains	Pump Stations
Pipes and pumps Length/quantity	[ ] MILES	[ ] MILES	[ ] NUMBER
Age of system 0 - 25 years old	[ ] % PERCENT	[ ] % PERCENT	[ ] % NUMBER
26 - 50 years old	[ ] % PERCENT	[ ] % PERCENT	[ ] % NUMBER
51 - 75 years old	[ ] % PERCENT	[ ] % PERCENT	[ ] % NUMBER
>76 years old	[ ] % PERCENT	[ ] % PERCENT	[ ] % NUMBER

Number of inverted siphons _____

SERVICE AREA CHARACTERISTICS

Service area [ ] ACRES

Service population [ ] PEOPLE

Annual precipitation [ ] INCHES

Number of Service Connections

Residential		Commercial		Industrial		TOTAL
[ ] NUMBER	+	[ ] NUMBER	+	[ ] NUMBER	=	[ ] NUMBER

Collection system service lateral responsibility *(check one)*

- ☐ At main line connection only
- ☐ From main line to property line or easement/cleanout
- ☐ Beyond property line/clean out
- ☐ Other: _____

Combined Sewer Systems

What percent of sewer system is served by combined sewers (i.e., sanitary sewage and storm water in the same pipe)? [ ] % PERCENT

Collection System Description

	Gravity Sewers	Force Mains
PIPE DIAMETER		
8 inches or less	% PERCENT	% PERCENT
9 - 18 inches	% PERCENT	% PERCENT
19 - 36 inches	% PERCENT	% PERCENT
>36 inches	% PERCENT	% PERCENT
PIPE MATERIALS		
Prestressed concrete cylinder pipe (PCCP)	% PERCENT	% PERCENT
High density polyethylene (HDPE)	% PERCENT	% PERCENT
Reinforced concrete pipe (RCP)	% PERCENT	% PERCENT
Polyvinyl chloride (PVC)	% PERCENT	N/A PERCENT
Vitrified clay pipe (VCP)	% PERCENT	N/A PERCENT
Ductile iron	% PERCENT	% PERCENT
Non-reinforced concrete pipe	% PERCENT	% PERCENT
Asbestos cement pipe	% PERCENT	% PERCENT
Cast iron	% PERCENT	% PERCENT
Brick	% PERCENT	% PERCENT
Fiberglass	% PERCENT	% PERCENT
Other (*Explain*)_____	% PERCENT	% PERCENT

Engineering Design (ED)

ED-01	Is there a document which includes design criteria and standard construction details?	YES	NO
ED-02	Is there a document that describes the procedures that the utility follows in construction design review?	YES	NO
ED-03	Are WWTP and O&M staff involved in the design review process?	YES	NO
ED-04	Is there a procedure for testing and inspecting new or rehabilitated system elements both during and after the construction is completed?	YES	NO
ED-05	Are construction sites supervised by qualified personnel (such as professional engineers or certified engineering technicians) to ascertain that the construction is taking place in accordance with the agreed upon plans and specifications?	YES	NO
ED-06	Are new manholes tested for inflow and infiltration?	YES	NO
ED-07	Are new gravity sewers checked using closed circuit TV inspection?	YES	NO
ED-08	Does the utility have documentation on private service lateral design and inspection standards?	YES	NO
ED-09	Does the utility attempt to standardize equipment and sewer system components?	YES	NO

Satellite Communities and Sewer Use Ordinance (SUO)

SUO-01	Does the utility receive flow from satellite communities? IF NO, GO TO PAGE 6	YES	NO
SUO-02	What is the total area from satellite communities that contribute flow to the collection system? *(Acres or square miles)* _____		
SUO-03	Does the utility require satellite communities to enter into an agreement? IF NO, GO TO QUESTION SUO-06.	YES	NO
SUO-04	Does the agreement include the requirements listed in the sewer use ordinance (SUO)?	YES	NO
SUO-05	Do the agreements have a date of termination and allow for renewal under different terms?	YES	NO
SUO-06	Does the utility maintain the legal authority to control the maximum flow introduced into the collection system from satellite communities?	YES	NO
SUO-07	Are standards, inspections, and approval for new connections clearly documented in a SUO?	YES	NO
SUO-08	Does the SUO require satellite communities to adopt the same industrial and commercial regulator discharge limits as the utility?	YES	NO
SUO-09	Does the SUO require satellite communities to adopt the same inspection and sampling schedules as required by the pretreatment ordinance?	YES	NO
SUO-10	Does the SUO require that satellite communities or the utility to issue control permits for significant industrial users?	YES	NO
SUO-11	Does the SUO contain provisions for addressing overstrength wastewater from satellite communities?	YES	NO

SUO-12 Does the SUO contain procedures for the following? *(Check all that apply)*

☐ Inspection standards ☐ Pretreatment requirements ☐ Building/sewer permit issues

SUO-13 Does the SUO contain general prohibitions of the following materials? *(Check all that apply)*

☐ Fire and explosions hazards ☐ Corrosive materials ☐ Obstructive materials

☐ Oils or petroleum ☐ Material which may cause interference at the wastewater treatment plant

SUO-14 Does the SUO contain procedures and enforcement actions for the following? *(Check all that apply)*

☐ Fats, oils, and grease (FOG) ☐ Storm water connections to sanitary lines (downspouts)

☐ Infiltration and inflow ☐ Defects in service laterals located on private property

☐ Building structures over the sewer lines ☐ Sump pumps, air conditioner connections

Organizational Structure (OC)

OC-01 Is an organizational chart available that shows the overall personnel structure for the utility, including operation and maintenance staff? YES NO

OC- 02 Are up-to-date job descriptions available that delineate responsibilities and authority for each position? YES NO

OC-03 Are the following items discussed in the job descriptions? *(Check all that apply)*

- ☐ Nature of work to be performed
- ☐ Examples of the types of work
- ☐ Minimum requirements for the position
- ☐ List of licenses required for the position
- ☐ Necessary special qualifications or certifications
- ☐ Performance measures or promotion potential

OC-04 What percent of staff positions are currently vacant? _____ %

OC-05 On average how long do positions remain vacant? *(months)* _____

OC-06 What percent of utility work is contracted out? _____ %

Internal Communications (IC)

IC-01 Which of the following methods are used to communicate with utility staff? *(Check all that apply)*

☐ Regular meetings ☐ Bulletin boards ☐ E-mail ☐ Other (walkie talkie/pager)

IC-02 How often are staff meetings held? *(e.g., Daily, Weekly, Monthly, etc.)* _____

IC-03 Are incentives offered to employees for performance improvements? YES NO

IC-04 Does the utility have an "Employee of the Month/Quarter/Year" program? YES NO

IC-05 How often are performance reviews conducted? *(e.g. Semi-annually, Annually, etc.)* _____

IC-06 Does the utility regularly communicate/coordinate with other municipal departments? YES NO

Budgeting (BUD)

BUD-01	What is the average annual fee for residential users?	$ _____
BUD-02	How often are user charges evaluated and adjusted? *(e.g. annually, biannually, etc.)*	_____
BUD-03	Are utility-generated funds used for non-utility programs?	YES NO
BUD-04	Are costs for collection system operation and maintenance (O&M) separated from other utility services such as water, storm water, and treatment plants? IF NO, GO TO QUESTION BUD-07.	YES NO
BUD-05	What is your average annual (O&M) budget?	$ _____
BUD-06	What percentage of the utility's overall budget is allocated to maintenance of the collection system?	_____ %
BUD-07	Does the utility have a Capital Improvement Plan (CIP) that provides for system repairs/replacements on a prioritized basis?	YES NO
BUD-08	What is your average annual CIP budget?	$ _____

BUD-09 What percentage of the maintenance budget is allotted to the following maintenance?

Predictive maintenance (tracking design, life span, and scheduled parts replacements)	_____ %
Preventive maintenance (identifying and fixing system weaknesses which, if left unaddressed, could lead to overflows)	_____ %
Corrective maintenance (fixing system components that are functioning but not at 100% capacity/efficiency; for example partially blocked lines)	_____ %
Emergency maintenance (reactive maintenance, overflows, equipment breakdowns)	_____ %

BUD-10	Does the utility have a budgeted program for the replacement of under-capacity pipes?	YES NO
BUD-11	Does the utility have a budgeted program for the replacement of over-capacity pipes?	YES NO

Training (TR)

TR-01 Does the utility have a formal job knowledge, skills, and abilities (KSA) training program? YES NO

TR-02 Does the training program address the fundamental mission, goals, and policies of the utility? YES NO

TR-03 Does the utility have mandatory training requirements identified for key employees? YES NO

TR-04 What percentage of employees met or exceeded their annual training goals during the past year? _____ %

TR-05 Does the utility provide training in the following areas? *(Check all that apply)*

- ☐ Safety
- ☐ Traffic control
- ☐ Public relations
- ☐ Routine line maintenance
- ☐ Record keeping
- ☐ SSO/Emergency response
- ☐ Confined space entry
- ☐ Electrical and instrumentation
- ☐ Pump station operations and maintenance
- ☐ Other
- ☐ Pipe repair
- ☐ CCTV and trench/shoring
- ☐ Bursting CIPP

TR-06 Are operator and maintenance certification programs used? IF NO, GO TO QUESTION TR-08 YES NO

TR-07 Are operator and maintenance certification programs required? YES NO

TR-08 Is on-the-job training progress and performance measured? YES NO

TR-09 Which of the following methods are used to assess the effectiveness of the training? *(Check all that apply)*

☐ None ☐ Periodic testing ☐ Drills ☐ Demonstrations

TR-10 What percentage of the training offered by the utility is in the form of the following?

Manufacturer training _____ % In-house classroom training _____ %

On-the-job training _____ % Industry-wide training _____ %

Safety (SAF)

SAF-01 Does the utility have a written safety policy? YES NO

SAF-02 How often are safety procedures reviewed and revised? *(e.g. Semiannually, Annually, etc.)* YES NO

SAF-03 Does the utility have a safety committee? YES NO

SAF-04 Are regular safety meetings held with the utility employees? YES NO

SAF-05 Does the utility have a safety training program? YES NO

SAF-06 Are records of employee safety training kept up to date? YES NO

SAF-07 Does the utility have written procedures for the following? *(Check all that apply)*

- ☐ Lockout/tagout
- ☐ Material safety date sheets (MSDS)
- ☐ Chemical handling
- ☐ Confined spaces permit program
- ☐ Trenching and excavations safety
- ☐ Biological hazards in wastewater
- ☐ Traffic control and work site safety
- ☐ Electrical and mechanical systems
- ☐ Pneumatic and hydraulic systems safety

SAF-08 What is your agency's lost-time injury rate? _____ % or _____ hours

SAF-09 Are the following equipment items available and in adequate supply? *(Check all that apply)*

- ☐ Rubber/disposable gloves
- ☐ Confined space ventilation equipment
- ☐ Hard hats, safety glasses, rubber boots
- ☐ Antibacterial soap and first aid kit
- ☐ Tripods or non-entry rescue equipment
- ☐ Fire extinguishers
- ☐ Equipment to enter manholes
- ☐ Portable crane/hoist
- ☐ Atmospheric testing equipment and gas detectors
- ☐ Oxygen sensors
- ☐ H_2S Monitors
- ☐ Full body harness
- ☐ Protective clothing
- ☐ Traffic/public access control equipment
- ☐ 5-minute escape breathing devices
- ☐ Life preservers for lagoons
- ☐ Safety buoy at activated sludge plants
- ☐ Fiberglass or wooden ladders for electrical work
- ☐ Respirators and/or self contained breathing apparatus
- ☐ Methane gas or optical vector (OVA) analyzer
- ☐ Lower explosion limit (LEL) metering

SAF-10 Are safety monitors clearly identified? YES NO

Customer Service (CS)

CS-01 Does the utility have a customer service and public relations program? IF NO GO TO QUESTION CS-03 YES NO

CS-02 Does the customer service program include giving formal presentations on the wastewater field to the following? *(Check all that apply)*

- ☐ Schools and universities
- ☐ Local officials
- ☐ Media
- ☐ Building Inspector(s)
- ☐ Community gatherings
- ☐ Businesses
- ☐ Citizens
- ☐ Public utility officials

CS-03 Are employees of the utility specifically trained in customer service? YES NO

CS-04 Are there sample correspondence, Q/A's, or "scripts" to help guide staff through written or oral responses to customers? YES NO

CS-05 What methods are used to notify the public of major construction or maintenance work? *(Check all that apply)*

- ☐ Door hangers
- ☐ Newspaper
- ☐ Fliers
- ☐ Signs
- ☐ Other
- ☐ None
- ☐ Public radio or T.V. announcements

CS-06 Is a homeowner notified prior to construction that his/her property may be affected? YES NO

CS-07 Do you provide information to residents on cleanup and safety procedures following basement backups and overflows from manholes when they occur? YES NO

