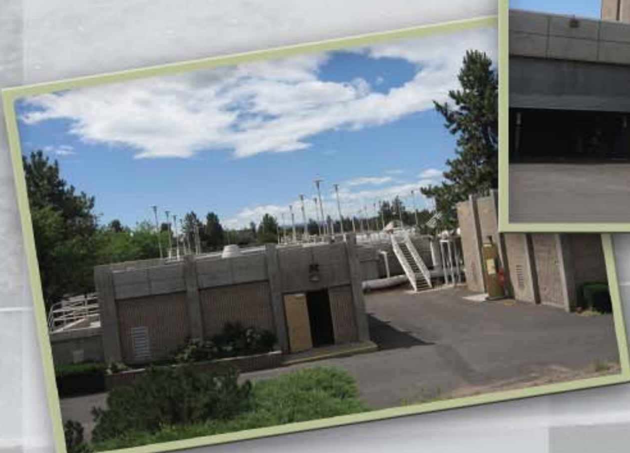
Water Reclamation Facilities Plan

City Project No. SW0701

VOLUME 1

April 2008



carollo

Engineers...Working Wonders With Water™

In association with

Vision Engineering

City of Bend

WATER RECLAMATION FACILITIES PLAN

April 2008

Engineers...Working Wonders With Water™

4380 SOUTHWEST MACADAM AVENUE • SUITE 350 • PORTLAND, OREGON 97239-6406 • (503) 227-1885 • FAX (503) 227-1747

City of Bend

WATER RECLAMATION FACILITIES PLAN

TABLE OF CONTENTS

Page

APPENDICES

<u>**LIST OF TABLES**</u>

<u>**LIST OF FIGURES**</u>

1.0 INTRODUCTION, PURPOSE AND NEED

The purpose of this Water Reclamation Facilities Plan (Facilities Plan) is to provide a systematic plan for expanding the City of Bend (City) Water Reclamation Facilities (WRF) to meet projected needs through the year 2030. This Facilities Plan was assembled based on guidelines provided by the Oregon Department of Environmental Quality (DEQ). This report generally follows the outline presented in the *Guidelines for the Preparation of Facilities Plans and Environmental Reports for Community Wastewater Projects* (December 2005), and is intended to meet DEQ requirements for approval and acquisition of funding through the State Revolving Fund (SRF) program.

The scope of this Facilities Plan included the following:

- Project future flows and plant loadings
- Review regulatory requirements
- Conduct a condition assessment of existing facilities
- Evaluate process alternatives for the treatment and ultimate disposal of effluent and biosolids
- Evaluate administration, laboratory, and maintenance areas
- Identify recommended improvements to reliably treat flows through 2030
- Develop planning-level cost estimates for recommended improvements
- Prepare a Facilities Plan consistent with DEQ requirements

Work completed as part of the Facilities Plan project has been documented in technical memoranda (TMs), as presented in Appendices A through J. This report consists of a summary of the key activities and findings presented in the TMs.

2.0 STUDY AREA CHARACTERISTICS

2.1 Study Area

The City of Bend is located in Deschutes County, close to the geographic center of the State of Oregon. The City has a current population of approximately 74,000, and is the sixth-fastest-growing Metropolitan area in the United States according to Census estimates released in September 2005. The City covers an area of approximately 32 square miles, and is surrounded by high desert vegetation to the east and U.S. Forest Service land to the west. The study area for the Facilities Plan was based on the City’s current Urban Growth Boundary (UGB), as shown in Figure 2.1. The WRF sits on a 1600-acre site northeast of the City, outside of the UGB.

2.2 Physical Environment

2.2.1 Climate

The City has a typical high desert climate, with low precipitation and relatively mild temperatures. Average maximum temperatures range from 40.6° F in January to 82.1° F in August.[1] Average minimum temperatures range from 21.7° F in January to 45.6° F in August.[1] Annual temperature extremes show that only one year out of five has a temperature colder than –17° F or warmer than 100°F. Frost can occur during any summer month.

The average annual precipitation in Bend is less than 12 inches; over half falls between November and February, often as snow. Brief thunderstorms provide much of the light summer precipitation. The average annual snowfall is 33.8 inches. Snow rarely accumulates to more than a few inches in depth or lies on the ground for an extended period. Snow depth in Bend exceeds 24 inches in only one winter out of twenty.

Surface winds prevail out of the south and southeast from October to February, then west and northwest for the remaining months. Wind speeds average from 5 to 7 miles per hour most months.

2.2.2 Soils

The area around Bend is made up of a broad expanse of Pleistocene lavas and tuffaceous deposits (approximate age of 0.011 to 1.8 million years). Soils at the WRF are a Gosney-Rock outcrop-Deskamp complex. These soils consist of relatively shallow loamy sands with basalt outcroppings and are generally stable in their native state. The soil is subject to erosion from concentrated surface runoff and is susceptible to wind erosion where the soil has been disturbed.

2.2.3 Natural Hazards

Potential natural hazards within the Bend area include floods from the Deschutes River, as well as potential geological faults. Official flood hazard maps for the Bend area and Deschutes County are published by the Federal Emergency Management Agency (FEMA). The flood hazard area within Bend is within or adjacent to the banks of the Deschutes River. The WRF site is approximately six miles from the Deschutes River and well removed from any identified flooding areas. The Oregon Department of Geology and Mineral Industries has mapped some faults within the urban area. Deschutes County generally has a low to moderate seismic risk.

---

[1] Based on data collected between 1/1/1928 through 1/31/2006, as reported by the Western Regional Climate Center (www.wrcc.dri.edu).

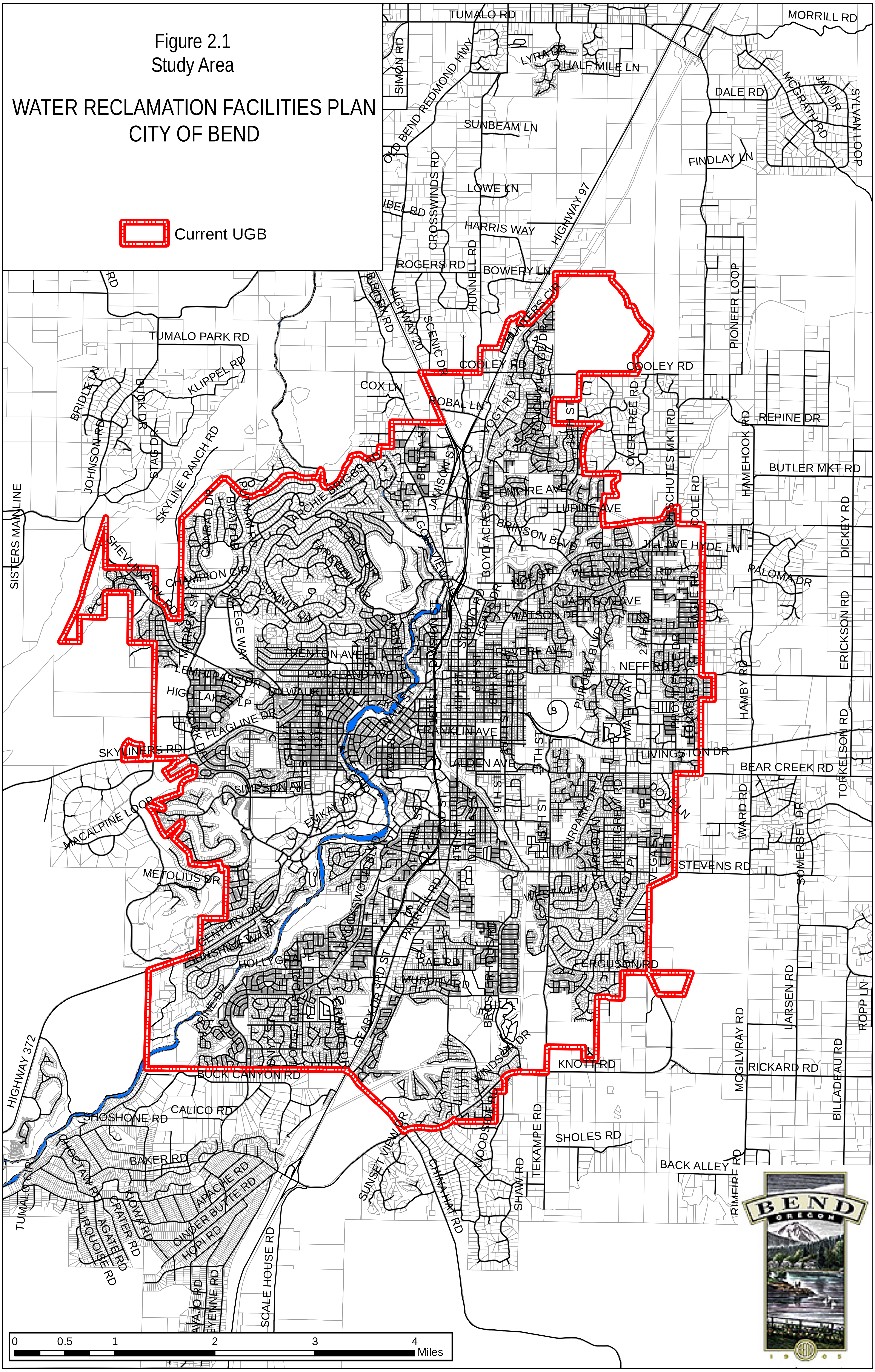


Figure 2.1
Study Area
WATER RECLAMATION FACILITIES PLAN
CITY OF BEND
Current UGB
TUMALO RD
MORRILL RD
SIMONS RD
LYRA DR
HALF MILE LN
DALE RD
MCGRATH RD
SYLVAN LOOP
OLD BEND REDMOND HWY
SUNBEAM LN
FINDLAY LN
CROSSWINDS RD
LOWE LN
HIGHWAY 97
HARRIS WAY
ROGERS RD
BOWERY LN
HUNNELL RD
PIONEER LOOP
TUMALO PARK RD
HIGHWAY 20
SCENIC DR
COOLEY RD
COX LN
KLIPPEL RD
BRIDLE LN
BUCK DR
ROBAL LN
REPINE DR
JOHNSON RD
STAG DR
SKYLINE RANCH RD
JAMISON ST
EMPIRE AVE
OVER TREE RD
DESCHUTES MKT RD
HAMEHOOK RD
BUTLER MKT RD
SISTERS MAINLINE
LUPINE AVE
BRINSON BLVD
COLE RD
DICKEY RD
BOYD ACRES RD
CHAMPION CIR
WELLS ACRES RD
PALOMA DR
COLLEGE WAY
JACKSON AVE
WATSON DR
ERICKSON RD
TRENTON AVE
REVERE AVE
NEFF RD
PORTLAND AVE
MILWAUKEE AVE
HAMBY RD
FLAGLINE DR
FRANKLIN AVE
LIVINGSTON DR
SKYLINERS RD
ALDEN AVE
BEAR CREEK RD
TORKELSON RD
SIMPSON AVE
MACALPINE LOOP
EMKAY DR
WARD RD
SOMERSET DR
STEVENS RD
METOLIUS DR
CENTURY DR
BROOKSWOOD BLVD
PARRELL RD
RAE RD
FERGUSON RD
MURPHY RD
LARSEN RD
ROPP LN
MCGILVRAY RD
RICKARD RD
KNOTT RD
BILLADEAU RD
HIGHWAY 372
BUCK CANYON RD
CALICO RD
SHOSHONE RD
BAKER RD
SHOLES RD
TEKAMPE RD
SUNSET VIEW DR
CHINA HAT RD
SHAW RD
BACK ALLEY RD
RIMFIRE RD
CHOCTAW RD
CRATER RD
KIOWA RD
APACHE RD
CINDER BUTTE RD
HOPI RD
TURQUOISE RD
AGATE RD
SCALE HOUSE RD
NAVAJO RD
CHEYENNE RD
0
0.5
1
2
3
4
Miles
BEND
OREGON

2.2.4 Public Health Hazards

There are no declared public health hazards within or adjacent to the City or the WRF. In isolated areas within the city limits, sewage disposal wells are still used. The City is working with its constituents to extend sewers to properties using disposal wells as financing and construction opportunities present themselves.

2.2.5 Energy Production and Consumption

Electricity is supplied to the Bend area by Pacific Power and Light and the Central Electric Cooperative (CEC). Electricity for the WRF is supplied by CEC. No significant electricity is generated within the Bend City limits. Cascade Natural Gas provides natural gas within the City limits. However, natural gas is not available at the WRF.

2.2.6 Water Resources

Surface water and groundwater are both extremely important water resources to the City. A portion of the City's drinking water comes from Bridge Creek, which is a tributary to Tumalo Creek and the Deschutes River. Bridge Creek has served as a source of drinking water for Bend since 1926, providing 10.6 million gallons per day (mgd) of water. The City's second drinking water source is groundwater from the Deschutes Formation Aquifer. The formation contains an extensive aquifer system that is capable of supplying high-capacity wells. The quality of groundwater is very good, and is similar to that derived from Bridge Creek.

2.2.7 Flora and Fauna

The City of Bend is located at a vegetation transition point where ponderosa pine forest changes to the arid high desert. Key wildlife areas include the riparian corridor and canyon walls along the Deschutes River, Tumalo Creek riparian and wildlife area, and deer and elk habitat west of the City. These areas support western juniper (*Juniperus occidentalis*), mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), antelope bitterbrush (*Purshia tridentata*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and Idaho fescue (*Festuca idahoensis*).[2] Wildlife species that inhabit these areas include: deer, elk, cougar, coyote, otter, beaver, mink, raccoon, osprey, red-tailed hawk, bald eagle, kingfisher, trout, whitefish, and several species of reptiles, amphibians, and waterfowl. Although there are many species that occupy these areas, the Oregon Department of Fish and Wildlife has determined that no significant wildlife habitat areas or nesting sites exist within the urban area that require special land use protection.[3]

---

[2] Information on Bend-area flora based on information provided in the *Natural Resources Conservation Service Soil Survey for the Upper Deschutes River*.
[3] Information on wildlife based on the *Bend Area General Plan*.

2.2.8 Air Quality and Noise

In Bend, the two air pollutants that are of concern and monitored on a regular basis are carbon monoxide (CO) and very small particulate matter (PM10).[4] Automobile exhaust and other incomplete combustion are typical sources of CO production. A variety of materials such as windblown dust, field and slash burning, wood stove smoke, and road cinders used for winter sanding can produce fine particles that fall into the PM10 air pollution category. Both standards have been exceeded twice since 1987. Although the few occurrences of exceeding these two air quality standards have *not* been of sufficient frequency to have Bend designated as an air quality “non-attainment area,” the forecast of significant population and economic growth for Bend and Deschutes County increases concerns about Bend’s ability to maintain compliance with the air quality standards.

The State sets forth rules and policy for regulating noise, including acceptable types and thresholds of noise. However, the State no longer enforces these rules and relies on the local governments for enforcement. Section 5.385 of the Bend Code was adopted by the City of Bend pursuant to the provisions of State statute ORS 467.100.[4] This code specifically identifies and defines different noises that are considered loud and raucous and are prohibited within the City. For other noise emissions not identified by the Bend Code, the City coordinates with the local DEQ staff and uses state statutes and regulations as a resource. The City of Bend Police Department assists in the actual enforcement of noise complaints.

2.2.9 Environmentally Sensitive Areas

The Oregon Department of Fish and Wildlife has determined that no significant wildlife habitat areas or nesting sites exist within the urban area that require special land use protection.[4] The Deschutes River is an Oregon State Scenic Waterway, both upriver and downriver of the City of Bend. State Scenic Waterway regulations require private landowners to obtain prior approval from the Oregon Parks and Recreation Commission before cutting any living tree, harvesting timber, and removing or manipulating vegetation that provides screening of structures as viewed from the river. The Deschutes River upstream of the Bend UGB is also a federal Wild and Scenic River with similar restrictions. A more detailed discussion and review of environmental issues is provided in TM No. 10, which found that there are not any significant environmental impacts associated with the recommended improvements.

2.2.10 Land Use Issues

The City of Bend has initiated the *Residential Lands Study* to assess its needs for housing and residential lands for the next 20 years. The goal is to ensure the City satisfies Oregon State planning laws with a 20-year supply of buildable land inside its UGB for needed housing. All phases of this project include numerous opportunities for public input.

---

[4] Information based on the *Bend Area General Plan*.

On June 11, 2007, the City submitted its proposed map and supporting materials for expansion of the UGB to the Oregon Department of Land Conservation and Development for review. A technical advisory committee, comprised of stakeholders from private, public, and non-profit organizations has been established to assist with the technical aspects of the expansion.

One planning consideration that needs to be noted for expansion at the WRF is the presence of the police training and hand gun shooting facility. Per Resolution No. 1951, the City recognized the need for such a facility and accepted its establishment on a potion of the effluent disposal site. It is anticipated that the training facility will remain throughout the planning period.

2.3 Socio-Economic Environment

2.3.1 Economic Conditions and Trends

The economy within the Bend area has historically focused on agriculture, horse and cattle ranching, heavy manufacturing, and resource extraction. In the 1970s, the Bend economy started to become more diverse with other manufacturing businesses, trade, medical services, and tourism providing a larger share of local jobs. Much of the recent economic growth has been in tourism.

In 2005, the City's economic profile consisted of five industrial categories: tourism; healthcare and social services; professional, scientific and technical services; wood products manufacturing; and recreation and transportation equipment. The five largest regional employers were St. Charles Medical Center, Bright Wood Corporation, Les Schwab Tire Center, Sunriver Resort, and Mt. Bachelor.

2.3.2 Current and Projected Population

Current and projected population estimates through 2030 were provided by City staff, as presented in Table 2.1. Estimates through 2016 were based on information provided by the Population Research Center (PRC) at Portland State University and average growth rates experienced by the City between 1980 and 2002. These estimates were extended through 2030 based on growth rate projections for Deschutes County provided by the Oregon Office of Economic Analysis. The current population of the City is estimated to be around 73,950 people, increasing to around 119,000 people by 2030.

According to City staff estimates, in 2005 there were 4,301 unsewered connections in the service area, representing a population of 10,322 people. In making projections of the future population to be served, it was assumed that these unsewered connections would all be connected to the sewer system over the 20-year period between 2006 and 2025, at a constant connection rate of 5% per year. This represents approximately 18% of the increase in sewered connections over the planning period.

Table 2.1	Service Area Population Projections Water Reclamation Facilities Plan City of Bend		
Year	**Projected Total Population**	**Year**	**Projected Total Population**
2007	73,948	2017	94,841
2008	76,551	2018	86,738
2009	79,245	2019	98,673
2010	81,242	2020	100,646
2011	83,135	2021	102,337
2012	85,075	2022	104,056
2013	87,054	2023	105,804
2014	89,083	2024	107,582
2015	91,158	2025	109,389
2016	92,981	2030	119,000

Note: From Collection System Master Plan (MWH) and Solids Master Plan (Vision Engineering), City of Bend, for years 2007 - 2025.

2.4 Land Use Regulations

2.4.1 County and City Comprehensive Plans

Development within the City of Bend and its UGB is governed under the *City of Bend Comprehensive Land Use Plan* and ordinances set forth in City Code 10-10. The WRF is located outside the City's UGB. Expansion and/or modification of the facility must conform to the *Deschutes County Comprehensive Land Use Plan* and its enabling ordinances that are codified in Deschutes County Code 18.

2.4.2 County Zoning Ordinance

The WRF resides on land that is zoned EFUAL (exclusive farm use - alfalfa subzone), which has associated subdivision and land use limitations. Chapter 18.16 of the Deschutes County Code establishes the outright and conditional uses that are allowed on any land that is zoned EFU. Wastewater treatment and disposal is neither an explicit outright use nor conditional use in EFU under Chapter 18.16. County officials, however, have indicated that the WRF is considered a utility, which is an explicit outright use in Chapter 18.16.

2.4.3 Intergovernmental Agreements

The City of Bend and Deschutes County have an intergovernmental agreement to provide for cooperation and coordination concerning lands within the UGB of the City of Bend. The WRF, however, is outside the UGB and land use issues associated with it are not covered by the agreement.

3.0 EXISTING WASTEWATER TREATMENT FACILITIES

3.1 Plant History

The WRF began operation in 1981. Prior to that time, the City operated a small wastewater facility east of Pilot Butte that received and treated sewage from the downtown area of Bend. Treated effluent was discharged into a lava crevice near the treatment plant site. Other areas of the City disposed of sewage individually either by a sewage drain hole or by septic tank and drain field.