CS-08 Does the utility have a customer service evaluation program to obtain feedback from the community? YES NO

CS-09 Do customer service records include the following information? *(Check all that apply)*

- ☐ Personnel who received the complaint or request
- ☐ Name, address, and telephone number of customer
- ☐ Nature of the complaint or request
- ☐ Location of the problem
- ☐ To whom the follow-up action was assigned
- ☐ Date the follow up action was assigned
- ☐ Date of the complaint or request
- ☐ Cause of the problem
- ☐ Date the complaint or request was resolved
- ☐ Feedback to customer
- ☐ Total days to end the problem

CS-10 Does the utility have a goal for how quickly customer complaints (or emergency calls) are resolved? IF NO, GO TO THE NEXT PAGE. YES NO

CS-11 What percentage of customer complaints (or emergency calls) are resolved within the timeline goals? _____ %

Equipment and Collection System Maintenance (ESM)

ESM-01 Is a maintenance card or record kept for each piece of mechanical equipment within the collection system? IF NO, GO TO QUESTION ESM-03. YES NO

ESM-02 Do equipment maintenance records include the following information? *(Check all that apply)*

- ☐ Maintenance recommendations
- ☐ Maintenance schedule
- ☐ Instructions on conducting the specific maintenance activity
- ☐ A record of maintenance on the equipment to date
- ☐ Other observations on the equipment

ESM-03 Are dated tags used to show out-of-service equipment? YES NO

ESM-04 Is there an established system for prioritizing equipment maintenance needs? YES NO

ESM-05 What percent of repair funds are spent on emergency repairs? _____ %

ESM-06 Are corrective repair work orders backlogged more than six months? YES NO

ESM-07 Do collection system personnel coordinate with state, county, and local personnel on repairs, before the street is paved? YES NO

Equipment Parts Inventory (EPI)

EPI-01	Have critical spare parts been identified?	YES	NO
EPI-02	Are adequate supplies on hand to allow for two point repairs in any part of the system?	YES	NO
EPI-03	Is there a parts standardization policy in place?	YES	NO
EPI-04	Does the utility have a central location for storing spare parts?	YES	NO
EPI-05	Does the utility maintain a stock of spare parts on its maintenance vehicles?	YES	NO
EPI-06	Does the utility have a system in place to track and maintain an accurate inventory of spare parts?	YES	NO
EPI-07	For those parts which are not kept in inventory, does the utility have a readily available source or supplier?	YES	NO

Management Information System (MIS)

MIS-01 Does the utility have a management information system (MIS) in place for tracking maintenance activities? *(Either electronic or good paper files)* IF NO, GO TO PAGE 15. YES NO

MIS-02 Are the MIS records maintained for a period of at least three years? YES NO

MIS-03 Is the MIS able to distinguish activities taken in response to an overflow event? YES NO

MIS-04 Are there written instructions for managing and tracking the following information? *(Check all that apply)*

- ☐ Complaint work orders
- ☐ Scheduled work orders
- ☐ Customer service
- ☐ Scheduled preventive maintenance
- ☐ Scheduled inspections
- ☐ Sewer system inventory
- ☐ Safety incidents
- ☐ Scheduled monitoring/ sampling
- ☐ Compliance/overflow tracking
- ☐ Equipment/tools tracking
- ☐ Parts inventory

MIS-05 Do the written instructions for tracking procedures include the following information? *(Check all that apply)*

- ☐ Accessing data and information
- ☐ Instructions for using the tracking system
- ☐ Updating the MIS
- ☐ Developing and printing reports

MIS-06 How often is the management information system updated? *(Check one)*

- ☐ Immediately
- ☐ Monthly
- ☐ Within one week of the "incident"
- ☐ As time permits

System Mapping (MAP)

MAP-01 Are "as built" plans (record drawings) or maps available for use by field crews in the office and in the field? YES NO

MAP-02 Is there a procedure for field crews to record changes or inaccuracies in the maps and update the mapping system? YES NO

MAP-03 Do the maps show the date the map was drafted and the date of the last revision? YES NO

MAP-04 Do the sewer line maps include the following? *(Check all that apply)*

- ☐ Scale
- ☐ North arrow
- ☐ Date the map was drafted
- ☐ Date of last revision
- ☐ Service area boundaries
- ☐ Property lines
- ☐ Other landmarks (Roads, water bodies, etc.)
- ☐ Manhole and other access points
- ☐ Location of building laterals
- ☐ Street names
- ☐ SSOs occurrences/CSOs outfalls
- ☐ Flow monitors
- ☐ Force mains
- ☐ Pump stations
- ☐ Lined sewers
- ☐ Main, trunk, and interceptor sewers
- ☐ Easement lines and dimensions
- ☐ Pipe material
- ☐ Pipe diameter
- ☐ Installation date
- ☐ Slope
- ☐ Manhole rim elevation
- ☐ Manhole coordinates
- ☐ Manhole invert elevation
- ☐ Distance between manholes

MAP-05 Are the following sewer attributes recorded? *(Check all that apply)*

- ☐ Size
- ☐ Shape
- ☐ Invert elevation
- ☐ Material
- ☐ Separate/combined sewer
- ☐ Installation Date

MAP-06 Are the following manhole attributes recorded? *(Check all that apply)*

- ☐ Shape
- ☐ Depth
- ☐ Age
- ☐ Type (e.g., precast, cast in place, etc.)
- ☐ Material

MAP-07 Is there a systematic numbering and identification method/system established to identify sewer system manhole, sewer lines, and other items (pump stations, etc.)? YES NO

Internal TV Inspection (TVI)

TVI-01 Does the utility have a standardized pipeline condition assessment program? YES NO

TVI-02 Is internal TV inspection used to perform condition assessment? IF NO, GO TO PAGE 17. YES NO

TVI-03 Are there written operation procedures and guidelines for the internal TV inspection program? YES NO

TVI-04 Do the internal TV record logs include the following? *(Check all that apply)*

- ☐ Pipe size, type, length, and joint spacing
- ☐ Distance recorded by internal TV
- ☐ Results of the internal TV inspection (including a structural rating)
- ☐ Internal TV operator name
- ☐ Cleanliness of the line
- ☐ Location and identification of line being televised by manholes

TVI-05 Is a rating system used to determine the severity of the defects found during the inspection process? YES NO

TVI-06 Is there documentation explaining the codes used for internal TV results reporting? YES NO

TVI-07 Approximately what percent of the total defects determined by TV inspection during the past 5 years were the following?

Failed coatings or linings	%	Line deflection	%
House connection leaks	%	Joint separation	%
Illegal connections	%	Crushed pipes	%
Pipe corrosion (H_2S)	%	Collapsed pipes	%
Fats, oil, and grease	%	Offset joints	%
Broken pipes	%	Root intrusions	%
Debris	%	Minor cracks	%
Other	%		

TVI-08 Are main line and lateral repairs checked by internal TV inspection after the repair(s) have been made? YES NO

Sewer Cleaning (CLN)

CLN-01	What is the system cleaning frequency? (the entire system is cleaned every "X" years)	_____
CLN-02	What is the utility's plan for system cleaning (% or frequency in years)?	_____
CLN-03	What percent of the sewer lines are cleaned, even high/repeat cleaning trouble spots, during the past year?	_____ %
CLN-04	Is there a program to identify sewer line segments, with chronic problems, that should be cleaned on a more frequent schedule?	YES NO
CLN-05	Does the utility have a root control program?	YES NO
CLN-06	Does the utility have a fats, oils, and grease (FOG) program?	YES NO
CLN-07	What is the average number of stoppages experienced per mile of sewer pipe per year?	_____ %
CLN-08	Has the number of stoppages increased, decreased, or stayed the same over the past 5 years? ☐ Increased ☐ Decreased ☐ Stayed the same	
CLN-09	Are stoppages plotted on maps and correlated with other data such as pipe size and material or location?	YES NO
CLN-10	Do the sewer cleaning records include the following information? *(Check all that apply)* ☐ Date and time ☐ Method of cleaning ☐ Identity of cleaning crew ☐ Cause of stoppage ☐ Location of stoppage or routine cleaning activity ☐ Further actions necessary/initiated	
CLN-11	If sewer cleaning is done by a contractor are videos taken of before and after cleaning?	YES NO

Manhole Inspection and Assessment (MAN)

MAN-01 Does the utility have a routine manhole inspection and assessment program? IF NO, GO TO QUESTION MAN-06. YES NO

MAN-02 Are the results and observations from the routine manhole inspections recorded? YES NO

MAN-03 Does the utility have a goal for the number of manholes inspected annually? YES NO

MAN-04 How many manholes were inspected during the past year? _____

MAN-05 Do the records for manhole/pipe inspection include the following? *(Check all that apply)*

- ☐ Conditions of the frame and cover
- ☐ Evidence of surcharge
- ☐ Offsets or misalignments
- ☐ Atmospheric hazards measurements (especially hydrogen sulfide)
- ☐ Details on the root cause of cracks or breaks in the manhole or pipe including blockages
- ☐ Recording conditions of (corbel, walls, bench, trough, and pipe seals)
- ☐ Presence of corrosion
- ☐ If repair is necessary
- ☐ Manhole identifying number/location
- ☐ Wastewater flow characteristics (flowing freely or backed up)
- ☐ Accumulations of grease, debris, or grit
- ☐ Presence of infiltration, location, and estimated quantity
- ☐ Inflow from manhole covers

MAN-06 Does the utility have a grouting program? YES NO

Pump Stations (PS)

PS-01	Are Standard Operation Procedures (SOPs) and Standard Maintenance Procedures (SMPs) used for each pump station?	YES	NO
PS-02	Are there enough trained personnel to properly maintain all pump stations?	YES	NO
PS-03	Is there an emergency operating procedure for each pump station?	YES	NO
PS-04	Is there an alarm system to notify personnel of pump station failures and overflow?	YES	NO
PS-05	Percent of pump stations with back up power sources	____ %	
PS-06	Does the utility use the following methods when loss of power ocurs? *(Check all that apply)* ☐ On-site electrical generators ☐ Portable electric generators ☐ Alternate power source ☐ Other ☐ Vacuum trucks to bypass pump station		
PS-07	Is there a procedure for manipulating pump operations (manually or automatically) during wet weather to increase in-line storage of wet weather flows?	YES	NO
PS-08	Are wet well operating levels set to limit pump start/stops?	YES	NO
PS-09	Are the lead, lag, and backup pumps rotated regularly?	YES	NO
PS-10	Are operation logs maintained for all pump stations?	YES	NO
PS-11	Are the original manuals that contain the manufacturers recommended maintenance schedules for all pump station equipment easily available?	YES	NO
PS-12	On average, how often were pump stations inspected during the past year?	YES	NO
PS-13	Are records maintained for each inspection?	YES	NO
PS-14	Average annual labor hours spent on pump station inspection	____	
PS-15	Percent of pump stations with pump capacity redundancy	____ %	
PS-16	Percent of pump stations with dry weather capacity limitations	____ %	
PS-17	Percent of pump stations with wet weather capacity limitations	____ %	
PS-18	Percent of pump stations calibrated annually	____ %	
PS-19	Percent of pump stations with permanent flow meters	____ %	

Capacity Assessment (CA)

CA-01	Does the utility have a flow monitoring program?	YES	NO
CA-02	Does the utility have a comprenhensive capacity assessment and planning program?	YES	NO
CA-03	Are flows measured prior to allowing new connections?	YES	NO
CA-04	Do you have a tool (hydraulic model, spreadsheet, etc.) for assessing whether adequate capacity exists in the sewer system? IF NO, GO TO QUESTION CA-06.	YES	NO
CA-05	Does your capacity assessment tool produce results consistent with conditions observed in the system?	YES	NO

CA-06 What is the ratio of peak wet weather flow to average dry weather flow at the wastewater treatment plant? _____

CA-07 How many permanent flow meters are currently in the system? *(Include meters at pump stations and wastewater treatment plants)* _____

CA-08 How frequently are the flow meters checked? *(e.g. Daily, Weekly, Monthly, etc.)* _____

CA-09 Do the flow meter checks include the following? *(Check all that apply)*

- ☐ Independent water level
- ☐ Velocity reading
- ☐ Downloading data
- ☐ Checking the desiccant
- ☐ Cleaning away debris
- ☐ Battery condition

CA-10	Are records maintained for each inspection? IF NO, GO TO QUESTION CA-12.	YES	NO

CA-11 Do the flow monitoring records include the following? *(Check all that apply)*

- ☐ Descriptive location of flow meter
- ☐ Frequency of flow meter inspection
- ☐ Type of flow meter
- ☐ Frequency of flow meter calibration

CA-12	Does the utility maintain any rain gauges or have access to local rainfall data?	YES	NO
CA-13	Does the utility have any wet weather capacity problems?	YES	NO
CA-14	Are low points or flood-plain areas monitored during rain events?	YES	NO
CA-15	Does the utility have any dry weather capacity problems?	YES	NO
CA-16	Is flow monitoring used for billing purposes, capacity analysis, and/or inflow and infiltration investigations?	YES	NO

Tracking SSOs (TRK)

TRK-01 How many SSO events have been reported in the past 5 years? _____

TRK-02 What percent of the SSOs were less than 1,000 gallons in the past 5 years ? _____ %

TRK-03 Does the utility document and report all SSOs regardless of size? YES NO

TRK-04 Does the utility document basement backups? YES NO

TRK-05 Are there areas that experience frequent basement or street flooding? YES NO

TRK-06 Approximately what percent of SSOs discharges were from each of the following in the last 5 years?