Recognizing potential groundwater pollution threats of the effluent disposal practices, the Oregon State Sanitary Authority asked the Federal Water Pollution Control Administration in 1966 to investigate the "environmental hazards associated with the disposal of sewage wastes in deep lava sinkholes in the Deschutes Valley, Oregon." The investigation was completed in 1968, as documented in the report *Liquid Waste Disposal in the Lava Terrain of Central Oregon* prepared by Jack E. Sceva.

Based upon the Sceva Report, the Oregon Environmental Quality Commission determined that continued use of sewage drain holes was a threat to groundwater quality and ordered their use eliminated by 1980. Construction of any new sewage drain holes was only allowed in urban areas where a city sewage collection, treatment, and disposal system would replace them by 1980.

Construction of the new WRF and collection system began in the summer of 1978. At the time, however, an acceptable means to dispose treated effluent was still not known. The original, approved facilities plan had called for land irrigation, but upon further investigation, the site for irrigation was not suitable. Seepage ponds were later identified as an environmentally acceptable alternative as part of an Environmental Impact Statement (EIS) process.

Two ponds were installed at the WRF as part of the initial facilities construction. High seepage areas were found in both ponds, which precluded the slow seepage designed to provide final polishing of the effluent prior to reaching the groundwater. In response, one pond was repaired and two additional ponds were constructed. Since that time (circa 1983), virtually all effluent has been disposed into the two new ponds with no evidence of rapid seepage or leaks.

The original WRF was a conventional activated sludge plant with a capacity of 6 million gallons per day (MGD) based on average annual flows. Many of the original facilities are still in operation. Significant upgrades to the facilities include the addition of two new seepage ponds around 1983, construction of a new solids handling building in 1996, and upgrades to the secondary treatment process in 2000. Projects currently underway include the design of mixing improvements to the two original anaerobic digesters and construction of a new headworks facility.

3.2 Plant Design

The WRF is an activated sludge plant with a currently permitted treatment capacity of 7 mgd based on average annual flows and a hydraulic capacity of 12 mgd. The major liquid treatment processes are as follows:

- **Headworks**. The plant influent is directed to the headworks facility, which consists of a Parshall Flume, two mechanical fine screens, and an aerated grit chamber. A new headworks facility is currently under construction and will include a magnetic flow meter and band screens.
- **Primary Treatment**. Flows from the headworks facility are routed to the primary influent flow splitter box, then to two circular primary clarifiers. Primary sludge and scum are pumped to the blend/feed tank at the digester complex, as described below.
- **Secondary Treatment**. Primary effluent flows through the aeration basin distribution structure to the two aeration basins. The aeration basins were originally conventional activated sludge basins, but were converted to the Modified Ludzack Ettinger (MLE) activated sludge process around 2000 to improve nitrogen removal. The effluent from the aeration basins flows to three circular secondary clarifiers. Two of the secondary clarifiers were part of the original plant construction, and the third was added around 2000 to expand capacity. The waste activated sludge (WAS) from the clarifiers is pumped to the gravity belt thickeners, as described below.
- **Disinfection**. Gaseous chlorine is added to the secondary effluent, and disinfection is achieved through two parallel serpentine basins. The disinfection facilities were part of the original WRF.
- **Tertiary Filtration**. A portion of the disinfected effluent is treated with cloth disk filters, which treat the water to Oregon Level IV reclaimed water standards. The effluent from the filters is conveyed directly to reclaimed water users.
- **Disposal**. Disposal of the remaining disinfected effluent is accomplished using two seepage ponds that were added to the WRF around 1983. The two original ponds are still in place, but are not currently in active service. A detailed analysis on the current effluent disposal system is provided in Appendix C.

The major solids treatment processes are as follows:

- **Gravity Belt Thickener (GBT)**. The GBT thickens WAS from the secondary clarifiers. Filtrate and wash water from the GBT are returned upstream of primary clarification. The thickened sludge is conveyed to the anaerobic digesters. The original facilities included a dissolved air flotation thickener (DAFT) for WAS thickening; these facilities were replaced with the GBT in 1996 due to capacity limitations and operations challenges associated with the DAFT.
- **Anaerobic Digestion**. Thickened WAS from the GBT and sludge from the primary clarifiers are conveyed to a series of three circular anaerobic digesters. Solids first go to Digester 3, which was added in 1999. Sludge then flows through the two original, smaller digesters in series operation. All digesters are heated; however, the two original digesters perform poorly due to poor mixing. Mixing improvements to the two original digesters are currently under design.
- **Belt Filter Press**. Sludge from the anaerobic digesters is dewatered in the belt filter press. Filtrate and wash water are returned upstream of primary clarification. Originally, drying beds were used for sludge drying. In 1996, a centrifuge dewatering unit was added as part of the solids handling building project. The centrifuge was replaced with a more-reliable belt filter press around 2004. The centrifuge remains operational and is available as a backup. The drying beds continue to be used for further drying and storage of solids.
- **Drying Beds**. The drying beds are used to store and further dry dewatered solids from the belt filter press. There is no return of supernatant from the beds. The dried solids are periodically removed and applied to agricultural fields in the area.

3.3 Plant Operations

The WRF operations staff consists of a WRF manager, plant supervisor, senior operator, five operators, four maintenance staff, and one utility staff. The water quality laboratory is staffed by a laboratory manager and three laboratory technicians. Operations staff members respond to all alarms on a 24/7 basis for the WRF. Safety of staff and the public is the staff’s highest priority. The second highest priority is maintaining WRF operations within NPDES permit parameters. All WRF operations are monitored and controlled by a central supervisory control and data acquisition (SCADA) system, which is accessed via the control room in the operations building.

Administration and operations (non-process) facilities consist of operations, training, and maintenance buildings. The operations building was constructed in 1977 as part of the original WRF and houses a reception area, the WRF plant manager’s office, locker rooms, the control room/break room, and the water quality laboratory. Additional administrative space is available in the training building, which was constructed in 2001. Maintenance facilities include a maintenance building currently used for both maintenance and office space.

Additional maintenance areas are available in a pole barn and a pre-fabricated metal building. Improvements to these facilities were considered as part of the Facilities Plan.

3.4 Unit Process Performance and Deficiencies

A summary of unit process performance and deficiencies is provided in Table 3.1. The capacities listed in Table 3.1 are based upon the current requirement to nitrify, and are lower than the previous non-nitrifying (permitted) plant capacity rating of 7 mgd. All treatment processes are generally performing well and meeting performance criteria. The main exceptions are the two original anaerobic digesters and the headworks facility, both of which are planned for upgrades in 2007-2008.

A number of processes do not meet the projected capacity requirements through 2030. These processes include all of the facilities except for the gravity belt thickener and effluent filters. In addition, the hydraulic capacity of the WRF is not sufficient to meet projected peak wet weather flows. Expansions of all processes with insufficient capacities to meet future flows were evaluated in the Facilities Plan, as discussed below.

3.5 Facility Site Evaluation

An evaluation of the condition of the existing facilities was conducted to determine the remaining useful life of major assets, as detailed in Appendix B. The purpose of the evaluation was to provide the City with information to support the identification and timing of renewal and replacement (R&R) projects. The facility site evaluation does not include a prioritization of the 294 assets reviewed, nor estimated costs to replace items in poor condition. However, a general replacement schedule is given in Appendix B.

3.5.1 Condition Assessment

The WRF assets were evaluated by a multi-discipline engineering team licensed and experienced in the areas of process, mechanical, structural, and electrical engineering. By visual inspection and interviews with operations and maintenance (O&M) personnel, the assessment team determined existing conditions for each facility. Facilities were ranked according to an internationally accepted, industry-wide standard for designating asset condition, as presented in Table 3.2.

A number of assets were identified to be in poor condition (Condition Level 4 or 5), requiring rehabilitation or replacement. The identified assets are summarized in Table 3.3. In addition, a large number of assets associated with the dissolved air flotation thickener were identified to be in poor condition. These items are not listed here, as continued use of this facility is not anticipated.

Table 3.1 Summary of Existing Treatment Processes
Water Reclamation Facilities Plan
City of Bend

Process	Process Type	Number of Units	Size	Nominal[1] Capacity	Performance
Liquids Processes					
Headworks	Magnetic flow meter Band screen	1 3	N/A 6 mm grid size	N/A 30 mgd[2]	• These are new facilities planned for construction in 2007-08 • Performance is anticipated to be good
Primary Clarification	Circular	2	65 ft (diameter) x 9 ft (side water depth)	6.2 mgd	• Performance is good • Average BOD removal - 39 percent • Average TSS removal - 75 percent
Aeration Basins	Modified Ludzack Ettinger with fine bubble diffusers	3	210 ft (length) x 44 ft (width) x 15 ft (depth) 3.15 MG total volume (1.08 MG anoxic; 2.07 MG aerobic)	6.0 mgd	• Performance is good • Average BOD removal - 39 percent • Average TSS removal - 75 percent
Secondary Clarification	Circular	3	80 ft (diameter) Side water depth - 2 units @ 12 ft and 1 unit @ 14 ft Total surface area - 15,080 sf	6.0 mgd	• Performance is good
Disinfection (Chlorination)	Serpentine basins	2	20 ft (length) x 15 ft (width) x 8.5 ft (side water depth) Volume per basin - 114,000 gallons	5.5 mgd[3]	• Performance is good • Average effluent fecal coliform concentration - 14.2 MPN/100mL (0.5 MPN/100 mL when treated for Level IV reclamation)

[1] ADMM, Unless otherwise indicated
[2] Peak Flow with one unit out of service
[3] Average flow with one unit out of service

Table 3.1 Summary of Existing Treatment Processes, continued
Water Reclamation Facilities Plan
City of Bend

Process	Process Type	Number of Units	Size	Nominal Capacity	Performance
Tertiary Filters	Cloth disk	2 units (12 disks per unit)	Total disk area - 1,290 sf (24 units @ 53.8 sf)	Average - 6 mgd (2 units @ 3 mgd) Peak - 10 mgd (2 units @ 5 mgd)	• Performance is good
Solids Processes					
WAS Thickening	Gravity belt thickener	1	Belt width of 1 m	11 mgd	• Performance is good • Thickened solids concentration 5 to 9 percent
Anaerobic digestion	Circular	3	Units 1 & 2 - 52 ft (diameter) x 28 ft (side water depth) 55 kcf each (volume) Unit 3 - 52 ft (diameter) x 52 ft (side water depth) 110 kcf (volume)	10 mgd (assuming installation of gravity thickeners)	• Performance of Digester 3 is good. • Planned mixing improvements will improve performance of Units 1 and 2.
Solids Dewatering	Belt filter press	1	2 meter (width)	8 mgd	• Performance is adequate; improvement expected • Dewatered solids concentration - 14 to 16 percent

Table 3.2	Asset Condition Ranking Scale [1] Water Reclamation Facilities Plan City of Bend	
Ranking	**Description**	**Percentage of Asset Requiring Repair[2]**
0	Non-Existent	N/A
1	Very Good Condition	0%
2	Minor Defects	5%
3	Maintenance Required to Return to Accepted Level of Service	10-20%
4	Requires Rehabilitation	20-40%
5	Asset Unserviceable	>50%

Notes:
1. Adapted from the International Infrastructure Management Manual.
2. "Percentage of asset requiring repair" is that percentage of the value of the asset needed to return the asset to a condition ranking of one.

Table 3.3	Assets in Poor Condition Water Reclamation Facilities Plan City of Bend	
Process	**Asset**	**Condition**
Headworks	Lime Feeder	5
	Electrical Room	5
	MCC-H	4
Septage Receiving	Rotary Screw Air Compressor	5
	Mini Power Center	5
	Septage Influent Submersible Pumps Nos. 1, 2, & 3	4
	Septage Pump Control Panel	4
Primary Clarification	Rake Arms Nos. 1 & 2 / Interior Mechanisms	4
	Primary Sludge Pumps Nos. 1 & 2	4
	External Lighting, Conduit, and Control Stations	4
	MCC-PSP	4
	DRC Controller Panels	4
	Sample Pump Panel	4
	Internal Conduit and Lighting	4
Aeration	Blowers Nos.1, 2, & 3	4 - 5
	Mixed Liquor Pumps Nos.1, 2, & 3	4
Secondary Clarification	RAS Sump Pumps Nos.1 & 2	5
RAS/WAS Building	RAS/WAS Indicator Panels	5
	RAS Pump VFDs	4
	MCC-RAS	4

Table 3.3	Assets in Poor Condition, continued Water Reclamation Facilities Plan City of Bend	
Process	**Asset**	**Condition**
Blower Building	Lighting, HVAC	5
	Switchboard B	4
	MCC-B	4
Disinfection	External Stations at CCBs	5
Digestion	Sediment Traps Nos.1 & 2	5
	HVAC Gas Master (Digester 3)	5
	Boilers Nos.1 & 2	4
	Digester No. 3 Feed Pump	4
	Boiler Conduit	4
	Boiler Instrumentation and Controls	4
Percolation Ponds	Percolation Pond No. 1	4
Degas	Motor Starters and Controls	4
Plant Water	Plant Water Pumps Nos. 1, 2, & 3	5
	Chlorine Residual Analyzer Pump and Panel	5
	Lighting, HVAC	5
	MCC-PW	5
	PLC Panel	4
Drinking Water	Deep Well Submersible Pump	4

3.5.2 Remaining Useful Life

The remaining useful life (RUL) of each asset was determined using three approaches, as described in Appendix B. The recommended approach for renewal and replacement (R&R) project timing is to use the economic remaining useful life methodology.

Further recommendations from the Facility Site Evaluation can be found in Appendix B, including a detailed discussion of the potential code impacts (also addressed in Section 5.1.1.2 of this report).

3.6 EXISTING EFFLUENT WATER QUALITY

An evaluation of current impacts of WRF effluent on the receiving groundwater can be found in Appendix C. The report discusses data found from several monitoring wells near the seepage ponds and compares values to federal drinking water standards and maximum contaminant levels (MCLs). The evaluation focuses on two major constituent categories: nitrogen (based on nitrate-nitrogen [N]) and metals.

3.6.1.1 Nitrate-Nitrogen

Using plant record data, the monthly averages of WRF effluent concentration for total nitrogen (including all forms of nitrogen) in 2005 are all less than or equal to the MCL for nitrate-N of 10 mg/L. The 2005 annual average effluent total nitrogen concentration was 6.85 mg/L. Based on monitoring data in the wells, nitrate-nitrogen levels in the groundwater down-gradient of the ponds has remained below 1.0 mg/L.

3.6.1.2 Metals

Metals data were evaluated for both the WRF effluent and the four groundwater wells. Effluent metals concentrations are summarized in Appendix C and are based on 12 effluent samples collected during four sampling periods in 2006. In general, most metals concentrations were below the method detection limit (MDL). The maximum detected concentrations of all metals were well below their respective MCLs.

Metals concentrations from the monitoring wells are also shown in Appendix C. All down-gradient metals concentrations were also far below their respective MCLs. Metals concentrations in the up-gradient wells were inconsistent in some cases, indicating that these two wells may not be suitable for long-term monitoring of up-gradient water quality.

Based on results of nitrate-nitrogen and metals concentrations, the evaluation concludes that the seepage ponds are not currently adversely impacting the groundwater in terms of the potential use as a domestic water supply. However, the report recommends additional sampling to confirm these conclusions.

4.0 WASTEWATER FLOWS AND LOADINGS

4.1 Wastewater Flows

This chapter summarizes the current and projected wastewater flows and loads at the WRF, based on existing and calculated projection data. Additional information is provided in Appendix A.

In evaluating influent flow, Carollo reviewed historic daily and weekly plant monitoring data from January 2000 to July 2006. Data prior to 2004 were examined, but not used since flows and loads to the plant increased at a significant and rapid rate making correlation between flows, loads, and population uncertain. Since the end of 2004, flows and loads to the WRF have been more stable.

In 2005, the WRF treated an annual average of 5.0 MGD, or approximately 5,600 acre-feet per year (AFY) of water. Of this volume, 260 AFY were used by a nearby golf course for irrigation water and the remainder was disposed of in the seepage pond system.

4.1.1 Dry Weather Flow, Wet Weather Flow, Infiltration and Inflow

The Bend area does not experience distinct wet and dry seasons. As such, historical influent flow data at the WRF do not reflect strong seasonal variation, as shown in Figure 4.1.

Infiltration due to groundwater is not a normal factor in Bend due to the normally deep groundwater elevations. Inflow at manholes has occurred during extreme precipitation events in the past, but there is no time of year when this is widespread and predictable. Normally, when such inflow occurs it is a localized phenomenon with little or no impact on the WRF. However, in December 2005 a large rain event inundated the storm and sewer systems and overwhelmed the WRF beyond metering capacity.

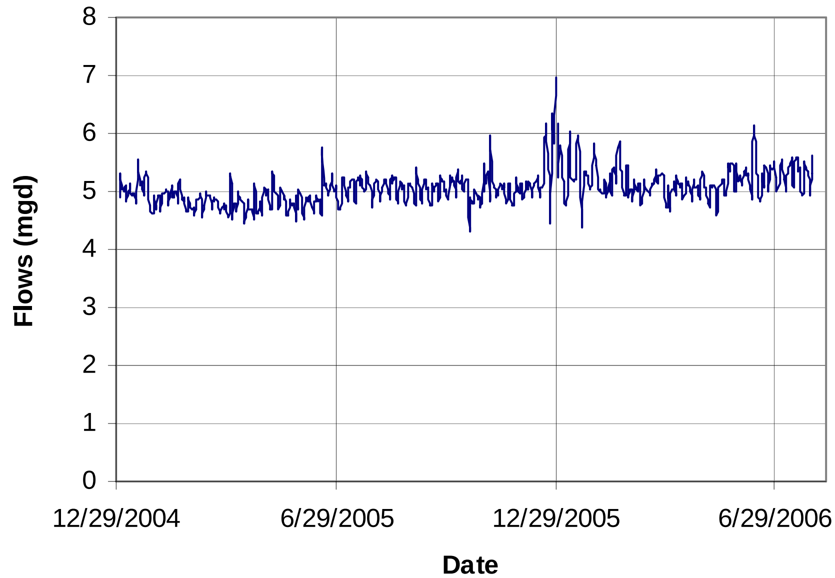


Figure 4.1 Influent Flows to the WRF - January 2005 through July 2006

4.1.2 Summary of Existing Flows

Using historical data of existing flows from the past three years, a table of current flows from average daily flows to peak wet weather flows was developed. The data is summarized in Table 4.1.

Table 4.1 Summary of Current Flows
Water Reclamation Facilities Plan
City of Bend

Parameter	Flows (mgd)
Average Daily Average Flow (AAF)	5.9
Average Daily Max Month Flow (ADMMF)	6.5
Peak Day Flow (PDF)	7.4
Peak Dry Weather Flow (PDWF)	11.6
Peak Wet Weather Flow (PWWF)	16.0

4.1.3 Projected Wastewater Flows

Flow projections are based on population projections and per capita flow, with ratios to account for commercial and industrial contributions. Because precipitation in the Bend area has little impact on sewage flows, flow projections in this report do not incorporate probability analyses of peak flows, as described in the DEQ flow-projection guidelines. The average annual projected flows for 2010 through 2030 are shown in Table 4.2.

Future additional wastewater flows will come from expansion of the City, as well as incorporation of unsewered areas. Projections assume that all areas within the UGB will be served by the WRF by the year 2025. For 2030, it is anticipated that the WRF will have annual average flows of 10.9 MGD or 12,210 AFY. It is assumed that the golf course will continue to use 260 AFY, with the remainder to be disposed of in the seepage pond system. This represents additional flows of 6,610 AFY.

Table 4.2 Average Annual Flow Projections, mgd
Water Reclamation Facilities Plan
City of Bend

Year	Residential	Commercial & Industrial	Total
2010	5.1	1.7	6.7
2020	6.7	2.2	9.0
2030	8.2	2.7	10.9

4.2 Wastewater Composition

4.2.1 Analysis of Plant Records

The WRF records from January 2000 to July 2006 provided an extensive record of the quantity and quality of wastewater treated and released. Combined with population data and industrial flow information, per capita flow and load contributions were determined for projected flows and loads.

4.2.2 Wastewater Composition

Table 4.3 presents a summary of the current plant influent flows and loadings, based on an analysis of data over the period of 2005-2006. The exceptions are the influent BOD and TSS concentrations, which were based on sampling results after April 2006 when the sampling location was changed to avoid sampling of plant recycle flows.