Manholes _____ % Main and trunk sewers _____ % Structural bypasses _____ %

Pump stations _____ % Lateral and branch sewers _____ %

TRK-07 Approximately what percent of SSOs discharges were caused by the following in the last 5 years?

Debris buildup _____ % Root intrusion _____ % Excessive infiltration and inflow _____ %

Collapsed pipe _____ % Capacity limitations _____ % Fats, oil, and grease _____ %

Vandalism _____ %

TRK-07A What percentage of SSOs were released to:

Soil _____ % Basements _____ % Paved area _____ %

Surface water (rivers/lakes/streams) _____ % Coastal, ocean, beaches _____ %

TRK-07B For surface water releases, what percent are to areas that could affect:

Contact recreation (beaches, swimming, areas) _____ % Drinking water sources _____ %

Shellfish growing areas _____ %

TRK-08 How many chronic SSO locations are in the collection system? _____

TRK-09 Are pipes with chronic SSOs being monitored for sufficient capacity and/or structural condition? YES NO

TRK-10 Prior to collapse, are structurally deteriorating pipelines being monitored for renewal or replacement? YES NO

Overflow Emergency Response Plan (OERP)

OERP-01 Does the utility have a documented OERP available for utility staff to use? IF NO, GO TO QUESTION OERP-04. YES NO

OERP-02 How often is the OERP reviewed and updated? *(Annually, Biannually, etc.)* _____

OERP-03 Are specific responsibilities detailed in the OERP for personnel who respond to emergencies? YES NO

OERP-04 Are staff continuously trained and drilled to respond to emergency situations? YES NO

OERP-05 Do work crews have immediate access to tools and equipment during emergencies? YES NO

OERP-06 Does the utility have standard procedures for notifying state agencies, local health departments, the NPDES authority, the public, and drinking water authorities of significant overflow events? YES NO

OERP-07 Does the procedure include a current list of the names, titles, phone numbers, and responsibilities of all personnel involved? YES NO

OERP-08 Does the utility have a public notification plan? YES NO

OERP-09 Does the utility have procedures to limit public access to and contact with areas affected with SSOs? *(Procedure can be delegated to another authority)* YES NO

OERP-10 Does the utility use containment techniques to protect the storm drainage systems? YES NO

OERP-11 Do the overflow records include the following information? *(Check all that apply)*

- ☐ Date and time
- ☐ Location
- ☐ Any remediation efforts
- ☐ Cause s)
- ☐ How it was stopped
- ☐ Estimated flow/volume discharged
- ☐ Names of affected receiving water(s)
- ☐ Duration of overflow

OERP-12 Does the utility have signage to keep public from effected area? YES NO

Smoke and Dye Testing (SDT)

SDT-01	Does the utility have a smoke testing program to identify sources of inflow and infiltration?	YES	NO
SDT-01A	Does the utility have a smoke testing program to identify sources of inflow and infiltration in illegal connectors?	YES	NO
SDT-01B	Does the utility have a smoke testing program to identify sources of inflow and infiltration in house laterals (private service laterals)?	YES	NO
SDT-02	Are there written procedures for the frequency and schedule of smoke testing?	YES	NO
SDT-03	Is there a documented procedure for isolating line segments?	YES	NO
SDT-04	Is there a documented procedure for notifying local residents that smoke testing will be conducted in their area?	YES	NO
SDT-05	What is the guideline for the maximum amount of the line to be tested at one time? *(Feet or Miles)*	_____	
SDT-06	Are there guidelines for the weather conditions under which smoke testing should be conducted?	YES	NO
SDT-07	Does the utility have a goal for the percent of the system smoke tested each year?	YES	NO
SDT-08	What percent of the system has been smoke tested over the past year?	_____ %	
SDT-09	Do the written records contain location, address, and description of the smoking element that produced a positive result?	YES	NO
SDT-10	Does the utility have a dye testing program?	YES	NO
SDT-11	Are there written procedures for dye testing?	YES	NO
SDT-12	Does the utility have a goal for the percent of the system dye tested each year?	YES	NO
SDT-13	What percent of the main collection system has been dye tested over the past year?	_____ %	
SDT-14	Does the utility share smoke and dye testing equipment with another utility?	YES	NO

Hydrogen Sulfide Monitoring and Control (HSMC)

HSMC-01 How would you rate the systems vulnerability for hydrogen sulfide corrosion? *(Check only one)*

☐ Not a problem ☐ Only in a few isolated areas ☐ A major problem

HSCM-02 Does the utility have a corrosion control program? YES NO

HSCM-03 Does the utility take hydrogen sulfide corrosion into consideration when designing new or replacement sewers? YES NO

HSCM-04 Does the utility have written procedures for the application of chemical dosages? YES NO

HSCM-05 Are the chemical dosages, dates, and locations documented? YES NO

HSCM-06 Does the utility document where odor is a continual problem in the system? YES NO

HSCM-07 Does the utility have a program in place for renewing or replacing severely corroded sewer lines to prevent collapse? YES NO

HSCM-08 Are the following methods used for hydrogen sulfide control? *(Check all that apply)*

☐ Aeration ☐ Chlorine ☐ Potassium permanganate
☐ Iron salts ☐ Sodium hydroxide ☐ Biofiltration
☐ Enzymes ☐ Hydrogen peroxide ☐ Other
☐ Activated charcoal canisters

HSCM-09 Does the system contain air relief valves at the high points of the force main system? YES NO

HSCM-10 How often are the valves maintained and inspected? *(Weekly, Monthly, etc.)* _____

HSMC-11 Does the utility enforce pretreatment requirements? YES NO

Infrastructure Security

Although outside the scope of a CMOM program, municipal wastewater utilities should also consider security vulnerabilities. To reduce the threat of both intentional and natural disasters, the utility should take steps to implement appropriate countermeasures and develop or update emergency response plans.

CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX P

POWER PURCHASE AGREEMENT CHECKLIST FOR STATE AND LOCAL GOVERNMENTS – NATIONAL RENEWABLE ENERGY LABORATORY FACT SHEET (U.S. DEPT. OF ENERGY, 2009)

National Renewable Energy Laboratory
Innovation for Our Energy Future

Energy Analysis

Fact Sheet Series on Financing Renewable Energy Projects

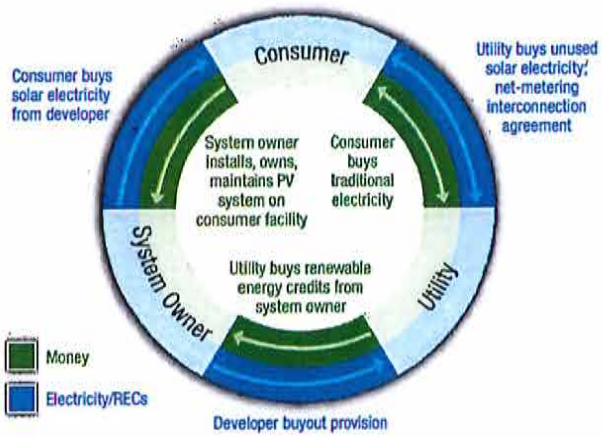
Power Purchase Agreement Checklist for State and Local Governments

This fact sheet provides information and guidance on the solar photovoltaic (PV) power purchase agreement (PPA), which is a financing mechanism that state and local government entities can use to acquire clean, renewable energy. We address the financial, logistical, and legal questions relevant to implementing a PPA, but we do not examine the technical details—those can be discussed later with the developer/contractor. This fact sheet is written to support decision makers in U.S. state and local governments who are aware of solar PPAs and may have a cursory knowledge of their structure but they still require further information before committing to a particular project.

Overview of PPA Financing

The PPA financing model is a "third-party" ownership model, which requires a separate, taxable entity ("system owner") to procure, install, and operate the solar PV system on a consumer's premises (i.e., the government agency). The government agency enters into a long-term contract (typically referred to as the PPA) to purchase 100% of the electricity generated by the system from the system owner. Figure 1 illustrates the financial and power flows among the consumer, system owner, and the utility. Renewable energy certificates (RECs), interconnection, and net metering are discussed later. Basic terms for three example PPAs are included at the end of this fact sheet.

Figure 1
Contracts and Cash Flow in Third-Party Ownership/PPA Model



Source: NREL

The system owner is often a third-party investor ("tax investor") who provides investment capital to the project in return for tax benefits. The tax investor is usually a limited liability corporation (LLC) backed by one or more financial institutions. In addition to receiving revenues from electricity sales, they can also benefit from federal tax incentives. These tax incentives can account for approximately 50% of the project's financial return (Bolinger 2009, Rahus 2008). Without the PPA structure, the government agency could not benefit from these federal incentives due to its tax-exempt status.[1]

The developer and the system owner often are distinct and separate legal entities. In this case, the developer structures the deal and is simply paid for its services. However, the developer will make the ownership structure transparent to the government agency and will be the only contact throughout the process. For this reason, this fact sheet will refer to "system owner" and developer as one in the same.

While there are other mechanisms to finance solar PV systems, this publication focuses solely on PPA financing because of its important advantages:[2]

1. No/low up-front cost.
2. Ability for tax-exempt entity to enjoy lower electricity prices thanks to savings passed on from federal tax incentives.
3. A predictable cost of electricity over 15–25 years.
4. No need to deal with complex system design and permitting process.
5. No operating and maintenance responsibilities.

[1] Clean renewable energy bonds (CREBs) are also available to municipalities and other public entities as an alternative means of benefiting from federal tax benefits.

[2] For a full discussion of alternative financing mechanisms, see Cory et al. 2009.

Power Purchase Agreement Checklist

High-Level Project Plan for Solar PV with PPA Financing

Implementing power purchase agreements involves many facets of an organization: decision maker, energy manager, facilities manager, contracting officer, attorney, budget official, real estate manager, environmental and safety experts, and potentially others (Shah 2009). While it is understood that some employees may hold several of these roles, it is important that all skill sets are engaged early in the process. Execution of a PPA requires the following project coordination efforts, although some may be concurrent:[3]

Step 1. Identify Potential Locations

Identify approximate area available for PV installation including any potential shading. The areas may be either on rooftops or on the ground. A general guideline for solar installations is 5–10 watts (W) per square foot of usable rooftop or other space.[4] In the planning stages, it is useful to create a CD that contains site plans and to use Google Earth software to capture photos of the proposed sites (Pechman 2008). In addition, it is helpful to identify current electricity costs. Estimating System Size (this page) discusses the online tools used to evaluate system performance for U.S. buildings.

Step 2. Issue a Request for Proposal (RFP) to Competitively Select a Developer

If the aggregated sites are 500 kW or more in electricity demand, then the request for proposal (RFP) process will likely be the best way to proceed. If the aggregate demand is significantly less, then it may not receive sufficient response rates from developers or it may receive responses with expensive electricity pricing. For smaller sites, government entities should either 1) seek to aggregate multiple sites into a single RFP or 2) contact developers directly to receive bids without a formal RFP process (if legally permissible within the jurisdiction).

Links to sample RFP documents (and other useful documents) can be found at the end of this fact sheet. The materials generated in Step 1 should be included in the RFP along with any language or requirements for the contract. In addition, the logistical information that bidders may require to create their proposals (described later) should be included. It is also worthwhile to create a process for site visits.

Renewable industry associations can help identify Web sites that accept RFPs. Each bidder will respond with an initial proposal including a term sheet specifying estimated output, pricing terms, ownership of environmental attributes (i.e., RECs) and any perceived engineering issues.

Step 3. Contract Development

After a winning bid is selected, the contracts must be negotiated—this is a time-sensitive process. In addition to the PPA between the government agency and the system owner, there will be a lease or easement specifying terms for access to the property (both for construction and maintenance). REC sales may be included in the PPA or as an annex to it (see Page 6 for details on RECs). Insurance and potential municipal law issues that may be pertinent to contract development are on Page 8.

Step 4. Permitting and Rebate Processing

The system owner (developer) will usually be responsible for filing permits and rebates in a timely manner. However, the government agency should note filing deadlines for state-level incentives because there may be limited windows or auction processes. The Database of State Incentives for Renewables and Efficiency (http://www.dsireusa.org/) is a useful resource to help understand the process for your state.

Step 5. Project Design, Procurement, Construction, and Commissioning

The developer will complete a detailed design based on the term sheet and more precise measurements; it will then procure, install, and commission the solar PV equipment. The commissioning step certifies interconnection with the utility and permits system startup. Once again, this needs to be done within the timing determined by the state incentives. Failure to meet the deadlines may result in forfeiture of benefits, which will likely change the electricity price to the government agency in the contract. The PPA should firmly establish realistic developer responsibilities along with a process for determining monetary damages for failure to perform.

Financial and Contractual Considerations

The developer's proposal should include detailed projections of all financial considerations. This section helps the government agency become a more informed purchaser by explaining key components that are needed for a complete proposal.

Estimating System Size

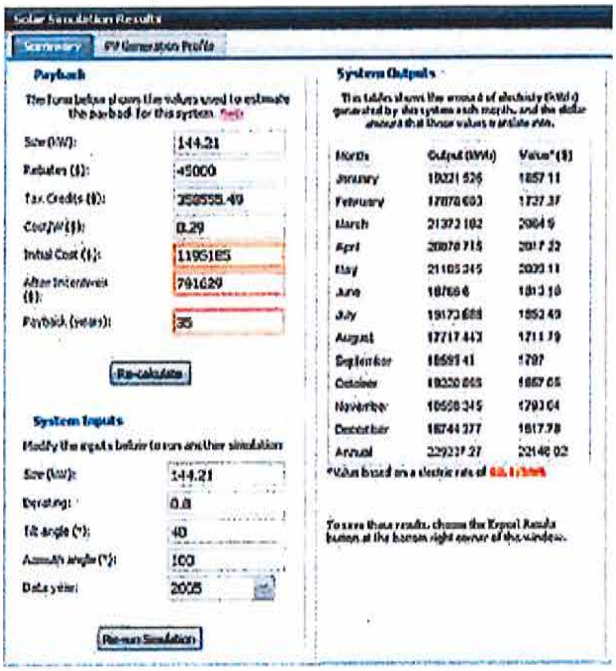
One of the first steps for determining the financial feasibility of a PPA is to estimate the available roof and ground space, and to approximate the size of the PV system or systems. NREL provides a free online tool called In My Backyard (IMBY) to make this assessment—the program can be found at http://www.nrel.gov/eis/imby/

[3] Adapted from a report by GreenTech Media (Guice 2008) and from conversations with Bob Westby, NREL technology manager for the Federal Energy Management Program (FEMP).

[4] This range represents both lower efficiency thin-film and higher efficiency crystalline solar installations. The location of the array (rooftop or ground) can also affect the power density. Source: http://www.solarbuzz.com/Consumer/FastFacts.htm

The IMBY tool, which uses a Google Maps interface, allows users to zoom-in on a particular building or location and trace the approximate perimeter of the potential solar array. From this information, IMBY simulates financial and technical aspects of the system; the results provide a first-level estimate and might not capture the exact situation (system performance, system cost, or utility bills) at a particular location (an example is shown in Figure 2). IMBY estimates the system size and annual electricity production as well as the monetary value of the electricity generated by the photovoltaic system. Users can adjust primary technical and financial inputs to simulate more specific conditions. The amount of electricity generated by the solar system can be compared to the facility's monthly utility electric bills to estimate potential offset capacity of the PV system.[5]

Figure 2
IMBY Example



Source: NREL

PPA Pricing

A key advantage of power purchase agreements is the predictable cost of electricity over the life of a 15- to 25-year contract. This avoids unpredictable price fluctuations from utility rates, which are typically dependent on fossil fuel prices in most of the United States. The approval of climate change legislation also may cause utility electricity rates to increase significantly; thus, the projected savings may be further accentuated. In a PPA, the electricity rates are predetermined, explicitly spelled out in the contract, and legally binding with no dependency on fossil fuel or climate change legislation.

The most common PPA pricing scenarios are **fixed price** and **fixed escalator**. In a **fixed-price** scheme, electricity produced by the PV system is sold to the government agency at a fixed rate over the life of the contract (see Figure 3 for an example of this scenario). Note that it is possible for the PPA price to be higher than the utility rate at the beginning. However, over time, the utility rate is expected to overtake the PPA price such that the PPA generates positive savings over the life of the contract. This structure is most favorable when there is concern that the utility rates will increase significantly.

In a **fixed-escalator** scheme, electricity produced by the system is sold to the government agency at a price that increases at a predetermined rate, usually 2–5% (see Figure 4 for an example of this scenario). Some system owners will offer a rate structure that escalates for a time period (e.g., 10 years) and then remains fixed for the remainder of the contract.

Figure 3
Fixed-Price PPA

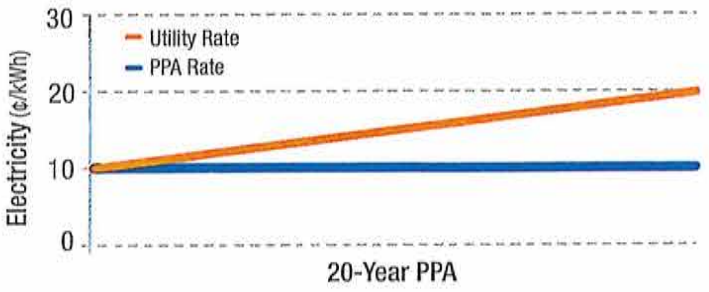
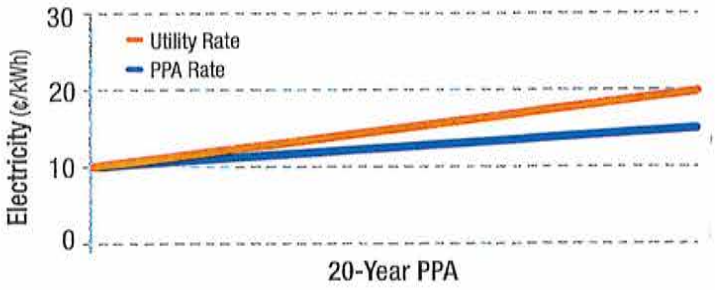
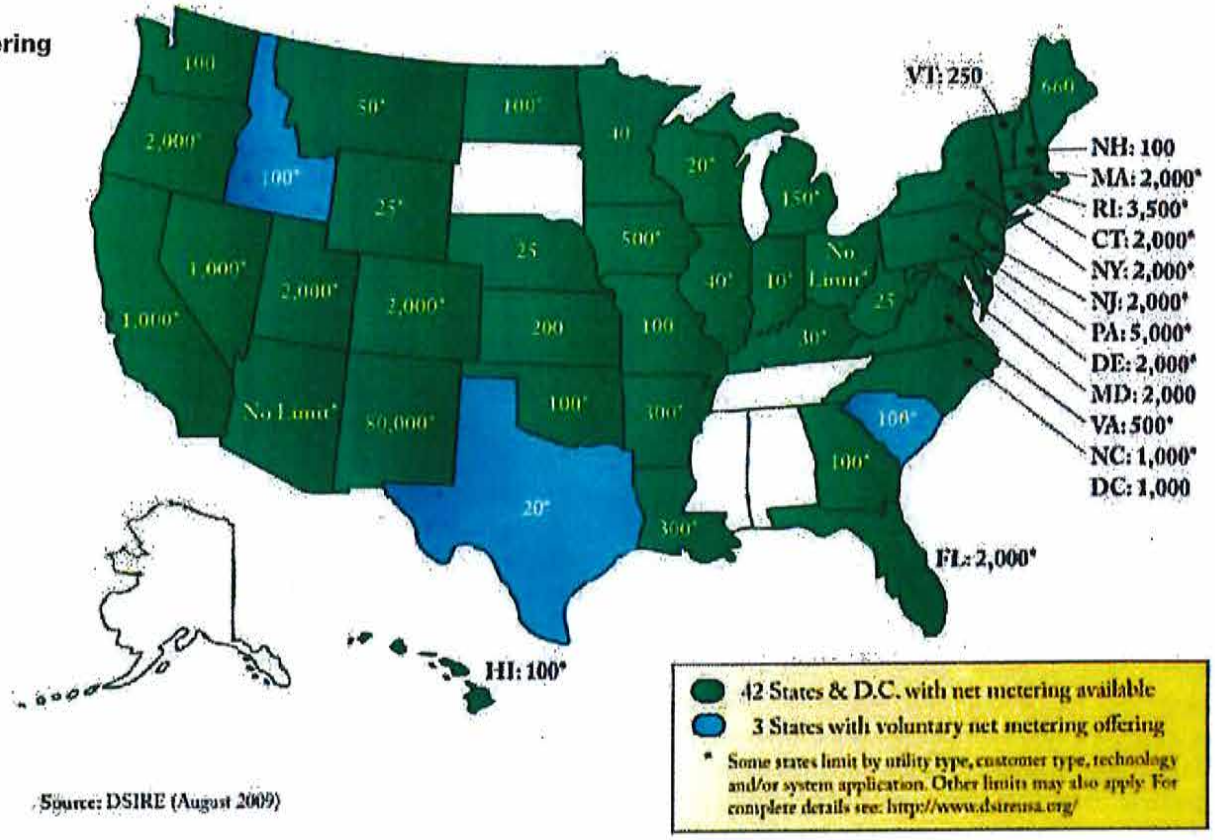


Figure 4
PPA Price Escalator



[5] It is important to be cognizant of any planned or potential changes to the facility that could affect the electrical demand (and, therefore, electricity offset) such as the additions to the facility.

Figure 5
Net Metering



A less common PPA pricing model involves the PPA price based on the utility rate with a predetermined discount. While this ensures that the PPA price is always lower than utility rates, it is complicated to structure and it undermines the price-predictability advantage of a PPA.

A recently emerging PPA structure has consumers either 1) prepay for a portion of the power to be generated by the PV system or 2) make certain investments at the site to lower the installed cost of the system. Either method can reduce the cost of electricity agreed to in the PPA itself. This structure takes advantage of a governmental entity's ability to issue tax-exempt debt or to tap other sources of funding to buy-down the cost of the project. Prepayments can improve economics for both parties and provide greater price stability over the life of the contract. Boulder County exercised this option by making investments to lower the project costs (see the table on Page 10, which provides examples of PPA pricing and structures from state and local government projects in California and Colorado).

Interconnection and Net Metering

Interconnection to the existing electrical grid and net metering are important policies to consider.[6] Interconnection standards vary according to state-mandated rules (and sometimes by utility), which regulate the process by which renewable energy systems are connected to the electrical grid. Federal policy mandates that utilities accept interconnection from solar power stations, but each utility's process varies. The system owner and utility develop an interconnection agreement, which spells out the conditions, equipment, and processes. Such conditions may include standby charges, which are fees that utilities impose on solar system owners to account for the cost of maintaining resources in case the solar system is not generating. Additionally, the project host and developer should consider utility tariff charges applicable to electricity purchased in backup mode—contact your local utility to fully comprehend the process of interconnection in the early stages of RFP development. The Interstate Renewable Energy Council has a report on state-specific interconnection standards, which is available at http://www.irecusa.org/index.php?id=86.

[6] The 2008 Edition of *Freeing the Grid*, issued by the Network for New Energy Choices, provides a listing of the best and worst practices in state net-metering policies and interconnection standards. Much of the report discusses the technical aspects, which your developer should be able to address. http://www.newenergychoices.org/uploads/FreeingTheGrid2008_report.pdf

Net metering is a policy that allows a solar-system owner to receive credit on his/her electricity bill for surplus solar electricity sent back to the utility. The electricity meter "spins backward," accurately tracking the excess electricity. Net-metering regulations vary by state but typically include specifications for the amount of excess electricity that the utility can count, the rate at which the utility can produce the credit, and the duration of the agreement (Rahus Institute 2008). States that do not have net-metering guidelines may require the system owner to install a second meter.

States differ on their net-metering pricing scheme, but they fall into three basic categories: (1) retail rate (the rate consumers pay), (2) the wholesale rate (market rate), or (3) the utilities' avoided-generation rate. Time of use (TOU) net metering is a system of indexing net-metering credits to the value of the power sold on the market during that time period. This is advantageous to solar power because it is strongest during electricity peak demand times (Rahus Institute 2008). Figure 5 shows the states with net-metering policies in place.

Sizing PV systems for specific locations/applications depends highly on energy demand schedules as well as net-metering laws. When sizing a PV system, it is important to avoid the potential for overproduction. If there are unanticipated changes in demand, or if electricity production is not coincident with electricity consumption at the site, the PV system may generate more electricity than the utility can credit the customer for—some net-metering laws cap this amount. The risk is overproducing and sending electricity to the grid without compensation. A facility can produce a disproportionate amount of energy during peak periods and may not make up for this discrepancy during off-peak periods (Pechman 2008).