Table 4.3 Summary of Current Loads Water Reclamation Facilities Plan City of Bend		
	Units	
Average Influent Concentrations @ AAF		
BOD_5	mg/L	350
TSS	mg/L	344
TKN3	mg/L	49
Ammonia-N3	mg/L	22
Organic-N3	mg/L	27
Alkalinity	mg/L	260
Max Month Peaking Factors		
BOD_5	--	1.22
TSS	--	1.36
Ammonia-N	--	1.25
TKN	--	1.30
Org-N	--	1.30
Influent Loadings @ ADMMF		
BOD_5	ppd	18,030
TSS	ppd	19,760
Ammonia-N	ppd	1,690
TKN	ppd	2,690
Org-N	ppd	1,480

4.3 Projected Wastewater Flows and Loadings

Wastewater flows and loadings were projected through the year 2030, based upon the observed flows and loading, current population, and projected growth. A summary of flows and loadings is presented in Table 4.4.

Table 4.4 Flow and Waste Load Projections Summary
Water Reclamation Facilities Plan
City of Bend

Parameter	Year 2010	2020	2030
Influent Flows, mgd			
AAF	6.7	9.0	10.9
ADMMF	7.3	9.8	11.9
PDF	8.4	11.2	13.6
PDWF	13.1	17.6	21.4
PWWF	17.9	24.0	29.1
BOD, pounds/day			
Annual Average	19,700	26,200	31,800
Average Day Maximum Month	24,000	32,000	38,800
TSS, pounds/day			
Annual Average	19,300	25,800	31,300
Average Day Maximum Month	26,200	35,100	42,600
TKN, pounds/day			
Annual Average	2,800	3,700	4,500
Average Day Maximum Month	3,600	4,800	5,900
NH_3-N, pounds/day			
Annual Average	1,800	2,400	2,900
Average Day Maximum Month	2,300	3,000	3,600

5.0 BASIS OF PLANNING

5.1 Basis for Design

5.1.1 Regulatory Requirements

5.1.1.1 Oregon Department of Environmental Quality

The Bend WRF discharges are regulated under the terms of a Water Pollution Control Facility (WPCF) permit issued by the DEQ. The current permit, No. 101572, is dated October 2005, and has an expiration date of September 2010. The permit describes conditions for four “outfalls”:

1) Outfall 001: Evaporation/seepage ponds
2) Outfall 002: Land Irrigation Level II
3) Outfall 003: Land Irrigation Level III
4) Outfall 004: Land Irrigation Level IV

The term outfall is used to describe each final discharge point. Outfalls 002, 003, and 004 describe use of treated effluent as reclaimed water treated to different levels according to Oregon Administrative Rule (OAR) requirements. In practice, only Level IV reclaimed water (the highest quality) is produced at the WRF. Table 5.1 summarizes the permit conditions.

Table 5.1	**Discharge Permit Conditions Water Reclamation Facilities Plan City of Bend**				
	Average Effluent Concentrations		**Monthly[1] Average**	**Weekly[1] Average**	**Daily[1] Maximum**
Parameter	Monthly	Weekly	Lb/day	Lb/day	Lbs
BOD_5	20 mg/L	30 mg/L	1,150	1,700	2,300
TSS	20 mg/L	30 mg/L	1,150	1,700	2,300
FC/100 ml[(2)]	200	400			
Other Parameters:					
Total Nitrogen	Annual monthly average of 10 mg/L				
pH	Shall be within range of 5.5 to 9.0				

Notes:
1. Based on average dry weather design flow of 7.0 mgd
2. FC = Fecal coliform

In addition to the general effluent parameters, Level IV reclaimed water must meet the following additional standards:

"(1) 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.

(2) Turbidity shall not exceed a 24-hour mean of 2 NTU, and shall not exceed 5 NTU for more than 5 percent of the time during a 24-hour period."

DEQ also has two major regulatory issues within its groundwater quality protection rules that need to be addressed in a permit modification application. These two requirements, found in OAR 340-040-0020 and 340-040-0030, can be categorized respectively as (1) anti-degradation, and (2) protection of the beneficial uses of groundwater. These requirements are summarized below:

- **Anti-degradation**. The rule stipulates that point sources shall employ the highest and best practicable methods to prevent the movement of pollutants to groundwater. Among other factors, available technologies for treatment and waste reduction, cost effectiveness, site characteristics, pollutant toxicity and persistence, and state and federal regulations shall be considered in arriving at a case-by-case determination of highest and best practicable methods that protect public health and the environment.
- **Protection of the Beneficial Uses of Groundwater**. The rule stipulates that all ground waters of the state shall be protected from pollution that could impair existing or potential beneficial uses. The rule identifies domestic water supply as the use that would usually require the highest level of water quality.

The current permit does not include a groundwater quality protection program, based on DEQ's determination that the current treatment and disposal method does not have the potential to adversely affect groundwater quality. This assertion was limited to an evaluation of the impact of nitrate-nitrogen in the groundwater.

5.1.1.2 International Building Code & National Fire Protection Association

The City's future renewal and replacement (R&R) projects may be impacted by recent code revisions. Certain code requirements may dictate that an asset be renewed or replaced earlier than would be expected based solely on its condition. To address this issue, potential impacts of the International Building Code (IBC) 2003, and the two applicable National Fire Protection Association (NFPA) codes governing electrical installations at wastewater processing facilities - NFPA 820 (*Standard for Fire Protection in Wastewater Treatment and Collection Facilities)* and NFPA 70 (*National Electric Code*) were reviewed in detail as shown in Appendix B.

- **International Building Code:** The recent IBC code changes could result in the need to construct new facilities with increased reinforcing steel and thicker walls and slabs than the existing structures. Additionally, construction costs for special inspection will likely increase due to code changes, as more items require special inspection.
- **NFPA 70 National Electric Code (NEC):** When reviewing existing design documents, no violations of the current code were found in existing equipment. A more complete inspection of the facility would be required to ensure current NEC code compliance. Each system should be individually inspected and evaluated for adverse effects due to aging.
- **NFPA 820 Fire Protection in Wastewater Treatment:** The requirements of the NFPA 820 standard will have the greatest impact, both in cost and in effort, in areas that are exposed to raw wastewater. The Bend WRF is currently in the process of replacing the existing headworks (built in 1980) with a new facility. The new headworks will be subject to all requirements of NFPA 820. In general, facilities designed before the issuance of the first NFPA 820 do not meet all parts of the standard, and a review of these facilities will be necessary as part of an upgrade project.

5.1.2 Effluent Quality

The analyses in this report are based on meeting the effluent discharge permit conditions. Appendix C includes a detailed analysis and discussion of potential groundwater impacts from the plant discharge, now and at projected future conditions. The effluent quality analysis found that the current discharge limit of 10 mg/L TN is protective of groundwater quality. As such, the recommended improvements identified in this report are based on continuing to meet the current requirements. However, the evaluation includes a review of technologies for achieving effluent total nitrogen (TN) levels of 10, 6, and 3 mg/L, and recommends improvements if regulatory requirements change during the planning period.

5.1.3 Plant Reliability Criteria

The EPA has defined three levels of system reliability in the document *Design Criteria for Mechanical, Electrical, and Fluid System and Component Reliability*. The levels are primarily based on the nature of the receiving water body. The Bend WRF's system of discharge does not clearly fit into any one of the classification schemes, but most likely would be considered a Class II facility as described below:

- Reliability Class I: Works which discharge into navigable waters that could be permanently or unacceptably damaged by effluent, which was degraded in quality for only a few hours.
- Reliability Class II: Works which discharge into waterways that would not be permanently or unacceptably damaged by short-term effluent quality degradation, but could be damaged by continued (on the order of several days) effluent quality degradation.

Table 5.2 presents a summary of the relevant criteria for the liquid processes for both classes. The only difference between the Class I and Class II requirements is the capacity required for the secondary clarifiers with one unit out of service. The Class I requirements include a minimum of four secondary clarifiers, such that when one is out of service the three remaining will be able to provide 75% of design capacity. The Class II requirements are for a minimum of two secondary clarifiers. Currently the plant has three secondary clarifiers; therefore, any expansion of the secondary clarification facilities will meet the more stringent Class I requirements as defined by the EPA. At a minimum, all other facilities will meet the EPA reliability requirements for Class I. Additional redundancy requirements are evaluated for each process to insure that permit limits can be met when a unit is removed from service due to failure and/or scheduled maintenance.

Table 5.2 Component Reliability Standards for Class I
Water Reclamation Facilities Plan
City of Bend

Component	Backup Feature Description
Bar screen	Backup screen required for peak flow.
Primary clarifiers	Multiple basins; with largest unit out of service, remaining basins have capacity for at least 50% design flow.
Aeration basins	Minimum of two of equal volume; no backup required.
Aeration blowers	Multiple units; with largest unit out of service remaining units have at capacity for at least 75% design flow.
Air diffusers	Multiple sections; with largest section out of service oxygen transfer capability not measurably impaired.

Table 5.2	Component Reliability Standards for Class I Water Reclamation Facilities Plan City of Bend
Secondary clarifiers	Multiple basins; with largest unit out of service, remaining basins have capacity for at least 75% design flow.
Filters	Multiple basins; with largest unit out of service, remaining basins have capacity for at least 75% design flow.
Chlorine contact basins	Multiple basins; with largest unit out of service, remaining basins have capacity for at least 75% design flow.
Anaerobic digesters	Minimum of two tanks.
Sludge pumping	Sufficient capacity to handle peak flow with one out of service. Backup may be uninstalled.

5.1.4 Unit Design Considerations

Unit process design criteria are based on industry-accepted standards and validated by process models, as described in later sections.

5.2 Basis for Cost Estimates

Estimates of the project and O&M costs associated with the preferred treatment alternatives were prepared and used during the evaluation process. All cost estimates prepared as part of the Facilities Plan are order-of-magnitude estimates, as defined by the American Association of Cost Engineers (AACE). An order of magnitude estimate is one that is made without detailed engineering data, and uses techniques such as cost curves and scaling factors from similar projects. The overall expected level of accuracy of the cost estimates presented is +50 percent to -30 percent. This is consistent with the guidelines established by the AACE for planning level studies.[1]

5.2.1 Project Costs

The project costs presented in this Facilities Plan include estimated construction dollars, contingencies, permitting, and all legal, administration, and engineering fees. Construction costs are based on preliminary layouts for treatment alternatives, and suggested unit process sizes. The costs have been estimated based on information from cost estimating guides, budgetary estimates provided by equipment manufacturers, and experience gained while designing similar facilities.

While the estimated construction costs prepared at the planning level are intended to represent average bidding conditions for projects that are similar in nature, variations in the bidding environment at the time of project implementation will likely affect actual construction costs. The alternatives presented herein will also likely be refined during the preliminary and final design phases, affecting overall project costs.

[1] *Recommended Practices and Standards*, American Association of Cost Engineers, 2000.

Although estimated costs have been adjusted to account for unknown conditions at this time, they are reflective of planning level efforts and are not likely to be as accurate as costs developed during final design. For these reasons, construction costs may be lower or higher than are estimated in this plan.

Costs for constructing municipal wastewater treatment projects have increased at a very rapid rate over the last few years, a trend that is projected to continue. The highly volatile market makes estimating current costs difficult, and cost estimates for future projects are even more uncertain. These escalation rates exceed the overall inflation rate, and therefore special considerations were made in developing the present worth estimates. The estimated compounded annual escalation rates, as shown in Table 5.3, were used for various construction dates through the planning period:

Table 5.3 Estimated Construction Cost Escalation Rates
Water Reclamation Facilities Plan
City of Bend

Construction Year	Compound Escalation Rate
2009	9.0%
2010	8.0%
2011	7.8%
2012	7.5%
2013	7.5%
2014	7.3%
2015	7.0%
2016	6.8%
2017	6.5%
2018	6.5%
2019	6.3%
2020	6.0%
2021	5.5%
2022	5.5%
2023	5.0%
2024	5.0%
2025	4.5%
2030	4.0%

5.2.2 Allied Project Costs

Preliminary cost estimates prepared during the planning effort include the costs to construct the improvements as well as a number of additional factors, including an allowance for the contractor's overhead and profit and mobilization/demobilization costs. Other factors used are:

- Contingency: 35 percent
- Electrical, instrumentation, and control: 35 percent

- Engineering, legal, and administrative: 25 percent

5.2.3 Operation and Maintenance Costs

O&M costs are based on estimated manpower needs, resource requirements (power and chemicals), and equipment replacement and maintenance costs. For certain analyses, the O&M costs were considered to be equivalent for the alternatives, so they were left out of the calculations. Where they were included, O&M costs were estimated by projecting existing costs into the future and modifying those costs to reflect process changes. They were calculated based on labor rates and power costs as follows:

- Labor rate: $47 per man-hour (includes fringes & administrative overhead)
- Power cost: $0.08 per kilowatt-hour

5.2.4 Net Present Worth Methodology

Economic evaluations of the alternatives presented in this plan are based on comparison of their estimated net present worth (NPW). An alternative's NPW is an estimate of the dollar value that would need to be invested in year zero, given an appropriate interest rate, in order to finance all capital and O&M costs that will be incurred over the planning period. Although all of the alternatives are assumed to have the same useful life over the planning period, each will have different capital and O&M cost requirements. Determination of the NPW is a way to compare alternativess on an equivalent basis.

Given estimates of project and O&M costs, the associated NPW is calculated by the equation:

$$NPW = PW_p + PW_{O\&M}$$

Where: PW_p = present worth of capital costs, including all initial and phased construction.

$PW_{O\&M}$ = present worth of O&M costs incurred over the planning period

The factors used are:

- Planning period: 23 years (2007 to 2030)
- Interest rate (bond cost): 6.0 percent
- General inflation: 3.0 percent

Other factors that can affect NPW economic analyses include equipment depreciation and replacement costs. These factors were not considered planning-level economic analyses.

5.3 Water Quality Impact

As described above, the Bend WRF discharges primarily to seepage ponds that allow percolation into an aquifer. A full evaluation of the impact of the WRF effluent on the receiving groundwater can be found in Appendix C.

Monitoring data from wells near the seepage ponds have been used to track groundwater quality up-gradient and down-gradient of the ponds for the last 25 years. The data shows that groundwater up-gradient of the ponds has low metals concentrations (generally below 1.0 mg/L), and low nitrate-nitrogen concentrations (generally below 0.8 mg/L).

5.4 Design Capacity of Wastewater Treatment Plant

5.4.1 Wastewater Treatment Plant Facilities

The treatment facilities will be designed to accommodate all flows and loadings as listed in Section 4 above.

5.4.2 Effluent Disposal

Effluent may be applied either to the evaporation/percolation pond system, or as reclaimed water. The existing effluent disposal capacity is described below and is further discussed in Appendix C. Four seepage ponds exist at the facility: Ponds 1, 2, 3A and 3B. Conservative calculations for Ponds 1 and 2 (which are currently not in service) yielded a capacity of 27.5 acre-feet per year (AFY) per acre of pond. The seepage rates for Ponds 3A and 3B were estimated to be 81 AFY per acre of pond.

A summary of the pond capacities is given in Table 5.4. Including the capacity from Ponds 1 and 2 in the overall effluent capacity calculation requires upgrading the ponds to a usable condition.

Table 5.4	Seepage Pond System Capacity Water Reclamation Facilities Plan City of Bend				
Pond	**Seepage Rate (AFY per acre)**	**Area Currently Inundated (Acres)**	**Current Infiltration (AFY) [1]**	**Available Area (Acres)**	**Pond Capacity (AFY) [1]**
1 [2]	27.5	0	0	77	2,117
2 [2]	27.5	0	0	87	2,392
3A	81	~30	2,430	49	3,969
3B	81	~30	2,430	44	3,564
Total		**60**	**4,860**	**257**	**12,042**

Notes:

1. Seepage Rates for Ponds 1 and 2 were assumed based on past studies and will need monitoring to confirm the rate.
2. Ponds 1 and 2 require upgrades to address areas of rapid leakage prior to being returned to regular operation.

5.4.3 Reclaimed Water Facilities

The City aims to maximize the use of reclaimed water through all feasible means. Currently, the City has a contract to supply water on an intermittent basis to a local golf course. The City intends to pursue other opportunities for reclaimed water use as they arise. This report does not include evaluation of these opportunities. The current filtration and disinfection facilities provide sufficient capacity to satisfy current commitments, and have reserve capacity for potential expansion of service. Therefore, expansion of those facilities is not included in this report. If future opportunities call for expansion of the capacity to produce reclaimed water, a supplement to this Facilities Plan will be produced (as appropriate).

6.0 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

6.1 Wastewater Treatment Plant Liquid Stream Treatment Alternatives

An evaluation of the alternatives for increasing the process capacity of the WRF addressed preliminary, primary, secondary, and tertiary processes. These evaluations of conventional activated sludge facilities were then compared with membrane bioreactor alternatives. A full summary of the liquids process assessment and MBR alternatives in included in Appendices D and E, respectively.

6.1.1 Preliminary Treatment

6.1.1.1 Background and Design Criteria

Table 6.1 presents the sizing of the headworks, which are currently under construction. The new headworks will include three 6 mm perforated plate band screens rated at 15 mgd each. The facility can also accommodate one additional screen. The channels have been sized such that the 6 mm screens could be replaced with 3 mm screens in future process expansion, including membrane bioreactors (MBRs) or tertiary membranes. In this case, the 3 mm fine screens would be rated at 10 mgd each.

**Table 6.1 Existing Preliminary Treatment Facilities
Water Reclamation Facilities Plan
City of Bend**

Parameter	Unit	Value
Type Screens	-	Perforated Plate Band Screens
Number of Units	-	3
Width	ft	4’8”
Opening	mm	6
Peak Capacity, each	mgd	15

Based on the reliability and redundancy requirements outlined in Section 5.1.3, the capacity should be based on one unit out of service during a peak flow event or with a manually cleaned bar screen.

The Solids Master Plan recommended that grit removal not be included in the new headworks for several reasons, as outlined in Appendix D. Provisions have been made in the design of the new headworks for the addition of grit removal in the future, if necessary.

6.1.1.2 Existing Capacity

The firm capacity of the new headworks with one screen out of service is 30 mgd, which is adequate for the 2030 capacity requirement of 29.1 mgd. The headworks includes a channel to install one future screen, which will increase firm capacity to 45 mgd.

6.1.1.3 Recommended Upgrades

Based on existing capacity, there is no need for additional screens until after 2030. If MBRs or tertiary membranes are included in the future expansion, the existing screens will need to be replaced with 3 mm fine screens to provide adequate protection of the membranes. The estimated capacity of each 3 mm screen is 10 mgd; therefore, four screens would meet firm capacity requirements (30 mgd) with one unit out of service.

6.1.2 Primary Treatment

6.1.2.1 Background and Design Criteria

The sizing of the existing primary clarifiers is presented in Table 6.2.

**Table 6.2 Existing Primary Clarifier Size
Water Reclamation Facilities Plan
City of Bend**

Parameter	Unit	Value
Type of clarifier	-	Circular
Number of Units	-	2
Diameter	ft	65
Side water depth	ft	9
Average BOD removal	%	39
Average TSS removal	%	75

The purpose of the primary clarifiers is to reduce loading on the secondary process. Primary clarifier performance was reviewed to establish design criteria for surface overflow rates (SORs). During that period, the SORs did not vary significantly and averaged approximately 750 gpd/sf with an average BOD removal of 38% and an average TSS removal of 75%. A primary clarification model was developed to estimate clarifier performance at higher overflow rates and to determine the effects on the secondary process performance. A hydraulic model was also developed to determine the capacity of the primary clarifiers under peak wet weather events.

**Table 6.3 Primary Clarifier Design Criteria
Water Reclamation Facilities Plan
City of Bend**

Condition	SOR (gpd/sf)	Notes
ADMMF	1000	All units in service
ADMMF	1500	One unit out of service
PWWF	3100	All units in service

The Primary Clarifier design criteria presented in Table 6.3 were developed based on both process performance and hydraulic capacity. The criteria for the ADMMF conditions were chosen to provide adequate BOD and TSS removal to minimize secondary expansion requirements. The design criteria also include provisions to take one unit out of service for maintenance. Peak wet weather criterion is based upon hydraulic capacity of the clarifiers. Because EPA redundancy requires capacity to treat 50% of design flow with one unit out of service, at least two equally sized units must be provided. This criterion is met by the current design and does not drive any improvements.

6.1.2.2 Existing Capacity

As illustrated in Table 6.4, the capacity of the existing primary clarifiers is limited by the ADMMF condition and additional primary clarifiers will need to be added to meet future flows.

Table 6.4 Capacity of Existing Primary Clarifiers
Water Reclamation Facilities Plan
City of Bend

Condition	Current Capacity (mgd)	Required Capacity (mgd)		
		2010	2020	2030
ADMMF - All units in service	6.2	6.7	9.0	10.9
ADMMF - One unit out of service	5.0	7.3	9.8	11.9
PWWF	20.6	17.9	24.0	29.1

6.1.2.3 Recommended Upgrades

Because the existing primary clarification performance is acceptable, it is recommended that expansion of the facilities be based on the addition of new primary clarifiers with designs similar to the existing clarifiers. As shown in Table 6.5, adding one new clarifier by 2009 and a second by 2020 will provide sufficient capacity for all scenarios through 2030.

Table 6.5 Recommended Primary Clarifier Upgrades
Water Reclamation Facilities Plan
City of Bend

	2010	2020	2030
Number of Clarifiers	3	4	4
Capacity			
ADMMF - All units in service	9.3	12.4	12.4
ADMMF - One unit out of service	10.0	15.0	15.0
PWWF	30.8	41.1	41.1

6.1.3 <u>Secondary Treatment</u>

6.1.3.1 Background and Design Criteria

The existing secondary process consists of three aeration basins and three secondary clarifiers, which are described in Table 6.6. The current configuration of the aeration basins is shown in Figure 6.1. The aeration basins are operated in the MLE mode, with all primary effluent (PE) fed to Zone 1. The PE piping is configured to allow PE to be fed to the first aerobic zone (Zone 4) and operated in a “step-feed” mode under high flow conditions. The aeration basins are followed by three secondary clarifiers.

Table 6.6 Sizing of Existing Secondary Facilities
Water Reclamation Facilities Plan
City of Bend

Parameter	Unit	Value
Aeration Basins		
Type of process	-	MLE
Number of basins	-	3
Length x width	ft x ft	210 x 44
Side water depth	ft	15
Volume per basin		
Total anoxic volume	MG	0.36
Total aerobic volume	MG	0.69
Total volume	MG	1.05
Number of anoxic zones per basin	-	3
Volume of Zone 1	MG	0.09
Volume of Zone 2	MG	0.09
Volume of Zone 3	MG	0.18
Number of Aerobic Zones per Basin	-	2
Volume of Zone 4	MG	0.34
Volume of Zone 5	MG	0.34
Mixed liquor return pumps		
Number	-	3
Flow rate, each	gpm	6,000

Table 6.6	Sizing of Existing Secondary Facilities Water Reclamation Facilities Plan City of Bend	
Parameter	**Unit**	**Value**
Aeration System		
Type of aeration	-	Fine bubble diffusers
Number of blowers installed	-	4
Capacity, each	scfm	3,800
Power, each	HP	250
Top of Aeration Basins	ft	3,360
Secondary Clarification		
Type of clarifiers	-	Circular
Number of clarifiers	-	3
Diameter	ft	80
Side water depth	ft	2 units @12 1 unit @ 14
Surface area per unit	sf	5,027
Total surface area	sf	15,080

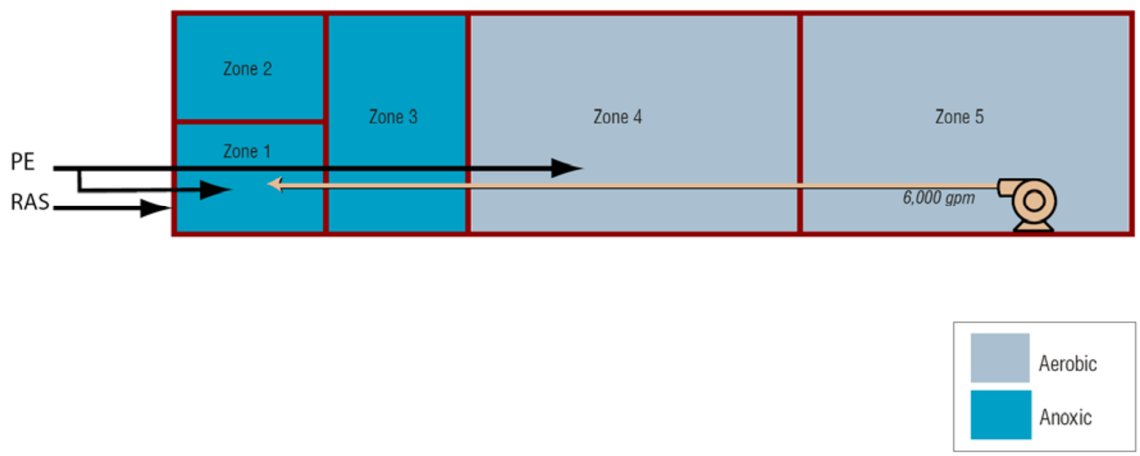


Figure 6.1 Existing Aeration Basin Configuration and Flow Distribution

The evaluation of alternatives for the expansion of the secondary process was based on two key objectives: (a) meeting the effluent TN permit limits, and (b) providing for cost-effective peak wet weather flow treatment. As previously stated, the future discharge requirements may include average annual TN limits of 10 mg/L, 6 mg/L or 3 mg/L. Therefore, expansion alternatives were developed to meet these permit limits under average annual conditions, and to assure that full nitrification is maintained during maximum month conditions. The recommended alternative was then evaluated for peak wet weather flow treatment. Wet weather operational and design modifications were developed to address short term (<1 day) events, with the primary focus being on biomass retention in the secondary process to meet the daily maximum permit limits for TSS and BOD.

The effluent TN is comprised of two main components: total inorganic nitrogen or TIN (ammonia + nitrates + nitrites) and organic nitrogen. Because the organic nitrogen in the effluent is largely refractory, the design focus is typically on the TIN component. The desired effluent ammonia concentration typically controls the design solids retention time (SRT) and basin sizing, while the desired nitrate concentration controls the basin configuration and mode of operation. For each of the three effluent TN limits, the design aerobic SRT values were selected based on achieving the limits during the average annual condition and ensuring that the plant would not slip out of nitrification during the coldest month under maximum monthly flow and load conditions. Higher SRT safety factors were selected for the stringent regulatory scenario requiring an effluent TN concentration of 3 mg/L. Additionally, to reduce effluent TN from 10 mg/L to 6 mg/L, the MLR rate will need to be increased. This will recycle more nitrate into the anoxic zone for denitrification reducing the effluent nitrate concentrations.

Another key criteria in secondary treatment process evaluations relates to the sludge settleability, as this directly impacts secondary clarifier (and overall process) capacity. For this analysis, settling curves were used to characterize the sludge settling velocity as a function of the sludge volume index (SVI).

Historical SVI values are shown in Appendix D. According to information from the plant staff, the uncommonly high values (>300 mL/g) are due to bulking as a result of filamentous bacteria growth, particularly M. *parvicella,* in the activated sludge.

Designing the plant using SVI values observed during bulking problems such as 300 or 400 mL/g will result in a significant derating of secondary treatment capacity. A more cost effective approach is to control the filamentous bacteria growth and design for lower SVI values. However, M. *parvicella* bulking as experienced at the WRF has been shown resistant to most methods for bulking control, including the chlorination and selector systems currently available at the plant. Recent research has shown that polyaluminum chloride (PAX) is an effective chemical for controlling M. *parvicella* and reducing SVI levels (see Appendix D for more details).

For the purposes of this evaluation, it is assumed that the implementation of appropriate bulking control strategies at the WRF will achieve an improvement of year-round sludge settleability to SVI values at or below 200 mL/g. Accordingly, all of the process analysis of the different secondary treatment alternatives is based on an SVI of 200 mL/g. The installation of facilities to feed PAX will be further investigated and field-testing will be performed to evaluate the efficiency of chemical addition for bulking control at this facility.

6.1.3.2 Existing Secondary Treatment Process Capacity

Table 6.7 presents the capacity of the existing secondary facilities. The existing facilities have enough process capacity to treat current AAF and ADMMF, as well as the PWWF conditions if operated in the step feed mode. However, the capacity of the existing system will be exceeded for all conditions by 2010. As previously discussed, the capacities listed in Table 6.7 assume that the incidences of high SVI can be reduced. If the SVI cannot be reduced, the listed capacities will need to be derated.

Table 6.7 Capacity of the Existing Secondary Process in the MLE Configuration
Water Reclamation Facilities Plan
City of Bend

Condition	Configuration	Current Capacity (mgd)	Required Capacity (mgd)			
			2006	2010	2020	2030
AAF	MLE	5.5	5.1	6.7	9.0	10.9
ADMMF	MLE	6.0	5.5	7.3	9.8	11.9
PWWF	MLE	11.0	14.8	17.9	24.0	29.1
	Step Feed	15.0				

6.1.3.3 Alternatives Evaluation

The alternatives evaluation section includes the following:

- Recommendations to meet near term capacity deficiencies for normal operation and peak wet weather flows.
- Review of alternatives to meet future treatment requirements based upon the 10 mg/L TN limit, which is anticipated in the upcoming permit renewal.
- Identification of modifications for the recommended alternative to meet the 6 mg/L and 3 mg/L TN limits.

Alternatives for treating PWWF, including blending, were also developed for the recommended alternative to meet the TN limits.

<u>Future Expansions with 10 mg/L TN Permit Limit</u>

The following three alternatives were developed for meeting a TN limit of 10 mg/L.

- **Alternative1: Existing Configuration:** All future aeration basins designed with a configuration identical to the existing aeration basins.
- **Alternative 2: Reduced Anoxic Zone:** All aeration basins designed with a configuration identical to the existing aeration basins, except that the anoxic zone is decreased from 34% to 17% (Figure 6.2). The existing aeration basins will also be

reconfigured with the reduced anoxic zone. To implement this alternative, the existing anoxic Zone 3 would be converted to an aerobic zone with a target oxygen concentration of 2 mg/L. This configuration results in an increased aerobic volume for nitrification, while continuing to provide sufficient anoxic volume to denitrify.

- **Alternative 3: Filtrate Reaeration:** All aeration basins designed with a configuration identical to the existing aerations basins, but the ammonia rich filtrate from solids dewatering will be pretreated in two newly constructed small aeration basins before being combined with primary effluent for treatment in the existing aeration basins. This configuration is shown in Figure 6.3. During side stream treatment, filtrate is brought in contact with RAS at high mixed liquor concentrations, resulting in almost complete nitrification of the ammonia. Consequently, ammonia loads to the aeration basins are greatly reduced and substantial capacity gains of the secondary treatment system can be achieved.

Process modeling was completed for all three alternatives. Estimated capacity for normal and peak wet weather for each alternative is summarized in Table 6.8.

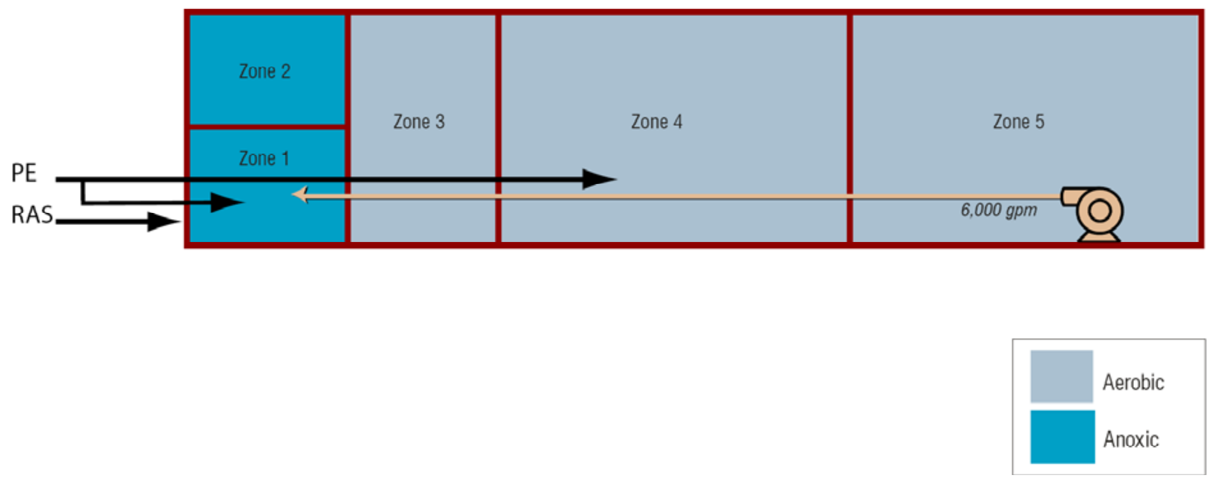


Figure 6.2 Alternative 2: Reduced Anoxic Zone

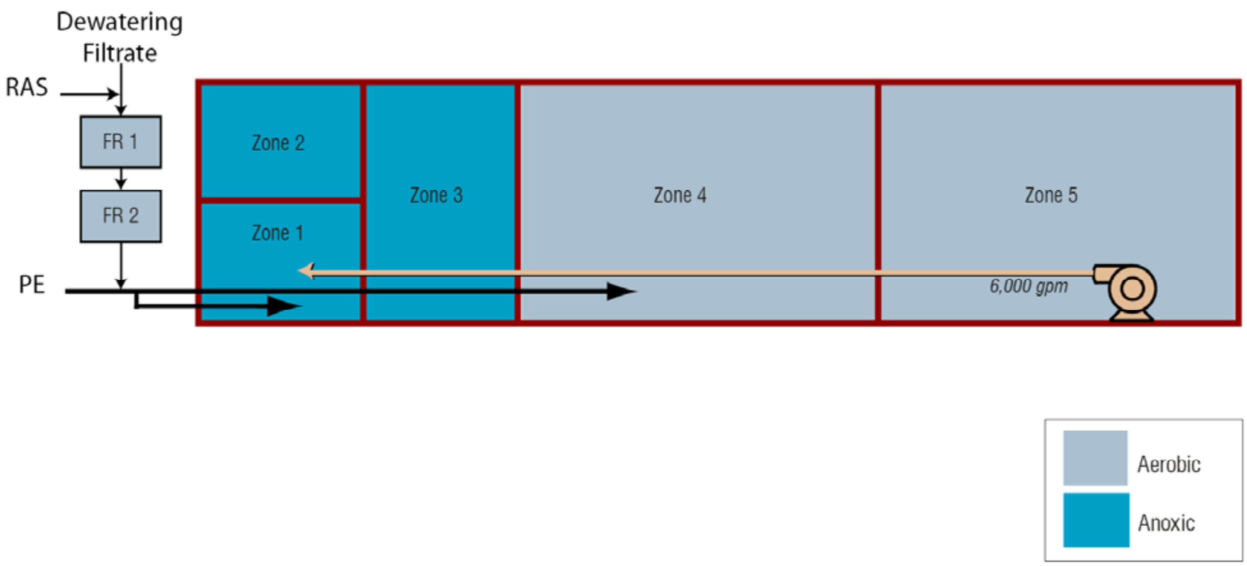


Figure 6.3 Alternative 3: Filtrate Reaeration

Table 6.8 Comparison of Alternatives for meeting a TN limit of 10 mg/L
Water Reclamation Facilities Plan
City of Bend

Alternative		**1**	**2**	**3**
Parameter	Unit	Existing	Reduced Anoxic Zone	Filtrate Reaeration
Capacity Per Basin / Total Capacity of Existing Basins				
AAF	mgd	1.83 / 5.5	2.0 / 6.0	2.4 / 7.2
ADMMF	mgd	2.0 / 6.0	2.2 / 6.5	2.6 / 7.8
PWWF (no step-feed)	mgd	3.7 / 11.0	4.0 / 12	4.8 / 14
PWWF (with step feed)	mgd	5.0 / 15	5.3 / 16	5.5 / 16.5
Basin Volume				
Aerobic, total	MG	2.04	2.61	2.04 + (2 x 0.2)
Anoxic, total	MG	1.08	0.54	1.08
All Basins	MG	3.12	3.12	3.12 + 0.4
MLR Rate				
Per basin	gpm	6,000	6,000	6,000

Table 6.8 indicates that the capacity of the existing MLE configuration is 5.5 mgd AAF. Alternative 2 can use the same basin volume and achieve a 0.5 mgd increase in AAF capacity, by reducing the anoxic zone from currently 35% to 17%. This upgrade would require the addition of diffusers into the last existing anoxic zone to convert this zone into an aerobic zone.

An even larger capacity increase will be achieved by implementing Alternative 3 via filtrate reaeration. By constructing two basins with a capacity of 0.2 mg each to treat dewatering filtrate, the capacity of the existing secondary facilities will be increased to 7.2 mgd without modifications to the existing aeration basins. Filtrate reaeration has been successfully implemented at full-scale at numerous facilities world-wide and has several benefits, as outlined in Appendix D.

Summaries of expansion requirements for each of the three alternatives are also shown in Appendix D. The size and dimensions of all future aeration basins and secondary clarifiers will match the existing facilities, except that new secondary clarifiers will be 14 feet deep instead of 12 feet deep.

For Alternative 1, the plant will need a total of six aeration basins and six secondary clarifiers to treat flows in 2030. Alternative 2 will require one less aeration basin in 2030, because of the greater aerated volume.

Alternative 3 provides the smallest overall footprint of all three configurations, as it requires only four aeration basins. Alternative 3 also increases the plant capacity under normal operation by 30%, and is expected to result in a slightly better effluent quality in terms of TN concentration. Two additional filtrate sides stream basins will need to be constructed with a volume of 0.2 MG each. Modifications to the RAS pump station and piping will also be required to direct the flow through the side stream basins back to the anoxic zone of the aeration basins. The MLR rate in Alternative 3 was designed to be consistent with pump capacity in the existing aeration basins. However, from a process standpoint this capacity can be reduced in future basins due to the increased nitrate return from the reaeration basin.

All three configurations utilize the same MLR rate, so that modifications of the MLR pumps in the existing aeration basins and associated hydraulic plant upgrades will not be required for normal plant operation.

Table 6.9 provides a summary of the estimated total present worth of the costs for each of the three alternatives. For all configurations, the differences in operating and maintenance costs are insignificant, so the costs shown are based on the net present worth of capital costs. These costs are based on construction costs, and are meant for comparison purposes. The costs for adding the capability to operate in the contact stabilization mode or facilities to feed chemicals for bulking control are not included, as these are common to all configurations.

Table 6.9	Representative Costs for TN Target 10 mg/L Water Reclamation Facilities Plan City of Bend	
	Alternative	**NPW Cost**
1	Existing MLE	$18,780,000
2	Reduced Anoxic Zone	$17,030,000
3	Filtrate Reaeration	$14,830,000

Based on cost, footprint, and process benefits, Filtrate Reaeration (Alternative 3) is recommended for meeting the TN limit of 10 mg/L.

6.1.3.4 Peak Wet Weather Capacity Expansion

As shown in Table 6.10, Alternative 3 will be able to treat all flows up to the PDWF condition when operated in the MLE configuration. However, the secondary facilities will not be able to treat PWWF in the step feed mode of operation if all aeration basins have the same design as the existing basins.

Table 6.10 Peak Hour Flow Process Capacities for Alternative 3
Water Reclamation Facilities Plan
City of Bend

Parameter	Unit	2006	2010	2020	2030
Peak Hour Flow Projections					
PDWF	mgd	10	13.1	17.6	21.4
PWWF	mgd	14.8	17.9	24.0	29.1
Capacities					
MLE	mgd	14.8	14.8	20	22
Step-Feed	mgd	16.5	16.5	24	27

The following three alternatives were evaluated for meeting a PWWF based on implementation of the recommended Filtrate Reaeration alternative:

- Alternative 3a: Full secondary treatment using contact stabilization for PWWF. Contact stabilization would be achieved by routing all PE flows to Zone 4 under PWWF conditions. Implementation of this alternative requires that an additional 8-inch pipe be routed from the PE header to Zone 4 in each basin.

- Alternative 3b: Bypass PE in excess of secondary treatment capacity. For this alternative, it is assumed that the plant will operate in the current step feed mode under PWWF conditions and flows to the secondary will be maximized. Flows in excess of the secondary capacity would be diverted through a diversion structure with a weir gate to approximately 200 feet of 24” diameter pipe connected to the head of the chlorine contact basin.

- Alternative 3c: Equalization of PE flows to allow for full secondary treatment. Flows in excess of the secondary treatment capacity would be diverted through a bypass structure with a weir gate to approximately 730 feet of 24” diameter pipe connected to the head of the degasification basins. The flows would then be pumped back to the secondary facilities under lower flow conditions.

Table 6.11 presents estimated net present worth costs for implementing each of the three alternatives. Note that because Alternative 3a involves adding several pipes as aeration basins are built, approximately 25% of these costs could be deferred until 2020. For Alternatives 3b and 3c, it is likely that any diversion structure and pipeline would be sized for 2030 flows; therefore, all costs will be incurred by 2010 for these options.