Federal Tax Incentives for the System Owner

An important aspect of the PPA structure is that a system owner can take advantage of federal tax incentives that a tax-exempt entity cannot. The two most significant tax benefits are the investment tax credit (ITC) and accelerated depreciation. The ITC offers tax-paying entities a 30% tax credit on the total cost of their solar system.[7] Accelerated depreciation is an accounting practice used to allocate the cost of wear and tear on a piece of equipment over time – in this case, more quickly than the expected system life. The Internal Revenue Service (IRS) allows a five-year modified accelerated cost recovery system (MACRS) for commercial PV systems. Although a solar array may produce power during the entirety of a 20-year PPA, the system owner can take advantage of the entire tax benefit within the first five years. Both of these incentives alleviate a great deal of financial risk for system owners, encourage project development, and help make renewable energy an affordable alternative to fossil fuel energy sources.

The Value of Renewable Energy Certificates

Twenty-nine states and the District of Columbia have implemented renewable portfolio standard (RPS) policies. An RPS requires utilities to provide their customers with a minimum percentage of renewable generation by statutory target dates. Failure to meet these requirements usually results in compliance penalties. Figure 6 shows these RPS policies by state.

Utilities typically prove RPS compliance using renewable energy certificates (RECs), which represent 1 megawatt-hour (MWh) of electricity produced from a renewable source. In many states, RECs can be traded separately from the electricity. In these cases, the RECs represent the environmental attributes of renewable energy. In addition, some states offer carve-outs for solar renewable energy certificates (SRECs) or distributed generation (DG) (see Figure 6). These states create separate markets for these RECs (usually at higher prices) or offer multiple credits for each megawatt-hour. For example, a 3x multiplier allows the utility to count each REC from solar electricity as 3 MWh for compliance purposes.[8]

States with RPS policies are known as "compliance markets." In these markets, utilities can include purchased RECs in demonstration of compliance with state energy mandates. This can provide an important source of cash flow to PV system owners. In addition, states with carve-outs for solar or DG can realize even higher prices for SRECs.

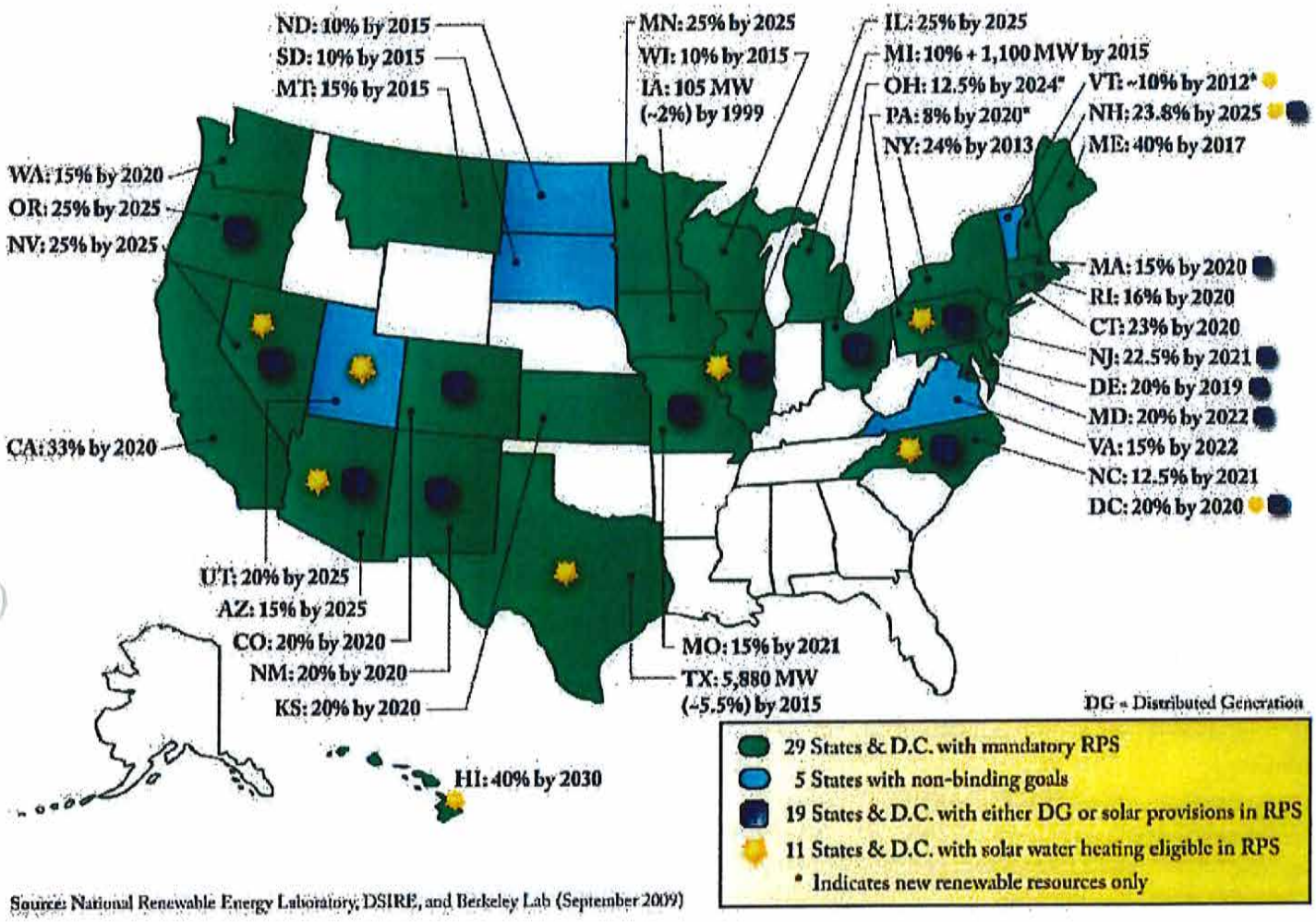
"Voluntary markets" also exist in which residential, commercial, and industrial consumers can buy SRECs from system owners to claim their energy is produced from renewable technologies. The advantage is that consumers do not have to develop renewable projects but still can claim the environmental benefits (Cory 2008).

In general, PPAs are structured so that the RECs remain with the system owner. However, the host can negotiate to buy the RECs along with the electricity. This will drive up the price per kilowatt-hour in the PPA to compensate the system owner for the RECs. If the host does not buy the RECs, it is important to manage the claims made regarding the PV system. The government agency can say it is hosting a renewable energy project but it cannot say that it is powered by renewable energy. One option is an SREC swap. In this case, the host would decide against buying the solar RECs from the PPA provider and instead buy cheaper replacement RECs (wind or biomass, for example) in the voluntary market (Coughlin 2009). REC prices in the voluntary markets are substantially

[7] Under the American Recovery and Reinvestment Act (Recovery Act), tax-paying entities can elect to recover the ITC using a Department of Treasury grant, once project construction is complete. This is expected to improve the financial benefits of the incentive.

[8] Under the Waxman-Markey bill (as of July 2009), Congress is considering a federal solar multiplier of 3x for all distributed generation projects.

Figure 6
States with Renewable Portfolio Standards (indicating solar/DG set-asides)



Source: National Renewable Energy Laboratory, DSIRE, and Berkeley Lab (September 2009)

lower than in the compliance market. This REC swap would allow the host to claim green power benefits (but not solar power because the replacement RECs were not SRECs).

State and Utility Cash Incentives

Other important state-level programs are those that provide cash incentives for system installation. These programs (often called "buy-down" or "rebate" programs) come in two varieties. The capacity-based incentive (CBI) provides a dollar amount per installed watt of PV. Incentives can also be structured as performance-based incentives (PBI). They do not provide up-front payments, but rather provide ongoing payments for each kilowatt-hour of electricity produced over a time period (e.g., five years). Consumers will normally prefer CBIs because of the up-front cash. However, some states prefer PBIs because they encourage better performance. The downside of these more recent programs is that the government agency must finance a large part of system costs (if not under a solar PPA) and incur performance risk (Bolinger 2009).

Approximately 20 states and 100 utilities offer financial incentives for solar photovoltaic projects. Depending on the state and local programs, these incentives can cover 20-50% of a project's cost (DSIRE 2009). Specifics for individual state programs can be found on the Database of State Incentives for Renewables and Efficiency (http://www.dsireusa.org/). Additional government incentives include state tax credits, sales tax exemptions, and property tax exemptions, which can be important under the solar PPA model.

System Purchase Options

If the host prefers, the solar PPA can include provisions for a consumer to buy the PV system. This can occur at any point during the life of the contract but almost always after the sixth year because of tax recapture issues related to the ITC. The buyout clause is phrased as the greater of fair market value (FMV) or some "termination" value (that is higher than the FMV). This termination value often includes the present value of the electricity that would have been generated under the remaining life of the PPA. Buyout options are more readily available in third-party PPAs in which the investors are motivated by the tax incentives rather than long-term electricity revenues. A different set of investors may have a longer-term investment horizon and may be less likely to favor early system-purchase options.

When issuing RFPs and evaluating bids, it is important to understand the project goals of the potential developers and decide which most closely align with those of your organization. From the government agency's point of view, there are both benefits and responsibilities that come with owning the system. The obvious benefit is that the electricity generated by the PV system can now be consumed by the host at no cost (financing charges notwithstanding); the costs and responsibilities revolve around the need to operate and maintain the PV system. Owner's costs include physical maintenance (including inverter replacement, which can be costly) and monitoring, as well as financial aspects such as insurance.

Although PPAs are inherently structured as a contract by which a government agency can buy electricity, system ownership may be a viable option at some point. If the buyout option is not available or not exercised by the end of the contract life, the government agency can purchase the system at "fair market value," extend the PPA, or request the system owner remove the system (Rahus 2008). Government hosts may want to consider requiring (in the RPF and the PPA) that the system owner pay for the cost of equipment removal at contract maturity.

Logistical Considerations

Appropriate roof or land areas must be identified, and there are also important logistical requirements to consider. The issues discussed in this section should be included in the RFP because they will allow the developer to provide a firmer bid with less assumptions and contingencies.

Rooftop Mounted Arrays

After the RFP, the winning bidder will conduct a structural analysis to determine whether the roof can sustain the load. By documenting the condition in the RFP, you may avoid potential adjustments. It is important to assess the following information:

- **Roof structure and type** (flat, angled, metal, wood, etc.) – determines the attachment methods that may be used.
- **Orientation of the roof** – especially important if it is a sloped roof. Southern facing roofs are ideal but not necessarily mandatory.
- **Roof manufacturer's warranty** – usually lasts a minimum of 10 years but can extend over 20 years. Before installing solar panels, it is important to ensure that the solar installation will not void the warranty. Systems that do not penetrate the roof surface or membrane are usually acceptable, but it is important to obtain this allowance in writing prior to moving forward with the solar project.
- **Planned roof replacement** – if it is to be scheduled within a few years, it a good idea to combine projects, which will cut costs and minimize facility disturbance.
- **Potential leak concern** – if this exists, you may opt for a formal roof survey to assess and document the condition of the roof prior to the solar installation.
- **Obstructions on the roof** – items such as roof vents and HVAC equipment can hinder the project.
- **Shade from adjacent trees or buildings** – can reduce solar potential.

Ground-Mounted Systems

Ground-mounted photovoltaic systems are advantageous in some situations because they can be cheaper and easier to install and can be scaled-up more easily. This reduces the cost per kilowatt-hour and translates into cheaper energy costs for the consumer. Additionally, ground systems offer flexibility in the type of technology that can be used. For example, the project may have tracking technologies, which can result in higher energy output and better project economics. One of the key logistical issues for ground-mounted systems is the wind speed the system is designed to withstand, which depends primarily on the location of the project site (e.g., hurricane risks); the soil type and strength characteristics are also important. To obtain more accurate bids, consumers often will have a third-party conduct soil sample tests prior to issuing an RFP. Wind and soil conditions can greatly influence the design and cost of a project. Perimeter fencing and site monitoring should be specified in the RFP to ensure security, safety, and compliance with local codes.

General Logistical Considerations

Electrical upgrades or changes may affect the system design and potential interconnection to the electrical grid. Any planned changes should be documented within the RFP.

For proper maintenance, accessibility to the inverter and solar array will be important to the system owners throughout the life of the project.

Fire departments will have building accessibility requirements, particularly for roof-mounted systems. Some jurisdictions formally specify these standards and will confirm that the system meets the requirements during the permitting phase and final approval process. In states that do not have such requirements, it is important for the government agency and the system owner to gain fire department approval early in the process.

Contractually, operation and ongoing maintenance of the solar system is typically the responsibility of the system owner unless otherwise specified.

Insurance[9]

While many governmental entities may be able to self-insure, it is important to investigate the minimum insurance required by your utility's interconnection rules. The requirements may necessitate additional coverage through private insurance.