Table 6.11 Representative Costs for Treating PWWF
Water Reclamation Facilities Plan
City of Bend

	Alternative	NPW Cost
3a	Contact Stabilization	\$250,000
3b	PE Bypass	\$300,000
3c	PE Equalization	\$700,000

Based on cost and the ability to provide full secondary treatment, it is recommended that contact stabilization be implemented for PWWF treatment.

6.1.3.5 Expansion Requirements for Lower TN limits

The recommended filtrate reaeration option provides the plant with the flexibility to be upgraded to meet a future limit of 6 mg/L and 3 mg/L TN. The additional upgrades needed to produce a TN effluent limit of 6 mg/L are as follows:

- Increase the MLR capacity in each basin to 20 mgd (new MLR pumps, modifications to piping, gates, etc.),
- Increase hydraulic capacity of the existing aeration basins (modifications to existing baffle walls, addition of gates, associated instrumentation control, etc.).

Total NPW costs for retrofitting the plant to meet effluent TN concentration of 6 mg/L are approximately \$17 million, which is approximately \$2 million more than the NPW cost for meeting the 10 mg/L TN limit.

A 4-stage Bardenpho process is recommended to meet an effluent TN limit of 3 mg/L. Upgrades to the Filtrate Reaeration configuration to meet a TN limit of 3 mg/L consist of:

- Modifications to existing aeration basins, as shown in Figure 6.4, including:
  - Additional compartmentalization

- Conversion of Zone 8 from aerobic to anoxic operation
- Relocation of MLR pumps from existing Zone 5 to newly constructed zone 6
- Addition of methanol feed into anoxic Zone 8

- Construction of three more aeration basins (total of 6)
- Construction of two more secondary clarifiers (total of 5)
- Construction of four filtrate reaeration basins
- New methanol storage and feed facility.

Major changes in construction sequencing and facility sizing are necessary to implement the Bardenpho process with Filtrate Reaeration. The NPW total project cost for this implementing Bardenpho with Filtrate Reaeration is approximately $27 million, which is nearly double the cost to meet the 10 mg/L TN limit.

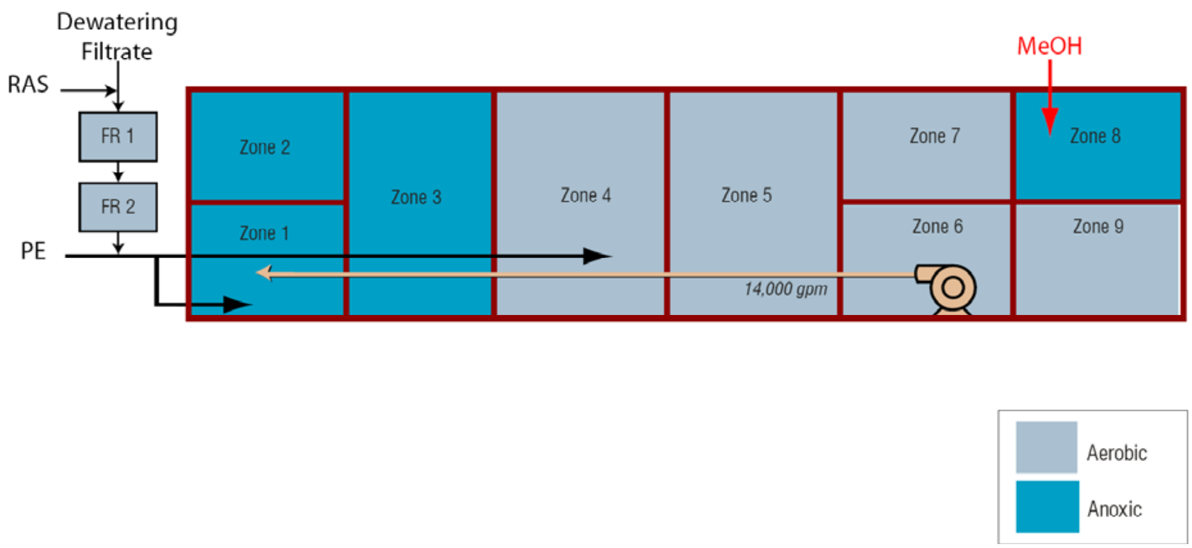


Figure 6.4 Layout of the aeration basins in the 4-Stage Bardenpho / Filtrate Reaeration configuration (TN = 3 mg/L)

It should be noted that the integration of Filtrate Reaeration with the Bardenpho process results in significant savings compared to other process alternatives evaluated to achieve TN effluent limits of 6 and 3 mg/L. For example, using a 4-stage Bardenpho process without Filtrate Reaeration to achieve a TN effluent limit of 3 mg/L would require at least 2 more aeration basins and one additional clarifier in 2030.

6.1.3.6 Summary of Recommended Secondary Treatment Upgrades

The following summarizes the upgrades and expansion requirements to implement the recommended filtrate reaeration alternative:

1) Miscellaneous improvements:

- Modifications to blower building and addition of one new blower in 2009, 2019, and 2024.
- New secondary clarifier splitter box and secondary clarifier piping modifications in 2013.
- Upgrade RAS/WAS Pump Station

2) Filtrate Reaeration
    - Construction of two aerated Filtrate Reaeration basins at 0.21 mg each
    - Reconfiguration of RAS/WAS pumping station and RAS / WAS piping configuration. Conservative cost based upon adding a new RAS pumping station was included in the CIP and shall be refined during Predesign.
    - Modifications to piping associated with dewatering filtrate

3) Aeration Basins and Secondary Clarifiers
    - Construction of one additional aeration basin in 2019
    - Construction of one additional clarifier in 2013 and 2024

4) Peak Flow Treatment
    - Extend PE header and add 8-inch pipes to feed PE to Zone 4 in all aeration basins

5) Solids Bulking and Elevated SVI Values:
    - Confirm seasonal identification of bulking agents and confirmation of M. *parvicella* as the primary agent causing poor settleability during winter months.
    - Conduct pilot scale testing of a PAX chemical feed system to evaluate the efficiency to control bulking caused by M. *parvicella* under site specific treatment conditions, dosage requirements, and other design parameters.
    - If PAX proves to be a feasible and effective control strategy, add a chemical feed system capable of dosing PAX into the RAS stream before the aeration basin.
    - Continued use of RAS chlorination to control other sources of bulking organisms.
    - Implement scum removal strategies for the secondary treatment design to reduce filamentous bacteria growth and recycle throughout the system.

A summary of the phasing schedule of the recommended improvements can be found in Appendix D and was used to develop the schedule in Section 7.0 of this report.

6.1.4 <u>Tertiary Filtration</u>

The existing tertiary filtration systems consists of a 12-disc cloth filtration system with an ADMMF capacity of approximately 6 mgd. The system was designed to treat secondary effluent to meet Level IV reuse requirements. The filters are used to provide reuse water from approximately March through October, but are also operated during non-reuse periods.

Based on the existing permit and the proposed conversion of the secondary system to contact stabilization for PWWF conditions, tertiary filtration will not be needed to meet permit requirements. If the TN permit limit is reduced to 3 mg/L, tertiary filtration may be used to remove particulate organic nitrogen (PON). Typically, secondary effluent contains less than 1 mg/L of PON and a fraction of that could be removed through filtration. This would not be enough to meet the TN limit without using the Bardenpho process, which will not drive an expansion of the filtration process.

Based on the permitting scenarios that have been evaluated, the only reason to increase tertiary filtration capacity will be to meet increased reuse demand. Currently, there are no projected increases in reuse demand; therefore, near-term expansion of the tertiary facilities is not anticipated.

6.1.5 Membrane Process Alternatives

An analysis was completed to evaluate membrane bioreactor (MBR) technology as an alternative and/or addition to the conventional activated sludge processes discussed in the previous sections. Further information is provided in Appendix E.

The MBR alternatives can provide additional treatment capacity without construction of additional aeration basins. MBR processes can be operated at MLSS concentrations of 8,000 mg/L to 10,000 mg/L, or more than twice the concentrations used in conventional systems. Settleability, which would otherwise be of concern at these MLSS concentrations, is not considered for MBRs since solid/liquid separation is accomplished physically by the straining action of membranes. This allows these systems to operate with lower basin volumes and maximizes the use of existing structures.

Three system configurations were considered using the TN limit of 10 mg/L. The first two alternatives evaluate using MBR systems for the entire 2030 flow. The third alternative evaluates splitting the 2030 flow between the existing conventional secondary treatment system and an MBR system.

6.1.5.1 MBR Alternatives 1 & 2

Since membrane equipment is relatively expensive, providing storage facilities for peak flows is common to allow sizing of the membranes at a lower capacity. Therefore, Alternative 1 includes a storage basin. Alternative 2 is based on handling all flows through the membranes.

The major elements of the process conversion for both systems are:

- Modifications to existing concrete biological process basins to accommodate increased flow rates.
- Modifications to the band screens to meet criteria for membrane systems (1 mm opening).

- Construction of six independently operating membrane trains, two in the north end of each of the three existing aeration basins.
- Construction of a building over the membrane zone to provide weather protection and prevent freezing of the membranes and associated equipment.
- Installation of membrane tank covers and concrete coating systems to minimize corrosion.
- Construction of a permeate pump station and pipe gallery on the north end of the existing aeration basins.
- Installation of membrane cleaning system pumps and piping and chemical facilities.
- Construction of new chemical facilities for membrane cleaning.
- Replacement of existing RAS pumps and piping to accommodate increased recycle rates required to maintain compatible (<10,000 mg/L) MLSS concentrations in the membrane basins.
- Installation of additional blowers to accommodate additional oxygen demands and membrane system aeration (cleaning) demands.
- Yard piping modifications.

Many of these facilities are larger for Alternative 2, since peak flows are all taken through the membranes. Alternative1 includes construction of lined earthen basins for storing flows in excess of 16 mgd and a pump station to return flows to the head of the aeration basins.

A detailed review of construction, operation, and maintenance costs for Alternatives 1 & 2 was completed, as presented in Table 6.12. The values shown for energy and labor reflect the added costs relative to the operation of the conventional systems, so these total NPW values can be compared to the conventional secondary treatment costs shown above.

Of the two alternatives, Alternative 1 is the lower cost. However, even its cost is about $26 million higher than the proposed Filtrate Rearation configuration proposed above.

Table 6.12	Summary of NPW for MBR Alternatives 1 and 2 Bend Wastewater Facilities Plan City of Bend	
Cost Component	**NPW MBR 1**	**NPW MBR 2**
Construction Costs through 2030	$33,300,000(1)	$39,900,000
Operation and Maintenance	$7,300,000	$9,500,000
Energy	$4,000,000	$5,300,000
Chemicals	$1,600,000	$2,100,000
Membrane Replacement	$1,700,000	$2,100,000
NPW, Total	**$40,600,000**	**$49,400,000**

Notes:
(1) If blending were utilized instead of storage, the capital cost could be reduced by approximately $500,000.

6.1.5.2 MBR Alternative 3

The third MBR alternative proposes that approximately half of the 2030 flow be treated through the existing basins and the remaining flows be treated through an MBR system. The entire maximum month flow and the majority of the peak flow will receive primary, secondary, and tertiary treatment through a mixture of the conventional treatment and MBRs. Appendix E portrays the process configuration and flow distribution in detail.

As presented in Table 6.13, the net present worth of the construction costs for the parallel conventional and MBR alternative is significantly less than the other two full MBR plant alternatives. Additionally, since operation and maintenance costs are higher for MBRs due to increased aeration, chemical, and pumping cost, the operation and maintenance costs will be lower for the parallel conventional and MBR alternative. This combination results in the parallel alternative being the most cost effective of the MBR alternatives. However, it is still significantly higher than the conventional alternative using Filtrate Reaeration.

Table 6.13	Summary of Construction Cost NPW for MBR Alternatives Bend Wastewater Facilities Plan City of Bend
Alternative	**NPW of Construction Costs**
MBR1 (MBR with storage)	$33,300,000
MBR2 (MBR for the entire peak flow)	$39,900,000
MBR3 (Parallel Conventional and MBR)	$21,900,000

6.1.6 <u>Liquid Stream Summary of Recommendations</u>

Based upon the preceding analysis, the existing secondary process should be expanded using the filtrate reaeration alternative. Peak wet weather flows should be accommodated by implementing full contact stabilization capability into the aeration basins. Additional tertiary treatment will only be required for meeting TN levels of 6 or 3 mg/L.

While MBRs are not currently cost-effective for expanding capacity at the WRF, an evaluation of a satellite MBR facility in the conveyance system is currently underway. Initial results indicate that this may be a cost-effective approach, as it results in significant savings in collection system improvements. Implementing a satellite MBR facility could defer several capital improvements at the WRF by approximately two years. Should this become a recommended option, a revised capital improvements phasing schedule will be developed.

6.2 Disinfection Alternatives

The existing gaseous chlorination system is operating near its design capacity, and near-term expansion will be required. Several alternative disinfection approaches and configurations were evaluated using either chlorination or ultraviolet (UV) disinfection. Appendix F includes the full analysis.

6.2.1 Existing Disinfection Requirements and Usage

The WRF currently uses chlorine for plant effluent disinfection and for control of filamentous organisms. In the existing system configuration when Level IV effluent is being produced, all the effluent must be disinfected to the 2.2 total coliform (TC) per 100 ml limit because the filters follow chlorination in the process train. A review of the plant data record from January 2000 to July 2006 indicates the facility maintains an average effluent residual chlorine level of 1.64 milligrams per liter (mg/L) and discharges effluent with an average fecal coliform (FC) count of 14.2 MPN/100 ml.

As shown in Table 6.14, chlorine usage could be reduced by not treating all plant flows to level IV standards.

Table 6.14 Chlorine Savings by Not Meeting Level IV
Disinfection Evaluation
City of Bend

Year	Average Day Flow, mgd	Peak Day Wet Weather Flow, mgd	Average Day Reduction by Not Meeting Level IV		Peak Day Reduction by Not Meeting Level IV	
			lbs Chlorine/ day	$ Saved[1] /day	lbs Chlorine/ day	$ Saved[1] /day
2010	6.7	13.2	81	$95	160	$185
2020	9.0	17.6	114	$175	212	$330
2030	10.9	21.4	132	$275	259	$540

[1] Based on $1.05/gal of Sodium Hypochlorite and Annual Inflation Factors

Therefore, if Level IV reclaimed water was consistently produced separately from the main effluent flow stream and disinfected separately, the size of chlorination system could be reduced and chemical savings realized. The approach and cost to implement a "split flow chlorination" system are described in the alternatives.

The WRF has maintained a history of chlorination at levels that produce effluent coliform counts well below permitted limits. For effluent treated for reclamation applications (currently all flow), ammonia is added after secondary clarification and prior to chlorination in the CCBs. The addition of ammonia to create chloramines drives the chlorine dosage to a weight ratio of 5:1 to ammonia. As a result, the WRF typically applies 10.44 mg/L of chlorine and approximately 2 mg/L of ammonia to achieve their disinfection goals. The alternatives discussed in the next section assume this dosage rate.

The facility also uses chlorination for control of filamentous organisms in the activated biological sludge process. Operations staff reports dosing the RAS at approximately 5 pounds (lb) of chlorine per 1,000 pounds of volatile suspended solids (VSS) in the aeration basins and secondary clarifiers. For analysis purposes, the interval between doses was 30 days, once per month, at a dose rate of 5 lb Cl_2/1,000 lb VSS.

The capacity of the existing two-basin chlorine contact system was examined for current and future flows, and the hydraulic retention time (HRT) was estimated for satisfactory disinfection. Details can be found in Appendix F. The following design criteria for the CCB are recommended:

- 15-minute HRT for peak hour flows with all basins in service.
- 30-minute HRT for average daily flow rate with one basin out of service.
- 20-minute HRT for peak day wet weather flow rates with all basins in service when Level IV effluent is not being produced.

Average daily flows above 5.49 mgd are already being experienced. With a 20-minute HRT and both basins in service, peak flows of up to 16.5 mgd can be accommodated. The ability to remove a basin from operation under average flow conditions appears to govern. The addition of a parallel third contact chamber would allow for average flows of up to 10.9 mgd with one basin out of service. However, additional testing should be performed as part of Predesign to determine if reduced detention times may be used.

The Handbook of Chlorination suggests that withdrawal rates from a single one-ton cylinder can safely be approximately 360 pounds per day without encountering problems associated with freezing. It is possible to achieve higher rates (e.g., 400 pounds per day per cylinder) by elevating the chlorine room building temperature to roughly 78°F. This is a common practice at treatment plants that have insufficient chlorination capacity under normal operations. However, it is not recommended as a planning or design criterion.

Two sets of one-ton cylinders are currently installed at the WRF; therefore, with two cylinders being utilized at the maximum suggested chlorine withdrawal rate of 360 lb/day per cylinder, approximately 720 lbs of chlorine is available per day. Assuming the 10.44

mg/L conservative feed rate, and a reserve of approximately 300 lbs per day for filamentous control, an average day flow rate of 5.7 mgd can be disinfected. Therefore, the existing gas portion of the chlorination system is near capacity.

6.2.2 Chlorine Disinfection Alternatives

Chlorine can be applied as a gas as in the current system or in a liquid form as sodium hypochlorite. Sodium hypochlorite can be purchased in a concentrated solution or produced on site.

Plant operating data were reviewed and chlorine usage patterns were established for these disinfection alternatives. This included allowances for disinfection for discharge, disinfection for production of reclaimed water, and chorine used to combat filamentous organisms in the activated sludge process. Table 6.15 provides a summary of the total chlorine demand at various points during the planning period.

6.2.2.1 Gaseous Chlorine

This alternative is based on continuing existing practices, expanding capacity as required, and adding safety features. As detailed in Appendix F, six pairs of one-ton cylinders will be needed at year 2030. With continuation of the MLE process for a TN limit of 10 mg/L, as is recommended, it is possible that five pairs of cylinders could meet peak demands in the future since the projections just slightly exceed the capacity of five pairs. However, the plan is based on six pairs.

**Table 6.15 Chlorine Demand Summary
Water Reclamation Facilities Plan
City of Bend**

	Projected Chlorine Demand (lbs/day)				
Year	Average Flow Based	Peak Day Wet Weather	MLE Filamentous Control	4-Stage Bardenpho Filamentous Control	Worst Case Total[1]
2010	584	1,149	434	722	1,306
2020	784	1,532	550	963	1,747
2030	949	1,863	683	1230	2,179

Notes:
1. Total of either AAF demand plus filamentous control or chlorination required for peak day wet weather flow. Filamentous control was assumed able to be accomplished at a time not corresponding to the max month flow condition.

Besides addition of chlorine tankage, the other needed improvements include:

- A third parallel chlorine contact basin.
- Emergency chlorine gas scrubber.

- Existing building modifications, including a new trolley and hoist for moving cylinders.
- New scales and chlorinators.
- New chlorine cylinder storage building.

6.2.2.2 Sodium Hypochlorite Disinfection

The use of liquid hypochlorite disinfection can be implemented to eliminate the gaseous chlorination systems and increase safety. The same chlorine demands outlined in Table 7.5 and chlorine contact times would apply. The third chlorine contact basin would also be required. There are two alternatives for incorporation of liquid hypochlorite; it can be generated on site electrolytically using salt, water, and power, or it can be purchased in a bulk solution form.

On-site Generation of Hypochlorite

On-site generation of hypochlorite uses only rock salt, conditioned water, and electricity. Rock salt is purchased in bulk and dissolved to make a concentrated brine (30 percent total dissolved solids). This brine is diluted with softened water and passed across electrodes. The result is a 0.8 percent hypochlorite solution and hydrogen as an off gas. This solution is dilute and sufficient generation capacity must be 'online' to meet the maximum daily demand, as should sufficient storage tank capacity for 24 hours of operation. Currently accepted general guidelines suggest that a 30-day supply of salt be on site and one additional rectifier be available as a standby unit.

Implementation of this alternative would include the following major elements:

- Third parallel chlorine contact basin.
- Salt storage silo for 30-day supply.
- Electrolytic equipment (rectifiers), including standby.
- Solution storage tanks.

The existing chlorination building could be used to house the electrolytic equipment and the existing one-ton cylinder room could be modified to hold the required tankage. The salt storage silo can be constructed east of the existing building. The existing gaseous chlorine system would be abandoned.

Bulk Commercial Sodium Hypochlorite Solution

For this alternative, commercially produced sodium hypochlorite solution (12 percent by weight) is delivered to the site, stored in tanks, and metered into the process flow as in the on-site generation alternative. The major differences are the smaller tanks, lack of salt storage and handling, and dramatically reduced electrical requirements. However, hypochlorite solution at this concentration is not stable and will readily degrade. The rate of degradation is impacted by heat, light, solution pH, and the presence of heavy metal cations.

For the WRF, storage of hypochlorite solution should not exceed 30 days, and 15 days storage at ADMM flows is recommended. Hypochlorite solution also off-gasses chlorine, and although not serious, it can be corrosive to surrounding equipment.

Implementation of this alternative would include the following major elements:

- Abandon existing gaseous chlorine system.
- Third parallel chlorine contact basin.
- New tanks and metering pumps.

The existing chlorination building can be modified to house all the necessary equipment.

6.2.2.3 Split Flow Chlorination

This alternative addresses the differing disinfection requirements for effluent treated for discharge and reclamation. Both systems use the same chlorination facilities; so much of the water treated for discharge to the ponds is unnecessarily dosed with high chlorine levels. With a split flow configuration, a third chlorine contact basin would be used to disinfect for Level IV reclaimed water when needed. The CCB could disinfect up to 5 mgd of reclaimed water production. It is anticipated that ammonia would be required for the reuse portion of effluent.

Costs for an upgraded and split disinfection system include the following major elements:

- Level IV reclamation water scalping pump station and piping.
- Bulk liquid hypochlorite improvements, as stated above.

6.2.3 UV Disinfection

The UV disinfection alternative is based upon abandoning the use of chlorine as the prime disinfectant. However, chlorine would continue to be used for control of filamentous organisms.

The system considered was configured to permit efficient operation for reclaimed water and for effluent discharge, involving split treatment of the two streams. The split would need to be changeable and expandable based upon the future demand for Level IV reclaimed water. While the WRF currently produces about 1.5 mgd of Level IV reclaimed water, future demand could rise to 5 mgd or beyond. Therefore, for comparison purposes against other forms of disinfection, the flow was assumed to be split with up to 5 mgd for Level IV reclamation and 16.4 mgd flowing to the seepage ponds on the peak day.

Water treated for reclamation would be filtered before disinfection, which results in a much more efficient disinfection process. In addition, the filters can be taken offline and all the effluent sent to the seepage ponds. For an open channel arrangement, this can be accommodated by use of a two-channel LPHO (low pressure, high output lamps) UV system with different numbers of lamp banks in each channel. Therefore, only LPHO UV systems were examined for the open channel UV alternative.

Construction of the UV system would include a new building to house the channels and UV equipment. Implementation of this alternative would include the following major elements:

- UV channel for seepage pond effluent – 30’ long, 3’-6” wide, 5’-2” deep.
- UV channel for Level IV reclamation water – 60’ long, 1’-8” wide, 5’-2” deep.
- UV equipment and control for both channels.
- Building to house equipment and channels.
- Site piping modifications.
- Bulk hypochlorite use for filamentous control, including abandoning the gas chlorination system.

6.2.4 Split Flow UV and Chlorine Disinfection

This option is a combination system in which effluent that is sent to the seepage ponds is treated with an upgraded gaseous chlorine system and Level IV reclaimed water is produced using a closed UV vessel configuration installed downstream of the existing reclaimed water distribution pumps (downstream of the filters).

This configuration would allow the flow split to occur after secondary clarification and before chlorination. A portion of the flow intended for reclamation would be “scalped” and directed to the reclamation filters. No ammonia would be added. Sufficient flows would be pumped to the filters to satisfy the reclaimed water demand, with minor excess filtered water being returned to the head of the chlorine contact basins.

Implementation of this alternative could result in a lessening of overall chlorine demand (due to the reduced dosage), because ammonia can be eliminated and the chlorine system would not be used to produce reclaimed water quality. However, during periods when no Level IV reclaimed water is produced the chlorination system would be required to treat the full plant flow. Implementation of this alternative would include the following major elements:

- New transfer structures and piping modifications to allow for flow splitting prior to disinfection.
- Redundant, parallel closed-vessel UV reactors.
- Gaseous chlorine system upgrades, as previously described.

6.2.5 Cost Analysis

Detailed estimates of capital and operating costs were made for the disinfection alternatives. This included detailed analysis of costs through the planning period as flows increase. Table 6.16 shows the total capital costs, O&M costs, and NPW for each of the disinfection alternatives.

Table 6.16 Net Present Worth of Disinfection Alternatives Disinfection Evaluation City of Bend			
	Capital	**O&M**	**Total**
Gaseous Chlorine	$4.6 million	$2.1 million	$6.7 million
Bulk Hypochlorite	$2.2 million	$5.5 million	$7.7 million
Onsite Hypochlorite Generation	$5.4 million	$2.4 million	$7.8 million
Split Flow Bulk Hypochlorite	$3.8 million	$4.7 million	$8.5 million
UV Disinfection-Channels	$8.2 million	$2.1 million	$10.4 million
UV Disinfection/Chlorine Disifection[1]	$10.2 million	$2.1 million	$12.3 million

Note: 1. 20% of Channel UV.

6.2.6 Disinfection Summary of Recommendations

The liquid hypochlorite system is the recommended approach. The UV alternatives are cost prohibitive, as the non-economic advantages do not justify the additional $3-5 million in NPW cost. The gaseous chlorination option has a higher capital cost compared to bulk hypochlorite, but it does have a lower overall present worth cost due the lower chemical cost. However, the non-economic advantages of a liquid hypochlorite system justify the increased cost. To our knowledge, all municipalities in Oregon equal to or larger than Bend have or are in the process of switching from gas to hypochlorite disinfection. The primary driver for this conversion is the significant safety issue of using gaseous chlorine.

The split flow chlorination option with filtration ahead of disinfection is not cost effective and is not recommended at this time. However, this approach may be required if DEQ adopts the proposed reclaimed water regulations, which require filtration to be provided upstream of disinfection.

An alternative split chlorination approach that leaves filtration downstream of disinfection process could significantly reduce operating costs. This option has a much lower capital cost compared the split flow option that moves filtration ahead of disinfection, since it only requires an additional chlorine feed point in the new contact basin and isolation gates in the filter pump station. The present worth O&M savings is approximately $650,000, which should justify the additional capital cost to provide the flexibility to isolate the new CCB as a dedicated reuse basin. Therefore, we recommend evaluating this option further during Predesign if upstream filtration is not required in the final reuse regulations. In addition to hypochlorite, it is assumed that ammonia addition would still be required during the reuse season to eliminate the past issues with free chlorine disinfection. Annual operating costs for hypochlorite and ammonia are summarized in TM 6.

6.3 Effluent Disposal

An evaluation of the existing effluent disposal method to meet requirements through 2030 can be found in Appendix C and is summarized below.

6.3.1 Disposal Alternatives

Disposal alternatives include reclamation or disposal to an alternate location. An alternate disposal location is not considered feasible. Limited reclaimed water production is currently practiced and will be expanded as opportunities arise. As such, the use of the seepage ponds represents the “highest and best practicable method” for disposal of the effluent.

Discharge of treated effluent into the Deschutes River or the nearby North Unit Canal was briefly considered. A discharge to the river was dismissed because of cost and public concerns that the discharge would impact Deschutes River water quality. Further, the river is water quality limited for temperature and Ph, and a discharge could not be permitted at this time. A discharge into North Unit Canal would require approval by the North Unit Irrigation District and such approval is unlikely. Further, the canal only flows between April 15 and October 15.

The City of Bend is receptive to reclamation of its treated effluent. The City currently provides 260 AFY of reclaimed water to Pronghorn Resort for use on its golf course. This practice is anticipated to continue through 2030. Reclamation within the City of Bend, however, is not practicable as the cost to return treated effluent to areas within the UGB is quite high (>$3,100/AF in 2003 dollars). The cost is high because of distance and since elevations within the UGB are between 120 and 500 feet higher than the WRF. However, the City is open to additional reclamation opportunities if the interest in or demand for reclaimed water increases.

Development of parts of the WRF site for agricultural use, with effluent and/or biosolids applied on an agronomic basis, was considered. It was quickly determined to be infeasible, based on several factors. These include the relatively poor soils quality on the site, and the high costs for installing and operating a suitable irrigation system.

6.3.2 Determination of Highest and Best Practicable Control

To demonstrate that the Bend WRF’s current treatment represents the highest and best practicable methods for effluent disposal, the existing capacity, impacts to groundwater, and removal efficiencies of constituents of concern were evaluated.

6.3.3 Disposal Capacity

As stated in section 4.1.3, the annual average flow is projected to be 10.9 MGD or 12,210 AFY in 2030. As shown in Table 5.4, Ponds 3A and 3B do not have sufficient capacity to meet the future capacity requirements. However, if Ponds 1 and 2 were reconditioned, as described below, the combined system would have sufficient capacity to meet future needs.

6.3.4 Projected Impact on Groundwater Quality

To estimate the potential impact on groundwater quality of expanded use of the seepage ponds, the aquifer flow rate and pollutant concentrations were estimated. As discussed in Section 3.6, the two primary consituents of concern are nitrate-nitrogen and metals.

6.3.4.1 Nitrate-Nitrogen

The effect of both the current WRF effluent nitrate-nitrogen concentration (6.85 mg/L) and the effluent limit under the WRF's current permit (10 mg/L) were evaluated. Both effluent concentrations resulted in projected down-gradient nitrate-N concentrations less than 1 mg/L and far below the MCL of 10 mg/L.

An evaluation of the feasibility and cost for upgrading the current treatment process (discharge limit 10 mg/L TN) to achieve lower effluent nitrogen levels is presented in Appendix D and summarized in Section 6.2 of this report. The evaluation shows additional costs (net present worth basis) as follows:

Total nitrogen = 6 mg/L: $2.0 million additional

Total nitrogen = 3 mg/L: $14.5 million additional

Note that the existing process actually achieves nitrogen concentrations significantly lower than 10 mg/L, so the expected improvement in the discharged TN would be somewhat less than the differences in target levels.

Based upon the low current and projected groundwater nitrate levels, and the cost associated with lower limits, an expanded wastewater facility providing current levels of treatment for total nitrogen should be considered to represent highest and best practicable control.

6.3.4.2 Metals

Projected 2030 metal concentrations in down-gradient wells were predicted using the same approach used to predict down-gradient nitrate concentrations. For these predictions, 2030 effluent concentrations were assumed similar to 2006 levels. Predictions were made only for those contaminants for which levels of concentration are detectable, including arsenic, lead, chromium, and zinc. Concentration data from the two up-gradient wells was used to project future concentrations. Because the concentration data varies signifacantly in the two different wells, the results of the analysis are incongruent. However, all projected concentrations were still far below the MCLs for each metal. The report concludes that additional data is needed to accurately predict the metals concentrations.

Overall, the evaluation demonstrated that increased use of the seepage ponds should not significantly impact groundwater quality.

6.3.5 Removal Efficiencies

Currently, the Bend WRF utilizes a Modified Ludzack-Ettinger (MLE) process to control total nitrogen discharge into the seepage ponds. This process began operating in September 2000 and resulted in a significant reduction in total nitrogen and higher removals of BOD_5 and TSS. In 2005, the annual average total nitrogen discharged to the seepage ponds was 6.85 mg/L. As discussed in previous sections, nitrate concentrations in down-gradient monitoring wells remain below 1.0 mg/L, which is only 10% of the MCL. Future down-gradient concentrations of nitrate should also remain below 1 mg/L at the current level of treatment.

Though the WRF is not specifically designed to remove metals, removal is quite effective for some metals based on 2006 concentrations as listed in Table 6.17. Many samples had constituents below their respective detection limits. For those constituents with multiple samples below detection limits, the calculated removals were based on very limited data and may not be representative. Removal efficiencies were considered reasonably accurate for arsenic, chromium, copper, lead, nickel, silver, and zinc. All influent and effluent cyanide samples were below detection limits; as such, no removal efficiency for cyanide could be determined. Removal of these constituents under future 2030 conditions is anticipated to be similar to 2006 results.

Table 6.17 Metals Removal Through Existing Treatment Process
Bend Water Reclamation Facility
City of Bend

DATA	Influent/ Effluent Non-detects	Influent Annual Average[1], μg/L	Effluent Annual Average[1], μg/L	Annual Average % Removal Rate
Arsenic	0/0	2.09	1.51	28%
Cadmium	9/9	0.31	0.34	-8%
Chromium	2/5	2.28	0.54	76%
Copper	0/0	69	12	83%
Lead	0/0	5.28	1.96	63%
Mercury	10/11	0.14	0.08	41%
Molybdenum	6/6	2.67	2.35	12%
Nickel	0/4	5.66	1.76	69%
Selenium	7/8	0.93	0.94	-1%
Silver	0/6	3.44	0.63	82%
Zinc	0/0	152	80	47%

Note:

1. In calculating the average concentration, one half of the minimum detection level was used when samples were reported below method detection limit (MDL).

The analysis concludes that highest and best practicable control for removal efficiencies will be provided with expansion of the existing treatment and disposal system.

6.3.6 Effluent Disposal Summary of Recommendations

The overall conclusion of the effluent disposal evaluation is that the current level of treatment and the existing seepage ponds represent the “highest and best practicable methods” for treatment and disposal of the WRF effluent, per the requirements of OAR 340-040-0020. This conclusion is based on the following:

1. The MLE treatment process produces a very good effluent with low total nitrogen, BOD_5 and TSS. Because projected down-gradient nitrate concentrations are so low, installation and operation of a treatment method to further reduce total nitrogen in the effluent would not provide a significant improvement to groundwater quality.
2. Current and projected groundwater nitrate-N levels are below 1 mg/L (less than 10 percent of the MCL of 10 mg/L). Current and projected metals concentrations are well below their respective MCLs. Of the 12 metals constituents considered, concentrations of six constituents are actually projected to decrease in one or both down-gradient wells. Of the constituents projected to increase, projected concentrations are all less than 10 percent of their respective MCLs.
3. Current disposal using the seepage ponds represents the available disposal method with the lowest environmental impact. Limited effluent reclamation is currently practiced and may be expanded in the future to the extent practical.

6.3.7 Proposed Expansion of Seepage Pond Use

Ponds 1 and 2 will need to be returned to regular operation in addition to current operation of Ponds 3A and 3B to meet projected future effluent disposal needs. Ponds 1 and 2 will need to be reconditioned to avoid rapid leakage from high-risk areas prior to being returned to service. The extent of required improvements was estimated based on contract documents from the original construction of Ponds 1 and 2, as well as additional surveys conducted in March of 2007. The construction costs for reconditioning of Ponds 1 and 2 were estimated to be approximately $587,000 and $459,000, respectively, with a total estimated construction cost of $1,046,000.

6.4 Solids Management

This section analyzes alternatives for expansion of the solids processing facilities. The current system is highly effective, and largely represents the state-of-the-art processes for facilities of this type and size. Further details are provided in Appendix G. The projected loadings for the two major solids streams are summarized in Table 6.18.

Table 6.18 Projected Solids Loadings Water Reclamation Facilities Plan City of Bend				
Stream	**2006**	**2010**	**2020**	**2030**
Primary sludge				
Lbs/day	16,800	22,800	30,600	35,500
% solids	4.4%	4.4%	4.4%	4.4%
Gal/day	45,800	62,100	83,400	96,700
Waste activated sludge				
Lbs/day	6,730	7,900	10,900	17,200
% solids	0.8%	0.8%	0.8%	0.8%
Gal/day	100,900	118,400	163,400	257,800

6.4.1 Primary Sludge Thickening Alternatives

The analysis of primary sludge thickening is closely related to the analysis of digestion capacity, since the performance of the thickening system has a direct impact on the amount of flow into the digesters. This is especially important for the WRF since over 70 percent of the digester feed is in the form of primary solids.

The current system of thickening in the primary clarifiers was considered against the alternatives of gravity thickeners and gravity belt thickeners. Gravity belt systems were rejected based on operation and maintenance issues. Gravity thickeners were evaluated in more detail. A thickened sludge concentration of 6.0 percent was assumed for a gravity thickener. When compared with the 4.4 percent normally achieved in the primary clarifiers, the addition of a gravity thickener could reduce overall flow to the digesters by about 23 percent.

The effect of this change is shown graphically in Figure 6.5. As shown, converting to gravity thickening could delay the need to expand digestion until nearly the end of the planning period.

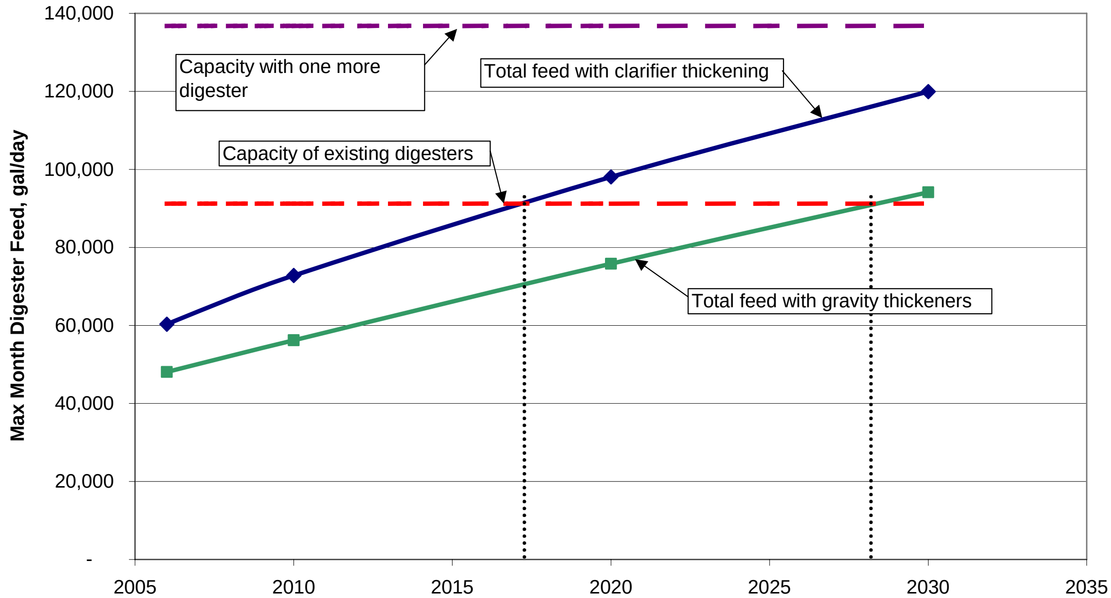


Figure 6.5 Digester Capacity Chart

Table 6.19 presents the results of a cost analysis of the two configurations, including both the thickening and digester construction components. The gravity thickener alternative is clearly cost-effective and recommended for implementation.

Table 6.19 Present Worth Analysis for Primary Sludge Thickening Alternatives Water Reclamation Facilities Plan City of Bend

Parameter	Primary Clarifier Thickening	Gravity Thickener
Thickener description	N/A	2 @ 35' diameter
Year for Installation:		
Gravity thickeners	N/A	2016
Digester	2016	2027
Total Present Worth	$2,865,000	$2,100,000

6.4.2 Waste Activated Sludge Thickening Alternatives

The existing gravity belt thickener (GBT) has sufficient capacity to handle projected loads throughout the planning period. Options for providing backup capability were considered, as the existing dissolved air flotation system is not large enough to handle loads through the period and has very high cost for upkeep. Co-thickening of WAS in the primary clarifiers (or gravity thickeners when installed) is only applicable for emergency, short-duration outages.

The recommended approach is to install a “dual-purpose” belt filter press (BFP). As described below, a second BFP is desirable to provide redundancy for the existing unit and to reduce the operating time. The existing BFP can be configured so that only the gravity deck is operated, allowing it to function as a backup GBT. Since this provides greater reliability for both thickening and dewatering operation, the "dual-purpose" BFP approach is recommended.

6.4.3 Solids Stabilization Alternatives

The current stabilization system using anaerobic digestion is highly effective, and is well established in the industry as the appropriate technology for this size and type of facility. This process will be retained.

The current project to upgrade the mixing systems in Digesters 1 and 2 will provide the capability to provide effective mixing at elevated solids levels. The addition of gravity thickening in around 2015 will increase the average solids concentration to the digesters from the current level of about 4.5 percent to more than 6.0 percent.

Appendix G shows the recommended loading criteria, along with calculated loading rates based on the assumed projections. The target operating parameters are based on all units in service. The EPA Reliability/Redundancy criteria only require a minimum of two digestion tanks and backup mixing equipment, both of which can be met with the existing system. In addition to those standards, a 15-day HRT is generally recommended with one unit out of service. A 15-day HRT can be provided though 2020 with one of the small digesters off-line, but is not met under current conditions if Digester 3 is removed from service. However, based upon discussion with City staff the following options are preferable to avoid the significant cost of building a large digester to serve as a backup:

1. Run at a reduced HRT and utilize the drying beds to meet the Class B requirements.
2. Send the dewatered biosolids to a landfill.