Unfortunately, insurance underwriters charge fairly high premiums for PV installations. These premiums can represent approximately 25% of the annual operating budget and may be as large as 0.25% to 0.50% of the project installed costs. According to discussions with developers, the cost of insurance can increase energy pricing by 5–10%. The high premiums are due to two underlying reasons: 1) Insurance underwriters still view PV as a risky technology due to its lack of long operating history, and 2) the relatively low number of projects do not allow underwriters to average risk across a large number of installations (i.e., "the law of large numbers"). Until recently, Lloyds of London was the only underwriter for PV in the United States; however, Munich Re, AIG, Zurich Insurance Group, ACE Ltd., and Chubb are also actively pursuing renewable energy policies. Reportedly, a fifth underwriter is developing a PV product, but no public announcements have been made (Kollins et al., forthcoming).

In general, insurance is the responsibility of the system owner (developer). At a minimum, the system owner should be expected to carry both general liability and property insurance. Additional considerations may be given to separate policies for location-specific risks (e.g., hurricane coverage in Florida), property-equivalent policies (which cover engineering), and environmental risk (inclusive of pre-existing conditions). If covered by the system owner, the cost of insurance will be factored into the PPA cost of electricity and not passed through separately. Thus, a fairly recent realization is that it may be cheaper for the government agency to insure the system directly, although they don't actually own the system. Then, the system owner is named as an additional insured party on the policy and agrees to reimburse the government agency for the premiums. Insurance companies have agreed to this in previous PPAs (Boylston 2008). Because this can reduce overall project costs, this arrangement deserves further investigation with a provider.

One final note concerns indemnification for bad-acts and pre-existing structural or environmental risks. Whether contractual or not, the government agency may want to acquire its own insurance to protect itself from the potential of future liabilities.

Potential Deal Constraints Embedded in Municipal Laws[10]

Municipal laws were written before PV installations were even a remote consideration. While each jurisdiction operates under its own unique statutes, this section lists some common constraints that may be encountered. Listed below are the categories that may require investigation. More detail on the following specific issues is provided at the end of this fact sheet:

1. **Debt limitations** in city codes, state statutes, and constitutions
2. Restrictions on **contracting power** in city codes and state statutes
3. **Budgeting, public purpose**, and **credit-lending** issues
4. **Public utility rules**
5. Authority to **grant site interests** and **buy electricity**

[9] Much of this section is adopted from a forthcoming NREL paper: "Insuring Solar Photovoltaics: Challenges and Possible Solutions"; Speer, B.; Mendelsohn, M.; and Cory, K.

[10] Much of this section is adapted from the transcript of a June 12, 2008, NREL conference call led by Patrick Boylston of Stoel Rives LLP.

Conclusions

Financing solar PV through a power purchase agreement allows state and local governments to benefit from clean renewable energy while minimizing up-front expenditures and outsourcing O&M responsibilities. Also important, a PPA provides a predictable electricity cost over the length of the contract.

This fact sheet is a concise guide that will help states and municipalities with the solar PPA process. The following five steps are recommended to formally launch a project (and are described in this brief):

Step 1: Identify Potential Locations

Step 2: Issue a Request for Proposal (RFP) to Competitively Select a Developer

Step 3: Contract Development

Step 4: Permitting and Rebate Processing

Step 5: Project Design, Procurement, Construction, and Commissioning

The U.S. Department of Energy (DOE) can help facilitate the process by providing quick, short-term access to expertise on renewable energy and energy efficiency programs. This is coordinated through the Technical Assistance Project (TAP) for state and local officials.[11] More information on the program can be found at http://apps1.eere.energy.gov/wip/tap.cfm.

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Stoel Rives LLP. (2008). "Lex Helius: The Law of Solar Energy, A Guide to Business and Legal Issues." First Edition. http://www.stoel.com/webfiles/lawofsolarenergy.pdf

[11] TAP currently has a focus on assisting programs that are related to Recovery Act funds.

Power Purchase Agreement Checklist

Sample Terms of Executed Power Purchase Agreements (PPAs)

Government Level	State	County	City
Name	Caltrans District 10 Solar Project	Boulder County Solar Project	Denver Airport Solar Project
Location	Stockton, California	Boulder County	Denver, Colorado
Customer	California Department of Transportation	Boulder County	Denver International Airport
Utility	Pacific Gas & Electric	Xcel Energy	Xcel Energy
Size (DC)	248 kW	615 kW	2,000 kW
Annual Production	347,407 kWh	869,100 kWh	3,000,000 kWh
Type	123 kW rooftop, 125 kW carport	570 kW rooftop, 45 kW ground	Ground-mount, single-axis tracking
Location	Maintenance Warehouse Maintenance Shop Parking Lot Canopy	Recycling Center Courthouse Clerk and Recorder Addiction Recovery Center Justice Center Walden Ponds (ground-mount) Sundquist	Ground of the Denver International Airport
Area	22,200 sq ft	8 county buildings	7.5 acres
Developer	Sun Edison, LLC	Bella Energy	World Water & Solar Technologies
Owner	Sun Edison, LLC	Rockwell Financial	MMA Renewable Ventures
PPA Terms	20 years, 5.5% discount from utility rates	20 years, fixed-price 6.5 ¢/kWh for first 7 years, renegotiate price and buyout option at beginning of year 8	25 years, fixed-price 6 ¢/kWh for first 5 years, buyout option at beginning of year 6 or price increases to 10.5 ¢/kWh
Status	Completed September 2007	Completed January 2009	Completed August 2008
Contact	Patrick McCoy (916) 375-5988 patrick.mccoy@dgs.ca.gov	Ann Livington (303) 441-3517 alivingston@bouldercounty.org	Woods Allee (303) 342-2632 woods.allee@flydenver.com

Source: NREL

Potential Deal Constraints Embedded in Municipal Laws

This table lists potential constraints posed by municipal laws. Not all issues will pertain to your jurisdiction; however, this table can serve as a short checklist for use in your investigation. The request for proposal (RFP) issue column is meant to qualify each issue as to whether it needs to be highlighted in the RFP.

Category	RFP Issue?	Issue	Implication	General Findings and Next Steps
1. Debt Limitations in City Codes, State Statutes, and Constitutions	No	Is PPA debt or contingent liability?	Debt would require public vote for approval. Contingent liability is allowed under purchasing authority without a vote.	Most states see as purchasing only what is consumed. Thus, a vote not is required. PPA agreements usually called "energy services agreement" to avoid any appearance of debt. Must be wary of "take or pay provisions" in PPA requiring payments regardless of use. Also, be careful to size so as to not over-produce based on net-metering rules
	No	Is system purchase option debt?	A vote will be required to approve debt for system purchase.	It is important that the PPA deems the purchase as optional at fair market value so that a vote is not needed until the option is exercised.
2. Restrictions on Contracting Power in City Codes and State Statutes	Yes	Contract Tenor statutes (e.g., limited to 10 yrs or 15 yrs)	May limit choice of developers based on investment goals.	Research of local rules and precedents may be required.
	Yes	Ability to buy/sell RECs	When codes and statutes were created, RECs were not envisioned. May determine where beneficial REC ownership is assigned in PPA.	Each jurisdiction will be different. Research of local rules and precedents is required. Is there enough general authority under electricity purchases (or other) to justify REC trading?
	Yes	Public bidding laws	May preclude RFP process unless there is an applicable exemption to public bidding laws.	Research of local rules and precedents may be required. Developer will ask for representation and warranty that the contract is exempt from public bidding rules.
3. Public Purpose and Lending of Credit Issues	Yes	Pre-paying for electricity	Is this a grant to a for-profit LLC that owns the PV system?	In most states, authority exists (such as in the opinion of attorneys general) that it is permissible if the entities are fulfilling a government purpose. Research may be required if pre-payment is envisioned.
4. Public Utility Rules	Yes	How many entities will be buying electricity (i.e., city, county, and/or other government entities occupy site)?	Most state laws and/or rules clarify that if you are selling electricity to a certain number of consumers, then you are a utility and subject to Public Utility Commission (PUC) regulation.[12] This can be prohibitively expensive for the developer.	Developers will generally want to contract only with a single entity that owns the meter. The costs can then be divided among various entities. If the entities are all behind the meter, then they would not be subject to PUC regulations.
5. Authority to Grant Site Interests and Purchase Electricity	No	Lease or easement?	A lease can have problems with disposal and interest in public property, which may require a public-bidding or offering process.	Framing the document as an "easement" instead of a "lease" has worked well. Works much like a lease except without ability to transfer it—except in accordance with agreement (usually restricted).

Source: Boylston 2008

[12] The threshold is set differently by each state. Most are in the two-five range.

Power Purchase Agreement Checklist

Sources for Sample Documents

Samples of requests for proposals can be found using simple Web searches—the links below will get you started in your search.

NV Energy (Nevada Power Company) is a good source for documents which have been previously tested in the marketplace:
http://www.nvenergy.com/company/doingbusiness/rfps/

Oregon University System
http://www.ous.edu/bapp/contractfiles/20090522_1545_Photovoltaic%20Power%20Purchase%20Agreement/RFP%202009-06%20Solar%20PPA.doc

City of Santa Ana
http://www.ci.santa-ana.ca.us/pwa/documents/RFP-SolarProjectandGuideline.pdf

The U.S. Navy recently released an RFP that is very thorough in its specifications:
http://www.allenmatkins.com/emails/Renewable/Img/NAVY.pdf

Example RFPs from several California municipalities:
http://www.lgc.org/spire/rfps.html

A current federal government RFP:
https://www.desc.dla.mil/DCM/DCMSolic.asp?SolicID=1533

Other Useful Documents:

The documents below are more detailed, in-depth solar financing guides.

The Customer's Guide to Solar Power Purchase Agreements, by the Rahus Institute
http://www.californiasolarcenter.org/sppa.html

Solar Photovoltaic Financing: Deployment on Public Property by State and Local Governments, by Karlynn Cory, Jason Coughlin, and Charles Coggeshall. This NREL report (May 2008) examines ways that state and local governments can optimize the financial structure of deploying solar PV for public uses. It can be accessed at http://www.nrel.gov/docs/fy08osti/43115.pdf

Solar Photovoltaic Financing: Residential Sector Deployment, by Jason Coughlin and Karlynn Cory. This NREL technical report (March 2009) can be accessed at http://www.nrel.gov/docs/fy09osti/44853.pdf.

Solar Photovoltaic Financing: Deployment by Federal Government Agencies, by Karlynn Cory, Charles Coggeshall, Jason Coughlin, and Claire Kreycik. This NREL technical report (August 2009) can be accessed at http://www.nrel.gov/docs/fy09osti/46397.pdf

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CITY OF MADRAS
WASTEWATER MASTER PLAN UPDATE

APPENDIX Q

WASTEWATER SYSTEM DEVELOPMENT CHARGE UPDATE
(FCS GROUP, MAY 2018)

City of Madras

Wastewater System Development Charge Update

May 2018

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I.A. INTRODUCTION

Oregon Revised Statutes (ORS) 223.297 to 223.314 authorize local governments to establish system development charges (SDCs). These are one-time fees on new development paid at the time of development. SDCs are intended to recover a fair share of the cost of existing and planned facilities that provide capacity to serve future growth. In general, SDCs are calculated by adding together a reimbursement fee component and an improvement fee component, as defined by ORS 223.299.

Reimbursement Fee: A reimbursement fee is designed to recover "costs associated with capital improvements already constructed, or under construction when the fee is established, for which the local government determines that capacity exists." ORS 223.304(1) states, in part, that a reimbursement fee must be based on "the value of unused capacity available to future system users or the cost of existing facilities" and must account for prior contributions by existing users and any gifted or grant-funded facilities. The calculation must "promote the objective of future system users contributing no more than an equitable share to the cost of existing facilities." A reimbursement fee may be spent on any capital improvement related to the system for which it is being charged (whether cash-financed or debt-financed) and on the costs of compliance with Oregon's SDC law.

Improvement Fee: An improvement fee is designed to recover "costs associated with capital improvements to be constructed." ORS 223.304(2) states, in part, that an improvement fee must be calculated to include only the cost of projected capital improvements needed to increase system capacity for future users. In other words, the cost of planned projects that correct existing deficiencies or do not otherwise increase capacity for future users may not be included in the improvement fee calculation. An improvement fee may be spent only on capital improvements (or portions thereof) that increase the capacity of the system for which it is being charged (whether cash-financed or debt-financed) and on the costs of compliance with Oregon's SDC law.

Compliance Cost Recovery: ORS 223.307(5) also authorizes the expenditure of SDCs for "the costs of complying with the provisions of ORS 223.297 to 223.314, including the costs of developing system development charge methodologies and providing an annual accounting of system development charge expenditures." To avoid spending monies for compliance that might otherwise have been spent on growth-related projects, this report includes an estimate of compliance costs in the SDC calculation.