Given these options, the recommendation is to construct a fourth digester late in the planning period to meet the design criteria with all digesters in service.

6.4.4 Biosolids Dewatering Alternatives

Digester biosolids dewatering consists of mechanical dewatering followed by air drying. The dewatering and drying processes are evaluated below.

6.4.4.1 Mechanical Dewatering

The existing belt filter press (BFP) was installed in 2005. It serves as the primary dewatering system, with the existing centrifuge as the backup. Backup capability is also provided by the ability to temporarily store solids in the degasification basins or to directly apply to the drying beds as in the original plant configuration.

The requirement for BFP capacity depends directly on the selected operating period. The 24-hour operation is possible due to the inclusion of the new solids storage hopper and by advanced system instrumentation and controls, enabling unattended operation with remote monitoring. Appendix G gives a summary of the rated capacity and calculated loadings on the BFP. A second BFP will be required by around 2020 to provide adequate dewatering capacity with all units in service.

A backup to the existing BFP is also recommended to provide adequate reliability, and is listed as a requirement per the EPA Reliability/Redundancy criteria for all reliability classes. The existing centrifuge was considered for this purpose, but is not recommended given the following considerations:

1. One of the primary drivers for installing the BFP was that the centrifuge proved difficult to keep operable and in service. These issues may be exacerbated due to infrequent use in a standby role.
2. As previously described, installation of a “dual-use” BFP will provide redundancy for the existing GBT, which becomes increasing desirable as thickening loads increase.
3. A second BFP will provide the flexibility to reduce the 24 hour/day operating period.

Therefore, a new dual-use BFP is recommended. The existing polymer system does not have adequate capacity to operate two BFPs in parallel, but may be upsized to meet this requirement by increasing the polymer feed loop pumping system capacity. The estimated construction cost for the BFP and polymer upgrade is approximately $1.0 million, based upon the assumption that the new unit is installed in the existing centrifuge location.

6.4.4.2 Drying Beds

In the original plant, liquid digested biosolids were applied to the drying beds, which were used to dewater and dry the liquid material through evaporation. They also provide storage, volume reduction, and additional stabilization. The existing degasification basins were used to temporarily store digester supernatant, and allow for controlled release of entrained gases before return to the liquid stream.

The addition of the centrifuge in 1996 provided mechanical dewatering of digested biosolids before application to the drying beds. This had the effect of extending the usable capacity of the drying beds. The degasification basins were converted to storage of BFP filtrate before it is sent back to the liquid treatment process. As noted earlier, they can also be used for emergency storage of digested biosolids.

In 2006, the drying beds were expanded from 8 to 12 acres. This is expected to serve the facility through the planning period.

6.5 Class A Biosolids Evaluation

6.5.1.1 Existing Program

The WRF enjoys a successful and low-cost program of beneficial reuse of Class B biosolids with application to local agricultural sites. This is expected to continue for the foreseeable future, and no changes are recommended at this time. Available acreage is sufficient for the planning period.

6.5.1.2 Use of WRF Site

While the current program is successful, municipalities benefit by having a backup program in the event of unforeseen changes in local land availability or other outside factors. Many agencies have sought to purchase suitable land strictly for use for biosolids application as insurance against changes in market conditions.

In Bend's case, the City in effect already has such a backup program. The City's property surrounding the WRF is permitted for biosolids application at the rate of 40 lbs/acre/year. Applications have been made at various points in the past, although application to outside sites is now the more feasible and beneficial approach. It is recommended that the City maintain the existing property for use as a backup biosolids application site. While it does not have the capacity for a permanent site, it would provide short-term capability if necessary.

6.5.2 Evaluation of Alternatives for Class A Biosolids

The current Class B biosolids program is efficient, protects public health, and is cost-effective. There is no current driver pushing for upgrade to a Class A system, in which the biosolids are further processed to render them virtually pathogen-free. However, there have been instances around the country in which Class A biosolids were required through local regulations. It is not considered likely that this will happen in Central Oregon during the planning period; however, producing a Class A product has some benefits. Primarily, Class A biosolids have almost no restrictions for distribution of the product, even to members of the public. This provides a number of opportunities for increased beneficial use of the material.

Currently available systems were reviewed to provide an evaluation of the feasibility and cost for implementation at the WRF. A summary of the results is provided in Table 6.20, and each are discussed further in Appendix G. The various technologies have differing product types as well as differing degrees of proven history.

Among these four alternatives, air drying and post processing via composting or mechanical drying were considered the most likely options. Advanced digestion processes and pre-pasteurization result in a stabilized product still has “sludge” type characteristics, making distribution of the material difficult. Also, recent studies have indicated potential pathogen regrowth issues with advanced digestion processing. Given these considerations, the Class A evaluation was limited to air drying and post-digestion processing.

**Table 6.20 Summary of Class A Biosolids Technologies
Water Reclamation Facilities Plan
City of Bend**

	Product Type	Current Status	Viability for Bend
Post-Processing Alternatives			
Air drying (existing system)	Dried cake	Site-specific; regulations require product testing	Possible; must be verified through testing
Composting	Soil-like	Viable process: attractive product	Possible, depending on bulking agent source & cost
Advanced alkaline stabilization (N-Viro; EnVessel Pasteurization)	Soil-like	Viable; but unlikely market for alkaline product	Moderate
Drying	Soil-like	Viable	Good
Advanced Digestion Technologies			
Temperature-phased digestion	Wet cake	Not established for continuous flow; batch system required	Poor
Pasteurization			
RDP-Cambi	Wet cake	Not established in US; heat exchanger problems	Poor
ECO-Therm	Wet cake	New technology; not well established	Moderate

A cost estimate of the viable options is presented in Table 6.21.

**Table 6.21 Preliminary Cost Estimates for Class A Alternatives
Water Reclamation Facility Plan
City of Bend**

	Capital Cost
Air drying (existing)	$0
Composting	$750,000
Dryer	$4 million

6.5.3 Biosolids Processing Summary of Recommendations

Major findings and recommendations for upgrading the solids handling system are summarized below:

1. Install two, 35-foot diameter gravity thickeners for primary sludge thickening. The gravity thickeners should be constructed and operational by (approximately) 2016 or as needed to defer construction of the fourth digester.
2. The existing GBT has adequate capacity through the 2030 planning period, provided a daily run-time of 8.6 hours is acceptable. The DAF does not provide adequate or reliable capacity as a backup unit. A dual-use BFP is recommended to serve as the backup. Co-thickening of primary and waste activated sludge may also be used for short-term, emergency situations.
3. The existing digesters are nearly adequate through the planning period, provided the primary sludge and WAS are thickened to a higher concentration. The Class B requirements cannot be met by digestion alone if the larger digester is removed from service. The partially stabilized solids will be dried to meet Class B requirements prior to land application or landfilled should the large digester need to be taken out of service.
4. As previously mentioned, a second BFP is recommended to provide additional reliability for both the GBT and dewatering operations. Polymer improvements should be made to allow both BFPs to operate in parallel.
5. The are not any drivers to implement a Class A biosolids program at this time. Testing should be performed to determine if the existing drying process results in a Class A product.

Among these recommendations, the only near term improvement is to install a second BFP.

6.6 Hydraulics

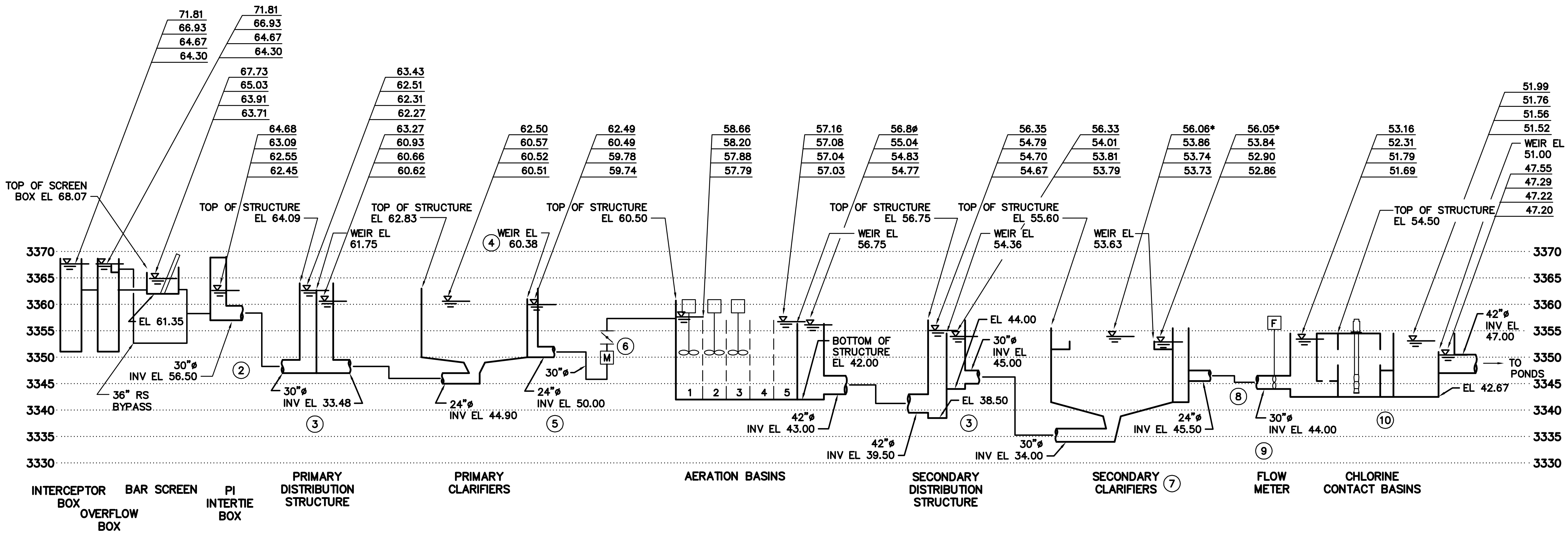
The hydraulic profile for the WRF under projected 2030 flow conditions is presented in Figure 6.6, and is based on the liquid stream recommendations outlined above. A detailed discussion of the hydraulic capacity can be found in Appendix H. A number of hydraulic bottlenecks were identified as summarized below:

- Preliminary Treatment: The existing headworks currently limits the plant's capacity and is under construction to alleviate the bottleneck. Improvements include additional band screens and flow measurement of the screened effluent.
- Primary Treatment: The current flow splitting structure at the primary clarifiers will not accommodate a fourth clarifier.
- Aeration Basins: The existing flow splitting structure from the primary clarifiers to the aeration basins do not have adequate capacity to match PWWF in the proposed liquid stream process configuration as described above.
- Secondary Clarifiers: The existing flow splitting structure at the secondary clarifiers is also inadequate for an additional two clarifiers as proposed.
- Chlorine Contact Basins: The existing chlorination configuration creates a significant amount of head loss under peak flow conditions.

Significant items that are recommended to alleviate the above bottlenecks and increase hydraulic capacity are summarized below:

- Installation of a parallel primary influent and effluent line to the west of the headworks with the addition of the fourth primary clarifier,
- Installation of parallel step feed lines to increase peak flow capacity to the existing aeration basins,
- Evaluate installation of flow gates in the aeration basin baffle walls to increase the available head for primary effluent flow splitting, and
- Implement a study to identify the most cost effective method for relieving the bottleneck created by the single 30-inch secondary effluent line and restrictions in the plant water pump station and chlorine contact basins

These improvements, along with the additional basins and their associated yard piping, will allow the plant to convey peak flows through the planning period. Further evaluation of improvements to address the WRF's hydraulic capacity should be completed in conjunction with the design of the recommended process improvements. It was assumed that the costs for hydraulic upgrades can be accommodated within the contingencies provided for site piping (5 percent) and miscellaneous site improvements (5 percent).



LEGEND

PWWF	(29.1 MGD) (1)
PHF	(21.4 MGD)
PDF	(13.6 MGD)
ADMMF	(11.9 MGD)

GENERAL NOTES:

1. DEFINE FROM LEGEND AS FOLLOWS:

ADMMF	AVERAGE DAILY MAX MONTH FLOW
PDF	PEAK DAILY FLOW
PHF	PEAK HOURLY FLOW
PWWF	PEAK WET WEATHER FLOW
*	INDICATES OVERFLOW OF STRUCTURE

KEY NOTES:

(1) ULTIMATE PLANT CONFIGURATION ASSUMES:

HEADWORKS:	FOUR SCREENS – ONE REDUNDANT
PRIMARIES:	FOUR UNITS
AERATION BASINS:	FOUR UNITS
SECONDARIES:	FIVE UNITS, 80' ø
DISINFECTION:	THREE CHLORINE CONTACT BASINS

(2) ADDED SECOND 30" DIA PRIMARY INFLUENT LINE IN PARALLEL TO EXISTING 30" DIA LINE.

(3) ADDED ONE ADDITIONAL MIXED LIQUOR AND PRIMARY EFFLUENT SPLITTER BOX STRUCTURE IDENTICAL TO EXISTING.

(4) PER JANUARY 2006 SITE SURVEY.

(5) INCREASED PRIMARY EFFLUENT LINE IN EFFLUENT GALLERY FROM 18" TO 24" DIA.

(6) FLOW CONTROL VALVE ASSUMED FULL OPEN.

(7) RAS FLOW ASSUMED TO BE 50% Q UP TO PDF AND 7.6 MGD FOR PHF AND PWWF.

(8) ASSUMED REPLACEMENT OF EXISTING 30" DIA SECONDARY EFFLUENT LINE WITH TWO 36" DIA LINES.

(9) REPLACED EXISTING 20" DIA FLOW METER ON SECONDARY EFFLUENT LINE WITH TWO PARALLEL 30" DIA METERS.

(10) ADDED ONE ADDITIONAL 36" DIA ORIFICE FOR ULTIMATE FLOW.

FIGURE 6.6
HYDRAULIC PROFILE
WATER RECLAMATION FACILITIES PLAN
CITY OF BEND

C:\Temp\BGPlot_2732\Figure 6.6 Hydraulic Profile 1-09-08 02:57pm RArmstrong XREFS:

VISION ENGINEERING

carollo Engineers...Working Wonders With Water™

6.7 Evaluation of Support Facilities

The purpose of this section is to evaluate the adequacy of existing non-process facilities to meet future needs, as detailed in Appendix I. Support facilities at the WRF fall under three main categories: administration, laboratory, and maintenance. Administration and laboratory functions are currently housed in the operations building, with additional space available in the training building. Maintenance functions are currently housed in the maintenance building, as well as a pole barn, insulated metal building, and a residential two-car garage. The condition, functionality, and capacity of these existing facilities were assessed to identify needed improvements.

6.7.1 Existing Laboratory, Administration, and Maintenance Facilities

The condition and functionality of the existing administration, laboratory, and maintenance facilities are described below:

Administration. Administration functions are currently housed in the operations building, which was constructed in 1977 as part of the original facilities and expanded in 2001. This building currently houses a reception area, the WRF Plant Manager's office, locker rooms, the control/break room, maintenance spaces, an electrical room, and the water quality laboratory (discussed below).

The building is generally in good condition. However, there is some deterioration in the interior, and electrical and mechanical systems are generally inadequate for long-term use. In addition, the building is poorly organized and is currently too small to meet projected needs. For example, there is only a single office, and a single room is used as a conference room, operations room, and break room.

Additional administrative space is available in the training building, which was constructed in 2001. The building is in good condition and has no current maintenance issues. The building was recently being used by conveyance staff, but is now vacant. Available spaces include a training room, storage space, services, a conference room, a map room, and three offices.

Water Quality Laboratory. The water quality laboratory is currently housed within the operations building and is used to analyze both drinking water and wastewater samples. The existing laboratory includes the following areas: sample receiving, wet chemistry, hood room, metals, instrumentation, chemical storage, and microbiology. Additional areas include an office for the laboratory manager, which is also currently used to house records. Challenges with the existing areas include insufficient air flow, unsafe working conditions, multiple sample receiving areas, poor power quality, and general inefficiencies in layout.

Maintenance. There are four structures used for maintenance operations, as follows:

- **Maintenance building**. The main maintenance building is in good condition. It was originally designed with five work bays, but since original construction, portions have been converted to office space and for other uses. The building currently houses office space, an electrical repair space, a timber storage mezzanine, equipment storage, and general maintenance areas. Generally, there is insufficient space to meet current and projected needs and the office space requires improvements.

- **Pole Barn**. A three-sided pole barn located adjacent to the maintenance building provides unsecured covered storage for large equipment and some smaller items. This building has sufficient capacity for current use, but may have limited long-term use due to security concerns.
- **Pre-fabricated Metal Building**. An insulated (freeze-protected) metal building is located next to the pole barn. The building is currently used for storage of chemicals, waste oil, and trailer-mounted equipment. This building appears to be in good condition for continued use as a storage facility.
- **Residential Two-car Garage**. A smaller storage structure is located south of the metal building. The space is used as a wood-working shop and for storage of chemicals, flammable materials, and small equipment. This structure was not designed to be occupied and should have limited future use.

6.7.2 Evaluation of Future Needs

A detailed assessment of future needs was conducted. In general, the recommended approach is structured so that spaces with related activities and similar program needs are grouped together. This improves the efficiency of the building by combining heating, cooling, plumbing, and lighting needs, providing the most cost-effective long and short-term solution. A synopsis for each of the types of use is as follows.

Administration. Additional office space is required to accommodate the current and projected future administration staff. Areas that are currently combined within the existing building (e.g., conference, control, and break rooms, as well as the electrical and information technology equipment) require separate dedicated areas. In addition, a number of dedicated areas within the existing building require expansion, including the locker rooms.

Laboratory. Very specific requirements were established for each of the major laboratory areas, including the following areas: dedicated sample receiving and storage area, wet chemistry area including fume hood and glassware washer, separate operator laboratory area, metals testing area with high purity air and hard washable surfaces, nutrients testing area, and a microbiology laboratory including autoclave and incubator. Additional requirements include a work area for six laboratory technicians, an office for the laboratory manager, a library and research area, and dedicated records storage. Specific items that were considered included the acid recovery system, bottled gases, chemical storage, deionized water, and the hot water system. It was determined that renovation of the existing space to meet these needs would be more expensive than new construction, assuming existing space within the operations building could be renovated for other purposes.

Maintenance. In general, all of the existing indoor maintenance areas require expansion, including office space, the electrical shop, and high bay equipment storage. New areas that are needed include a dedicated fabrication shop, a new lubrication and service bay for maintaining facility vehicles, organized storage for flammable and toxic chemicals, and secure tool and parts storage. Addition of new drive-through service bays would also afford greater flexibility.

6.7.3 Development and Evaluation of Alternatives

Proposed improvements were developed based on the needs assessment and input from City staff. The proposed improvements included renovation of the existing operations building to meet administration needs, construction of a new water quality laboratory, renovation of the existing maintenance building, and construction of a new maintenance building. Two main alternatives were developed for the new water quality laboratory, while single proposals were developed for the remaining facilities. Recommended improvements were as described herein.

Administration. It is recommended that the existing operations building (including the existing water quality laboratory) be renovated to provide expanded administration and support facilities. The renovation would include three new offices, two new conference spaces, and dedicated control, break room, copy and storage, records, electrical, mechanical, and IT rooms. Overall, the changes would include a 37 percent increase in administration space and a 260 percent increase in office space.

Water Quality Laboratory. There were two main alternatives proposed for a new laboratory facility: Option A consists of use of the existing training building with two additions along the north and south sides of the building, and Option B consists of an addition along the east side of the operations building. Both options include similar facilities to meet the needs identified above and had similar costs, though Option B was slightly more expensive. Option B was selected as the preferred option, as it allows some facilities to be shared with the operations building, allows more of a cultural connection between lab employees and plant staff, and would allow the training building to be used to house staff during renovation of the operations building.

Maintenance. It is recommended that the existing maintenance building be renovated and a new maintenance building be constructed. The existing maintenance building would be renovated to include additional office and conference space, an expanded electrical repair area, and heavy and high bay equipment storage areas. A new facility is required to meet additional needs, including new drive through heavy equipment and lube bays, secure storage for parts and tools, a designated flammable storage area, and a new fabrication shop.

Table 6.22 displays estimated project costs associated with the non-process facilities alternatives.

6.7.4 Recommended Improvements

The non-process evaluation concludes that Option B for laboratory building improvements and the other associated building changes are recommended, though for non-economic reasons. These improvements include: renovations to the existing operations building, a new water quality laboratory addition to the operations building, renovations to the existing maintenance building, and a new maintenance building.