Figure 1. SDC Equation

Reimbursement Fee		Improvement Fee				
Eligible costs of available capacity in existing facilities	+	Eligible costs of capacity-increasing capital improvements	+	Pro-rata share of costs of complying with Oregon SDC law	=	SDC per MCE
Units of growth (MCEs)		Units of growth (MCEs)				

I.B. CUSTOMER BASE

In order to calculate an SDC component, a numerator and a denominator must be developed. This section focuses on the denominator (i.e. the customer base). The denominator represents growth that can be served once the capital improvement plan has been executed. In other words, future customers. For the City of Madras wastewater service, the denominator will be developed in two steps:

- Determine future treatment plant capacity in million gallons per day (mgd). [Both the North and South treatment plants are included to determine total system capacity.]
- Calculate growth in mgd, from current, to treatment plant capacity.
- Convert million gallons per day into meter capacity equivalents. The City administers the SDC based on a customer's meter size, which corresponds to meter capacity equivalents (MCEs) depending on the size of the meter.

I.B.1. Capacity in Million Gallons per Day

After the execution of the capital plan identified in the utility's comprehensive plan, the wastewater utility is expected to have 1.65 mgd in treatment capacity. After removing the estimated existing City customer flows as well as the contractual amount allotted to the corrections facility, 0.927 mgd of capacity remains for future customers that have not yet connected to the system. Neither the North Plant's Phase 2 and 3 capacities (nor costs) are incorporated into this SDC.

Figure 2. Future Capacity in mgd

Future Capacity in Million Gallons per Day (mgd)	
Future Capacity (mgd)	
South Plant	1.150
North Plant	0.500
Total Future Capacity	1.650
Total Capacity with New CIP (mgd)	1.650
Less Existing Flows	(0.493)
Less Amount Reserved for Department of Corrections	(0.230)
Net Total Capacity for Future Growth	0.927

I.B.2. Capacity in Meter Capacity Equivalents (MCEs)

Now that the flow-related capacity has been determined, it must be converted into MCEs so that the charge calculation can align with how it is administered. To do this, the existing flows of 0.493 mgd will be compared to existing meter capacity equivalents within the utility. That will provide an estimate of mgd per MCE.

The City currently has 2,023 meters in the wastewater utility, comprised of customers served by two water systems—the City's water system and the Deschutes Valley Water District (DVWD). The six

inch meter serves the Department of Correction's Deer Ridge facility and is therefore excluded since the facilities entire contracted amount of 0.23 mgd has already been deducted from future capacity in **Figure 2** above.

Based on meter capacity equivalent ratios drawn from the American Water Works Association (AWWA) M1 Manual, each meter size has a corresponding number of meter capacity equivalents. Each number is based on the maximum safe flow capacity in gallons per minute, relative to a base 5/8 x 3/4 inch meter. By multiplying the MCE ratio and the number of meters in each size, 2,023 meters equates to 3,074 meter capacity equivalents.

Figure 3. Meters & Meter Capacity Equivalents

Meter Size	Meters in City Water System	Meters in DVWD Water System	Less: Department of Corrections	Total Meter Count	Meter Capacity Equivalent (MCE)	Number of MCEs
5/8"	883	935	-	1,818	1.00	1,818
1"	40	39	-	79	2.50	198
1.5"	16	1	-	17	5.00	85
2"	44	57	-	101	8.00	808
3"	3	3	-	6	17.50	105
4"	-	2	-	2	30.00	60
5"	-	-	-	-	62.50	-
6"	-	1	(1)	-	90.00	-
Total	**986**	**1,038**	**(1)**	**2,023**		**3,074**

By comparing existing flows with existing meter capacity equivalents, **Figure 4** shows that one MCE is equal to 0.000160 million gallons per day (0.493 mgd ÷ 3,074 MCEs). Additionally, it is estimated that 0.927 mgd of capacity will be available for new customers once the capital plan has been executed (as shown in **Figure 2**). By dividing 0.927 mgd by 0.000160, an additional 5,779 MCEs can be served by the new capacity.

Figure 4. Future MCEs Able to be Served

Meter Capacity Equivalents Served by Plant Expansion		
Existing Flows (mgd)	A	0.493
Existing MCEs	B	3,074
MGD per MCE	C = A ÷ B	0.000160
Capacity for Growth (mgd)	D	0.927
MGD per MCE	C	0.000160
Capacity for Growth MCEs	E = D ÷ C	**5,779**

I.C. REIMBURSEMENT FEE

The reimbursement fee's numerator is based on the original cost of the existing system's "unused capacity available to future system users." As shown in **Figure 5**, there is approximately 30% remaining capacity for future customers. The remaining 70% is assumed to be utilized by existing customers plus the capacity contractually reserved for the Deer Ridge facility.

Figure 5. Remaining Capacity in Existing Facilities

Treatment Plant Analysis	Existing Flows / Capacity
Peak Month Flows (mgd)	
Prison (contract capacity)	0.230
All Others (2016-17 Actuals)	0.493
Total Existing Flows + Contract Capacity	0.723
Existing Capacity (mgd)	
South Plant	0.540
North Plant	0.500
Total Capacity	1.040
% Remaining Capacity	30%

The total original cost of existing assets in the wastewater utility totals $32.4 million, with $10.7 million of that estimated to have been funded with grants. The remaining $21.7 million is assumed to be funded with utility resources. **Figure 6** shows that 30% of the utility-funded assets results in $6,624,457, which is eligible to be included in the reimbursement fee.

Figure 6. Net Reimbursement Cost Basis

Reimbursement Cost Basis					
Asset Category	Original Cost	Grants	Original Cost less Grants	% Available Capacity	Reimbursement Cost Fee Basis
Treatment	$ 27,909,455	$ 9,195,436	$ 18,714,020	30%	$ 5,704,177
Collection	$ 2,163,660	$ 915,107	$ 1,248,553	30%	$ 380,569
General	$ 2,360,881	$ 590,220	$ 1,770,661	30%	$ 539,711
Total	**$ 32,433,996**	**$ 10,700,762**	**$ 21,733,233**		**$ 6,624,457**

The calculated reimbursement fee is shown in **Figure 7**, which totals $586 after deducting unused reimbursement SDC fund balance and a pro-rata share of outstanding debt principal. Outstanding debt principal is deducted from the reimbursement fee cost basis because debt principal is paid for with ratepayer revenue. By deducting a pro-rata share of outstanding debt principal, the fee avoids double-charging for an asset included in the cost basis that may have been funded with debt.

Figure 7. Reimbursement Fee

Reimbursement Fee		
Cost of Net Unused Capacity	$	6,624,457
Less: Unused Reimbursement SDC Fund Balance	$	(35,686)
Less: Pro-Rata Share of Debt Principal (growth related)	$	(3,202,197)
Reimbursement Cost Basis	$	3,386,575
Estimated Capacity (MCEs)		5,779
Reimbursement Fee:		**$586**

I.D. Improvement Fees

This section summarizes the improvement fee cost basis and resulting fee. Planned project cost data was provided by City staff and the City's consulting engineering firm. The wastewater utility's 20-year capital improvement plan was evaluated to determine which projects (or portions thereof) provided additional capacity for future customers. The 20-year capital improvement plan identified $111,530,000 in projects (in 2017 dollars). To determine the net eligible costs, two types of costs were excluded:

- Projects not expected to be funded by the utility: $65,470,000
  - The bulk of the cost in this category consists of Phases 2 and 3 of the North Wastewater Treatment Plant and related collection system projects (e.g. North Area Parallel Sewer). These capacity expanding phases would only be constructed if a new, significant customer needed capacity. Per City direction, the cost share would be negotiated at that time. To be conservative, all of those costs are assumed to be ineligible at this time.
- Projects funded by the City utility that do not increase capacity: $21,083,447
  - These projects are funded by the City's wastewater utility, but do not provide additional capacity for future customers. An example of this type of project would be an 8" collection pipe replacing an existing 8" collection pipe. No additional capacity would be created.

Once these adjustments have been made, **$24,976,553** can be incorporated into the improvement fee calculation. A detailed, project-by-project list can be seen in the appendix.

Figure 8. Eligible Future Capital Costs

Summary of Capital Plan (in December 2017 dollars)	
Total Capital	$ 111,530,000
Less: Projects not funded by utility	(65,470,000)
Cost potentially Eligible for SDC	$ 46,060,000
Less: Non-Capacity Expanding Share	$ (21,083,447)
Capacity Expanding Costs Funded by City Utility	$ 24,976,553

The total of capacity expanding costs is further adjusted by the improvement SDC fund balance, resulting in a total eligible cost of $24,739,089. With a denominator of 5,779 MCEs, the resulting improvement fee equals $4,281.

Figure 9. Improvement Fee Calculation

Improvement Fee	
Capacity Expanding Projects	$ 24,976,553
Less: Unused Improvement SDC Fund Balance	$ (237,464)
Improvement Fee Cost Basis	$ 24,739,089
Estimated Capacity (MCEs)	5,779
Improvement Fee:	**$4,281**

I.E. ADJUSTMENTS

ORS 223.307(5) authorizes the expenditure of SDCs on "the costs of complying with the provisions of ORS 223.297 to 223.314, including the costs of developing system development charge methodologies and providing an annual accounting of system development charge expenditures." This SDC methodology assumes a compliance cost of 5.7 percent.

Figure 10. Administrative Adjustment for Compliance

Administrative Cost Recovery		
Net Annual Administrative Cost related to Wastewater SDC	$	2,000
Amortization of SDC Study Cost over 5 years (1):		2,310
Net Annual SDC Administrative Cost:	$	4,310
Projected Annual Number of New Connections		15.44
Annual Administrative Cost per Connection	$	279
Estimated Annual Proposed SDC Revenues before Admin. Cost	$	75,163
Admin. Cost / Total Annual SDC Revenues:		**5.7%**

NOTES:

(1)	Cost of:	$ 10,000	(Cost of FCS GROUP study)
	at:	5.0%	
	over:	5	years

The administrative adjustment is incorporated into the SDC by adding the $279 shown in Figure 10 to the reimbursement and improvement fees. The combined SDC totals $5,146, which is a decrease of $143 from the existing SDC of $5,289 (Figure 11).

Figure 11. Total System Development Charge

Total System Development Charge		
Reimbursement Fee		$586
Improvement Fee		$4,281
SDC Subtotal		$4,867
plus: Administrative Cost Recovery	5.7%	$279
TOTAL WASTEWATER SDC		**$5,146**
Existing SDC per MCE		$5,289
Change (%) - Calculated from Existing SDC		-3%
Change ($) - Calculated from Existing SDC		($143)

I.F. SUMMARY

SDCs are one-time fees imposed on new and increased development to recover the cost of system facilities needed to serve that growth. As discussed previously, an SDC can include three components: a reimbursement fee, an improvement fee, and a component for compliance cost recovery. The total calculated SDC is shown in **Figure 12**. For a basic 5/8 x 3/4 meter, the calculated SDC would be $5,146 instead of the existing SDC of $5,289.

Figure 12. SDC Schedule by Meter Size

Wastewater SDC Fee Schedule			
Meter Size	**MCEs per Size**	**Existing**	**Calculated**
5/8"	1.00	$5,289	$5,146
1"	2.50	$13,223	$12,864
1.5"	5.00	$26,445	$25,729
2"	8.00	$42,312	$41,166
3"	17.50	$92,558	$90,051
4"	30.00	$158,670	$154,373
5"	62.50	$330,563	$321,611
6"	90.00	$476,010	$463,120

We do not recommend any changes to the City's existing methodology related to multi-unit structures such as apartments or hotels. The following fee schedule would apply to multiple family residences and lodging facilities. The schedule maintains the existing assumed values of 0.71 MCEs per Multiple Family Residence unit and 0.74 MCEs per Lodging Facility unit.

Figure 13. SDC Fee Schedules for Multiple Family / Lodging Facilities

Wastewater SDC Fee Schedule			
	Assumed MCE per Unit	**SDC per 1.0 MCE**	**Total SDC per Unit**
Multiple Family Residences per Unit (i.e. Apartments)	0.71	$5,146	$3,654
Lodging Facility per Unit (i.e. Hotel)	0.74	$5,146	$3,808

I.G. INDEXING

Oregon law (ORS 223.304) also allows for the periodic indexing of system development charges for inflation, as long as the index used is:

> "(A) A relevant measurement of the average change in prices or costs over an identified time period for materials, labor, real property or a combination of the three;
>
> (B) Published by a recognized organization or agency that produces the index or data source for reasons that are independent of the system development charge methodology; and
>
> (C) Incorporated as part of the established methodology or identified and adopted in a separate ordinance, resolution or order."

We recommend that the City index its charges to the Engineering News Record 20-City Average Construction Cost Index, and adjust the charges annually as per that index. There is no comparable Oregon-specific index.

I.H. APPENDIX

Capital Project Costs, Funding Source, and Before/After Capacity

Improvement Fee Cost Basis Project Name	Total Value	Funding Source	Current Capacity	Future Capacity	Eligible Portion	Full CIP
Gravity Sewers						
Mountain View / Sky Ridge Sewer Extensions	$ 1,175,000	City Utility Fund	0.00	8.00	100%	$ 1,175,000
Jefferson Street / North Unit	$ 555,000	City Utility Fund	0.00	8.00	100%	$ 555,000
Bel Air / Herzberg Heights -- Grant Funded	$ 500,000	CIAC	0.00	8.00	100%	$ -
Bel Air / Herzberg Heights	$ 655,000	City Utility Fund	0.00	8.00	100%	$ 655,000
Hess Street Sewer	$ 350,000	City Utility Fund	0.00	8.00	100%	$ 350,000
Mill Street Sewer	$ 300,000	City Utility Fund	0.00	8.00	100%	$ 300,000
North Y Sewer Replacement	$ 880,000	City Utility Fund	8.00	12.00	56%	$ 488,889
Culver Hwy, Parallel Sewer	$ 760,000	City Utility Fund	0.00	10.00	100%	$ 760,000
Juniper Heights Sewer Extension	$ 1,400,000	City Utility Fund	0.00	8.00	100%	$ 1,400,000
Willow Creek North Sewer Extension	$ 565,000	City Utility Fund	0.00	8.00	100%	$ 565,000
Potential Sewers for Major Industrial Park Users						
North Area Parallel Sewer -- Airport Way	$ 940,000					
Pump Stations						
Influent Screen at "B" Street North PS – No expansion	$ 465,000	City Utility Fund	1.11	1.11	0%	$ -
Golf Course PS Replacement -- Expanded Capacity	$ 490,000	City Utility Fund	17.00	213.00	92%	$ 450,892
"B" Street North PS Renovation -- No expansion	$ 610,000	City Utility Fund	1.11	1.11	0%	$ -
"B" Street North & South Generator Set Replacement	$ 245,000	City Utility Fund	0.00	0.00	0%	$ -
South U.S. 97 PS Renovation -- No Expansion	$ 60,000	City Utility Fund	0.06	0.06	0%	$ -
"B" Street South PS Expansion & Renovation	$ 730,000	City Utility Fund	1.33	2.66	50%	$ 365,000
Demers PS Replacement -- Expanded Capacity	$ 1,790,000					
Demers Force Main Replacement -- 8" Pipe	$ 1,585,000					
Airport Area PS and Force Main	$ 2,340,000					
WWTPs & Effluent Recycling						
NWWTP Phase 1A Improvements	$ -	City Utility Fund	0.50	0.50	0%	$ -
Alternate NWWTP Phase 1A Improvements	$ 1,355,000	City Utility Fund	0.50	0.50	0%	$ -
SWWTP Biosolids Thickening System	$ 1,255,000	City Utility Fund	0.54	0.65	17%	$ 212,385
SWWTP Phase 1 Expansion/Renovation	$ 1,245,000	City Utility Fund	0.54	0.65	17%	$ 210,692
SWWTP Irrigation System Expansion	$ 515,000	City Utility Fund	0.00	0.65	100%	$ 515,000
NWWTP Phase 1B Improvements	$ 8,210,000	City Utility Fund	0.50	0.50	0%	$ -
NWWTP Phase 1 Land Acquisition & Irrigation System	$ 1,600,000	City Utility Fund	0.50	0.50	0%	$ -
SWWTP Phase 2 Expansion and Renovation	$ 10,025,000	City Utility Fund	0.65	1.15	43%	$ 4,358,696
SWWTP Phase 2 Effluent Storage Expansion	$ 9,200,000	City Utility Fund	0.00	0.50	100%	$ 9,200,000
SWWTP Phase 2 Farmland Acquisition & Irrigation System	$ 3,415,000	City Utility Fund	0.00	0.50	100%	$ 3,415,000
NWWTP Phase 2 Treatment Module w/aerated lagoons	$ 10,685,000					
NWWTP Phase 2 Effluent Storage Pond	$ 12,535,000					
NWWTP Phase 2 Farmland Acquisition & Irrigation System	$ 4,695,000					
NWWTP Phase 3 Treatment Module w/aerated lagoons	$ 12,490,000					
NWWTP Phase 3 Effluent Storage Pond	$ 12,535,000					
NWWTP Phase 3 Farmland Acquisition & Irrigation System	$ 5,375,000					
Total	**$ 111,530,000**					**$ 24,976,553**

CIAC means contributions in aid of construction—essentially NOT funded with Utility resources—be it grants or developer funded.

Current and Future capacity notes:

- Gravity sewer: size of pipe in inches
- Pump Stations: million gallons per day (mgd)
  - Golf Course PS Replacement project: Dwelling Units served before and after (17, 213 respectively)
- WWTP and Effluent Recycling: million gallons per day (mgd)

Existing System Flows (0.493 mgd)

Data from Harper Houf Peterson Righellis Inc. in May 2018.

Summary of Flow Data - North & South Combined (MGD)

2017	Flow Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mar-Oct w/o Aug
Total Avg Flow	(MGD)	0.616	0.589	0.569	0.569	0.558	0.573	0.586	0.627	0.587	0.582	0.570	0.588	0.575
Avg Prison Flow	(MGD)	0.081	0.083	0.079	0.082	0.072	0.072	0.072	0.076	0.071	0.070	0.074	0.086	0.074
Net Flow w/o Prison	(MGD)	0.536	0.506	0.489	0.487	0.486	0.501	0.514	0.552	0.515	0.512	0.496	0.502	0.501
2016	**Flow Unit**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Mar-Oct w/o Sept**
Total Avg Flow	(MGD)	0.526	0.523	0.518	0.526	0.557	0.555	0.560	0.549	0.503	0.555	0.538	0.576	0.546
Avg Prison Flow	(MGD)	0.047	0.059	0.058	0.059	0.062	0.062	0.063	0.062	0.061	0.061	ND [4]	ND [4]	0.061
Net Flow w/o Prison	(MGD)	0.478	0.464	0.460	0.467	0.495	0.493	0.497	0.487	0.442	0.494	—	—	0.485
2016-17 Net Flow	(MGD)	0.507	0.485	0.475	0.477	0.490	0.497	0.505	0.519	0.479	0.503			0.493
													Net Flow Per MCE (MGD)	0.000160
													(gpd)	160

Notes:
1. Exclude Winter months due to inflow from snowmelt (particularly high during winter of 2016-17)
2. Exclude August 2017 due to unusually high flows from visitors for eclipse.
3. Exclude September 2016 due to flow instrument failure.
4. No prison flow data available for November-December 2016.
5. Total MCE = 3,074

ODOC Contract Capacity (0.23 mgd)

Data from Harper Houf Peterson Righellis INC. in 2017.

WASTEWATER MASTER PLAN UPDATE **CITY OF MADRAS**

The plant headworks consist of influent screening and grit removal processes. The screenings and grit removed by these processes are disposed of at a landfill. The SBR process is an activated-sludge system that provides biological treatment. The filters remove suspended solids to reduce chlorine demand and prevent fouling of irrigation components. Because the City does not need to produce Class A effluent, chemicals are not added upstream of the filters to increase solids removal.

The SWWTP was designed to ultimately have three 0.5-MGD SBR modules and two of those modules have been built. But when the second module was added, the plant design was modified to treat more-highly concentrated WW from the prison. The design WW strength for the prison is three times the design strength for the City. As a result, the expansion increased the capacity to treat a higher organic loading, but did not significantly increase the flow capacity. Now the two SBR modules have a 0.54-MGD average design flow capacity rather than a 1.0-MGD capacity.

The agreement between the City and the ODOC stipulates that an average flow capacity of 0.23 MGD at the SWWTP is dedicated to serving the prison. Although the prison is not fully occupied, this study assumes it will be contributing the maximum allowed flow within five years to avoid reliance on capacity that is dedicated to the prison. This currently leaves the City with an available capacity of 0.31 MGD at the SWWTP.

North Plant Existing Design Capacity (0.50 mgd)

Data from Harper Houf Peterson Righellis INC. in 2017.

Table 2-3
Existing NWWTP Design Parameters and Components

1. Plant Influent Design Parameters	
Average Daily Flow:	0.50 MGD
Peak Hourly Flow:	1.35 MGD
Design Average BOD_5 Concentration:	200 mg/L
Design Average TSS Concentration:	215 mg/L
2. Biological (Oxidation) Process	
Process:	Partially-Aerated/Facultative Lagoon System
Total System Surface Area & Volume:	28 acres & 50 MG
Average Organic Surface Loading Rate:	30 lbs. BOD_5/acre/day
Primary Lagoon Aerators (each cell):	10 units @ 5.0 hp each (50 hp/cell)
3. Clarification/Filtration Process	
Process Capacity:	1.0 MGD Avg. Recycling Flow
Clarification Process:	Krofta SupraCell (SPC) Dissolved Air Flotation (DAF) Clarifier
Filtration Process (Not Used):	Krofta Sandfloat (SASF 20) Filter
4. Disinfection Process	
Disinfectant:	Sodium Hypochlorite Solution
Maximum Feed Rate:	170 gpd
5. Effluent Storage Pond	
Total Storage Volume:	79 MG
Design Storage Capacity:	Five Months @ 0.5 MGD Avg. Flow
6. Intermediate Lift & Effluent Irrigation Pumps	
No. of Pumps:	Two (one intermediate & one effluent)
Design Pump Capacity:	700 gpm each
7. Sludge Drying Beds	
No. of Beds:	24
Bed Dimensions:	24 ft. x 100 ft. x 12 in. Deep (each)

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South Plant Existing Design Capacity (0.54 mgd)

Data from Harper Houf Peterson Righellis INC. in 2017.

Table 2-4
Existing SWWTP Design Parameters and Components

1. Plant Influent Design Parameters	
Average Daily Flow:	0.54 MGD
Peak Hourly Flow:	1.33 MGD
Design Average BOD_5 Concentration:	465 mg/L
Design Average TSS Concentration:	465 mg/L
2. Headworks	
Influent Screening:	One Mechanically-Cleaned Fine Screen
Design Screen Capacity:	4.0 MGD
Grit Removal Process	One Low-Energy Vortex Circular Chamber
Design Grit Removal Capacity:	2.5 MGD
3. Biological (Oxidation) Process	
Process:	SBR, Activated-Sludge System
No. of SBR Basins:	Two
Design Effluent BOD_5 Concentration:	10 mg/L
Design Organic Loading Rate:	0.5 lbs. BOD_5/lb. MLSS @ 4,500 mg/L MLSS
Design Oxygen Requirements:	1.5 lbs. O_2/lb. BOD_5 and 4.6 lbs. O_2/lb. TKN
4. Filter Process	
Process:	Cloth-Media Disk Filter
Peak Process Capacity:	2.4 MGD
No. of Filter Disks:	Four
Design Effluent TSS Concentration:	5.0 mg/L
5. Disinfection Process	
Disinfectant:	Sodium Hypochlorite Solution
Maximum Feed Rate:	170 gpd
6. Biosolids Handling	
Stabilization Process:	Aerobic Digesters
No. of Digester Basins:	Three
Design Avg. Retention Time:	60 Days
Drying Process:	AC-Lined Sludge Drying Beds @ NWWTP
Biosolids Disposal:	Land Application of Class B Biosolids
7. Storage Ponds	
Lower Pond Volume:	25 MG (Onsite SBR Effluent Storage)
Upper Pond Volume:	88 MG (Remote Site)
Design Storage Capacity:	Five Months @ 0.54 MGD Avg. Flow
8. Effluent Pumps	
No. of Pumps:	Two
Design Pump Capacity:	1,050 gpm each

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Future South (1.15 mgd) and North Plant (0.50 mgd) Capacities

It is assumed that the South Plant will have a future capacity of 1.15 mgd once the plan is completed.

> The evaluation assumes the SWWTP will be expanded in two phases as described in Chapter 5 to provide a design capacity of 1.15|MGD. These SWWTP expansions would provide flexibility both in freeing up capacity at the NWWTP for industrial developments and accommodating gravity service to east-side developments in the Main Collection System. Plus, this would take advantage of the existing SWWTP design to accommodate such expansions resulting in capital savings relative to an entire new 0.5-MGD treatment facility at the NWWTP.
>
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It is assumed that the North Plant will have a future capacity of 0.50 when the plan is completed—the same as the existing capacity. This does not include the Phase 2 or Phase 3, which are entirely excluded from the SDC calculation.

B. North WWTP Upgrades				
1. Phase 1 Retrofit to Maintain 0.5 MGD Capacity	10-12	0.50	0.50	$10,180,000
2. Phase 2 Retrofit for 0.5 MGD Expansion (to 1.0 MGD)	(2)	0.50	1.00	$10,740,000
3. Construct Effluent Storage for 0.5 MGD Expansion	(2)	0.50	1.00	$12,137,000
4. Phase 3 — Construct 0.5-MGD Module (Expand to 1.5 MGD)	(2)	--	1.5	$12,333,000
5. Effluent Storage Ponds for Expansion to 1.5 MGD	(2)	--	1.5	$12,137,000