Table 6.22 City of Bend
Water Reclamation Facility Plan
Non-Process Facilities Estimated Cost

	Total	No Change or Light TI	Renov-ation	New Cons-truction	Option A	Option B
Facility Description	**SF**	**SF**	**SF**	**SF**	**$**	**$**
Existing Operations Building	7,160					
Existing Training Building	2,724					
Option A						
Operations	6,656	940	5,716		$1,775,140	
Lab at Training	4,905	1,626	1,266	2,013	$1,544,745	
Excavation @ North End	300				$10,000	
Option B						
Operations	6,656	940	5,716			$1,775,140
Lab Addition	3,620			3,279		1,918,215
Maintenance	13,013	7,420	2,186	3,407	$1,916,220	$1,916,220
Totals					**$5,246,105**	**$5,609,575**
Estimating Contingency @ 35%					$7,082,242	$7,572,926
Engineering/Legal/ Admin @ 25%					$8,852,802	$9,466,158
Project Totals					**$8,852,802**	**$9,466,158**

Cost Basis ($/sf)

- New Lab - $585/sf
- New Office - $370/sf
- TI - Light Office Reno - $125/sf
- Reno Office - $290/sf
- Reno Maintenance - $125/sf
- New Maintenance - $210/sf
- New Maintenance Bays - $335/sf

7.0 RECOMMENDED PLAN

7.1 Introduction

This section provides a summary of the recommended approach for expanding the existing treatment and disposal facilities to accommodate growth through 2030. The site layout for the recommended facilities is shown in Figure 7.1.

7.2 Project Selection

The plan is primarily based on expansion of the current facilities and processes with like systems, although some alterations to certain areas are included. Selected processes include:

- **Liquids Treatment**. Liquids treatment will continue to be based on the MLE activated sludge process. The addition of a filtrate sidestream aeration process will provide cost-effective expansion of process capacity. The addition of a contact stabilization mode to the existing basins will provide additional wet-weather flow capacity.
- **Disinfection**. The current gaseous chlorine disinfection system will be replaced with a liquid hypochlorite system and new third chlorine contact basin constructed.
- **Effluent Filtration**. The effluent filtration system will remain in place, to be expanded only in the event of a substantial growth in the reclaimed water program.
- **Effluent Disposal**. The evaporation/percolation ponds will continue to be used as the primary disposal system. Repairs to ponds 1 and 2 will provide sufficient capacity through the existing basins through the planning period. Expansion of the reclaimed water program is a continuing goal.

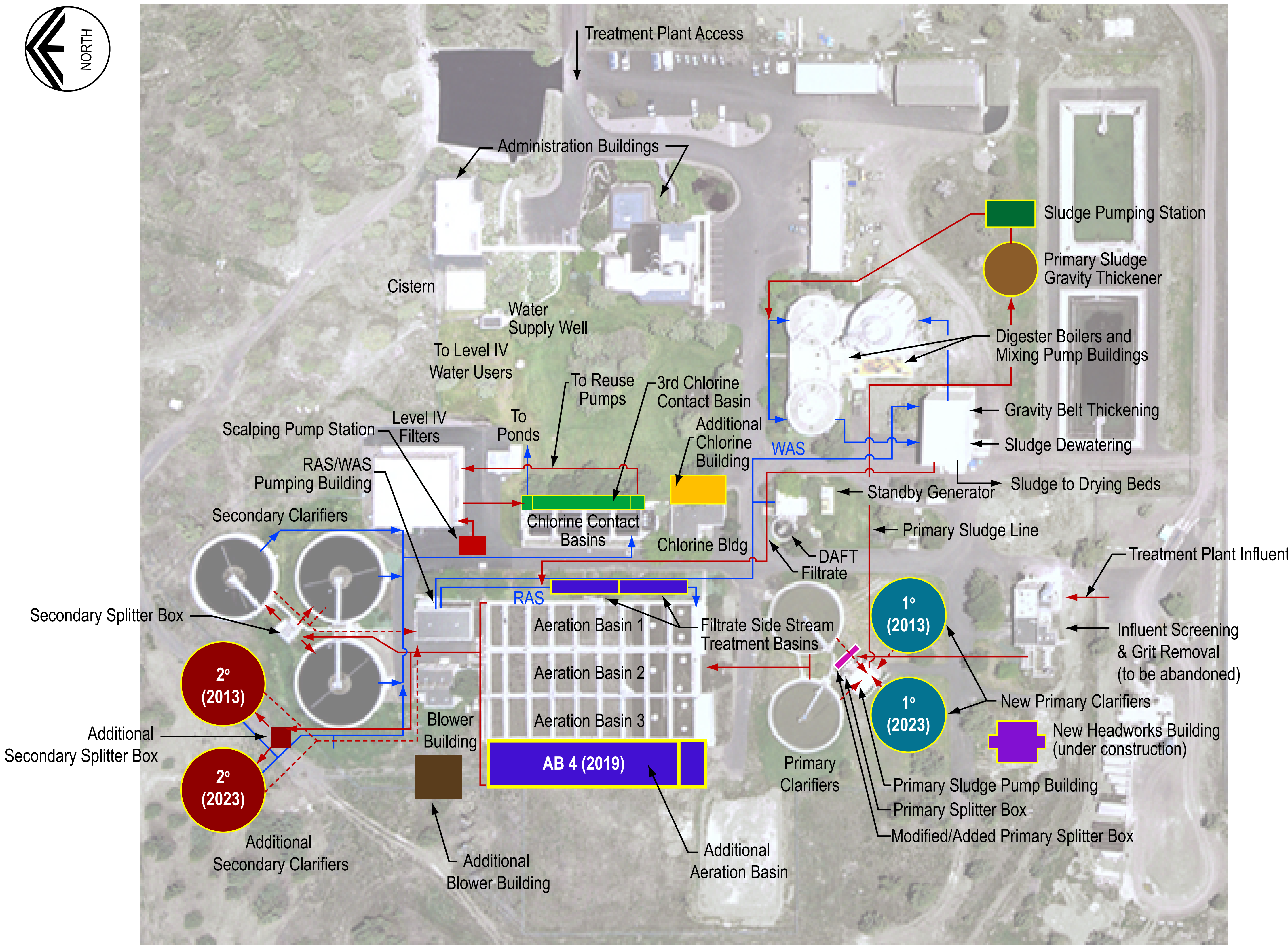


Figure 7
Recommended Facilities Expansion
WATER RECLAMATION FACILITIES PLAN
CITY OF BEND

bend408f7_7622.ai

carollo
Engineers...Working Wonders With Water™

BEND OREGON

- **Solids Processing**. Solids processing will continue with the current systems, except for the addition of gravity thickening for primary sludge. A “dual-use” BFP that can serve as a backup for both GBT thickening and dewatering is also recommended.

7.3 Project Descriptions and Design Data

The following are descriptions of the recommend process upgrades, expansions, and additions.

7.3.1 Liquids Treatment

Expanding the liquids treatment system by using the same basic processes now in place is recommended. Besides adding capacity to handle load increases associated with growth, the capability of the process to handle short-term wet weather flow events will be improved. Figure 7.2 presents the proposed process flow schematic for 2030. The elements of the liquids expansion during the planning period include:

- Addition of two primary clarifiers, with splitter box and sludge pumping.
- Addition of one aeration basin.
- Addition of filtrate side stream aeration basins.
- Addition of contact stabilization capability to aeration basins.
- Addition of two secondary clarifiers, with new flow splitter.
- Addition of blowers, including expansion of the blower building.
- Addition of a PAX feed system to aid in controlling filamentous organism growth.
- Expansion of RAS and WAS pumping capacity.
- Addition of one chlorine contact basin.
- Replacement of the existing gaseous chlorination system with liquid hypochlorite.

7.3.2 Effluent Disposal

It is recommended that the WRF continue to use the existing seepage ponds for effluent disposal. Recommendations over the planning period include:

- Keep existing ponds in service, with eventual use of Ponds 1 and 2 as Ponds 3A and 3B reach their capacity.
- Make repairs to defects in Ponds 1 and 2 to fully develop their capacity.
- Continue efforts to maximize the extent of the production and distribution of reclaimed water.

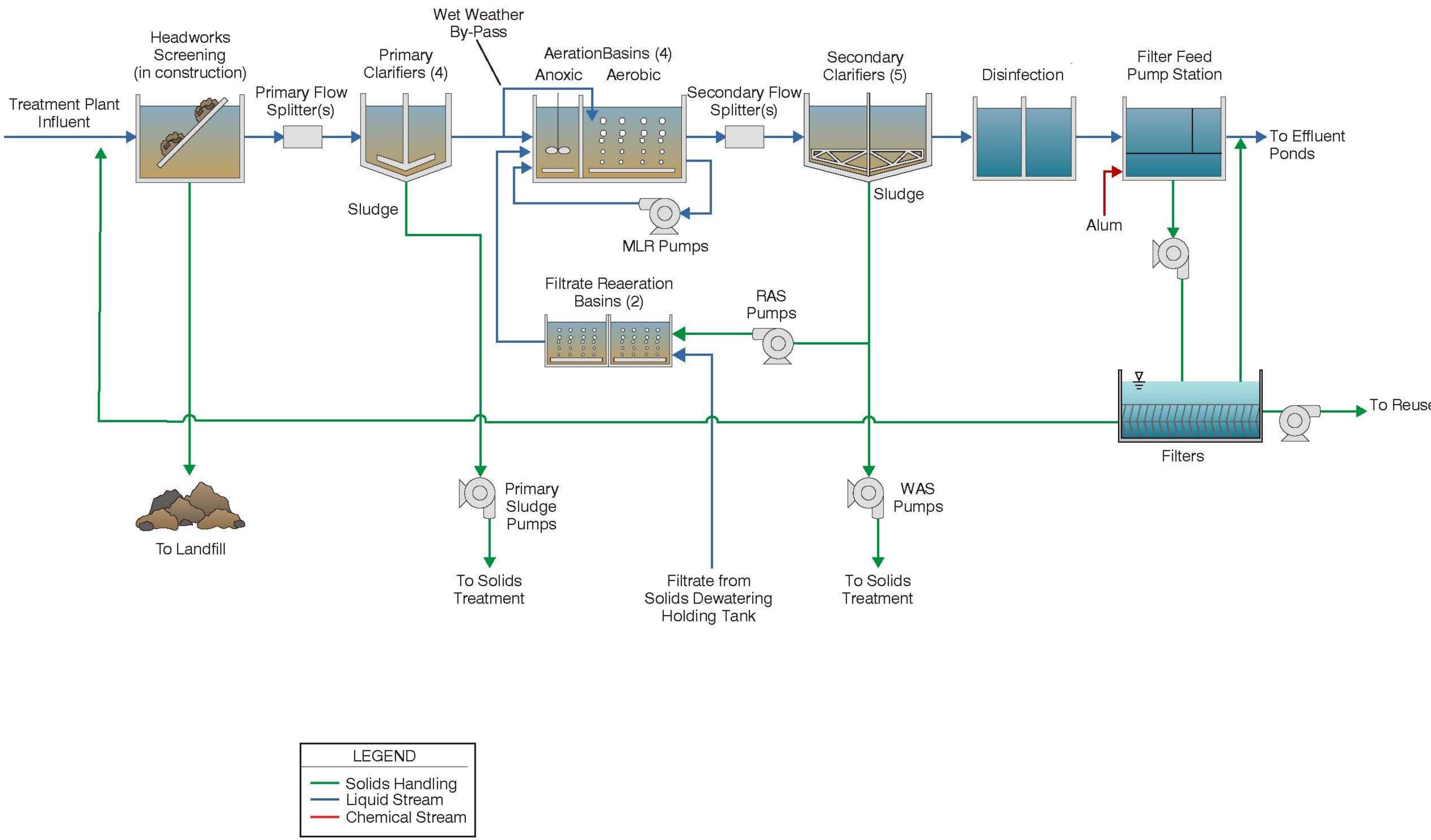


FIGURE 7.2
PROCESS FLOW SCHEMATIC
WATER RECLAMATION FACILITIES PLAN
CITY OF BEND

7.3.3 Solids Processing

It is recommended that the existing solids processes be expanded as needed to handle increasing solids loads. Gravity thickeners will be added for thickening of primary sludge. Recommended projects are as follows:

- Addition of two gravity thickeners for primary sludge, with pumping facilities.
- Addition of a second belt filter press. The unit will also serve as a backup to the GBT.
- Addition of a fourth digester.

7.3.4 Support Facilities

The current facilities available for administration, laboratory, and maintenance functions are insufficient to meet future needs. Recommended improvements are as follows:

- Remodel existing operations building to improve its utility.
- Expand the operations building to construct new lab facilities.
- Renovate existing maintenance building and construct new maintenance building.

The design criteria for the recommended projects are summarized in Table 7.1.

Table 7.1 Maximum Month Process Design Data for 2030
Water Reclamation Facilities Plan
City of Bend

Parameter	Unit	Value
Preliminary Treatment		
Type Screens	-	Perforated Plate Band Screens
Number of Units	-	3[1]
Width	ft	4'-8"
Opening	mm	6
Peak Capacity, Each	mgd	15
Primary Clarification		
Type of clarifier	-	Circular
Number of Units	-	4
Diameter	ft	65
Surface area per unit	sf	3,300
Total surface area	sf	13,200

[1] With space for a fourth screen

Table 7.1 Maximum Month Process Design Data for 2030, continued
Water Reclamation Facilities Plan
City of Bend

Parameter	Unit	Value
Hydraulic loading rate, ADMMF	gpd/sf	1000
Hydraulic loading rate, ADMMF (one unit out of service)	gpd/sf	1500
Hydraulic loading rate, PWWF	gpd/sf	3100
Aeration Basins		
Type of process	-	MLE
Number of basins	-	4
Volumes		
Total anoxic volume	MG	1.44
Total aerobic volume	MG	2.76
Total basin volume	MG	4.2
Hydraulic retention time @ ADMMF	hrs	8.4
Mixed liquor return pumps		
Number	-	4
Flow rate, each	gpm	6,000
Side Stream Aeration Basins		
Number of basins	-	2
Basin volume, each	MG	0.21
% of main stream AB volume	%	10
Total system aerobic solids retention time (main + side stream)		
Design minimum, 10 mg/L of TN, Average Annual Condition	days	5.1
Design minimum, 10 mg/L of TN, Winter Max. Month	days	5.4
Aeration System		
Type of aeration	-	Fine bubble diffusers
Number of blowers installed	-	6
Capacity, each	scfm	3,800
Power, each	HP	250

Table 7.1 Maximum Month Process Design Data for 2030, continued
Water Reclamation Facilities Plan
City of Bend

Parameter	Unit	Value
Secondary Clarification		
Type of clarifiers	-	Circular
Number of clarifiers	-	5
Diameter	ft	80
Side water depth	ft	2 units @12 3 units @ 14
Surface area per unit	sf	5,027
Total surface area	sf	25,135
Chlorine Contact Basins		
Number of basins	-	3
Volume per basin	gal	114,400
Total volume	gal	343,200
Hydraulic retention time		
Average annual flow - one basin out of service	min	30.2
Peak flow - all basins	min	15.7
Number of ton cylinders	-	6
Chlorine feed capacity	lb/hr	2,160
Chlorine dose at PWWF	mg/L	8
Effluent Filters		
Number of filters	-	2
Number of disks per filter unit	-	12
Type	-	Cloth Disk
Capacity		
Average, each	mgd	3
Peak, each	mgd	5
Filter Feed Pumps		
Number	-	2
Type	-	Submersible, VFD
Capacity, each	mgd	5
Horsepower, each	HP	50

Table 7.1 Maximum Month Process Design Data for 2030, continued
Water Reclamation Facilities Plan
City of Bend

Parameter	Unit	Value
Reclamation Pumps		
Number	-	2
Capacity, each	mgd	2.5
Horsepower, each		50
Alum Feed System		
Storage	gal	400 gal tote
Number of pumps	-	2
Type	-	Metering pumps
Capacity, each	gph	4.5
WAS Thickening		
Type of thickening	-	Gravity belt thickener
Number of units	-	1
Belt width	M	2
Solids loading rate	lb/hr	2,000
Recycle routing	-	Filtrate to primary clarifiers
Gravity Thickening		
Type of tanks	-	Circular
Number	-	2
Diameter	ft	35
Side water depth	ft	14
Surface area per unit	sf	962
Total surface area	sf	1,920
Solids loading rate	lb/sf/day	15
Recycle routing	-	Overflow to primary clarifiers
Anaerobic Digestion		
Number of units	-	4
Units 1 & 2		
Diameter	ft	52
Side water depth	ft	28
Volume per unit	kcf	55

Table 7.1 Maximum Month Process Design Data for 2030, continued Water Reclamation Facilities Plan City of Bend		
Parameter	**Unit**	**Value**
Units 3 & 4		
Diameter	ft	52
Side water depth	ft	52
Volume per unit	kcf	110
Total digester volume	kcf	330
Hydraulic retention time	days	26
Solids Dewatering		
Type of dewatering	-	Belt filter press
Number of units	-	2
Width of belt	m	2
Capacity per unit	lb/hr	1,400
Loading rate (24 hr/5 days/wk)	lb/hr/unit	910
Recycle routing	-	Through degasification basins to sidestream aeration basins

7.4 Project Cost Summary

The present day project costs for the recommended improvements are presented in Table 7.2. Projects are organized according to the projected schedule for implementation to meet capacity requirements. The CIP below gives one scenario for project implementation; additional refinement to the phasing plan by City staff is anticipated. This scenario does not include the addition of a fourth digester, as it very likely that the other solids handling improvements will allow it to be deferred past 2030.

7.5 Financing Strategy

Project financing and anticipated rate and system development charges are developed in the *Water and Wastewater System Development Charge Methodology Report* and the *Water and Sewer Rate Study Report.* The reports are being updated to reflect the WRF improvements in the CIP outlined below, as well as other sewer system collection and infrastructure improvements that were not evaluated as part of this Facilities Plan. The current financing strategy does not include the use of outside loan (e.g. State Revolving Funding) sources. The financing strategy may be modified to include SRF funding, provided that it is in City's best interest to do so and DEQ determines that the project is eligible.

7.6 Implementation Program and Schedule

The improvements shown in Table 7.2 can be arranged into logical packages. Each package, or construction phase, can be combined into a single project for design and construction. The contents of each proposed phase are listed in Table 7.3.

Table 7.2 Capital Improvements Phasing Schedule

Bend WRF Facilities Plan

Item Description	Construction Year					
	2008-2010	2011-2013	2014-2016	2017-2019	2020-2030	Total
Liquids Treatment						
Primary Splitter Box	$370					$370
Primary Clarifier	$2,320			$2,320		$4,640
Aeration Basin				$3,930		$3,930
Contact Stabilization Piping Mods	$310					$310
Blower Building	$580					$580
Blowers	$510			$510	$510	$1,530
Secondary Clarifier Splitter		$370				$370
Secondary Clarifier		$3,120			$3,120	$6,240
Side Stream Aeration Basins	$3,290					$3,290
Blower Piping Exterior	$330			$330	$330	$990
Influent Piping Mods	$1,210					$1,210
Secondary Clarifier Piping Mods		$1,960				$1,960
Upgraded RAS Pumps	$2,460					$2,460
Upgraded WAS Pumps				$1,640		$1,640
PAX Feed System	$510					$510
Chlorine Contact Basin	$1,120					$1,120
Hypochlorite System	$920					$920
Evaporation/Percolation Ponds						
Repairs to Ponds 1 and 2				$1,310		$1,310
Solids Treatment						
Gravity Thickener System			$3,300			$3,300
Belt Filter Press	$1,250					$1,250
Support Facilities						
Renovate Admin. Building		$3,550				$3,550
New Laboratory		$3,280				$3,280
Maintenance Upgrades		$2,550				$2,550
Miscellaneous						
Misc Site Improvements (5%)	$760	$740	$170	$500	$200	$2,370
Site Piping (5%)	$760	$740	$170	$500	$200	$2,370
TOTALS (In $1,000)	$16,700	$16,310	$3,640	$11,040	$4,360	$52,050

Table 7.3 Recommended Project Phasing Plan
Water Reclamation Facilities Plan
City of Bend

Phase/Timing	Description	Cost Estimate
<u>Phase 1 - 2008/2010</u>		
Influent Piping	Modify influent piping	$1,210,000
Primary clarification upgrade	Add primary clarifier; splitter box; sludge pumps	$2,690,000
Upgrade existing aeration basins	Add contact stabilization capability	$310,000
Upgrade blowers	Blower building expansion; one new blower; new piping	$1,420,000
Side stream aeration basins	Construct two new basins, including influent piping modifications	$3,290,000
RAS pumping upgrade	Install additional RAS pumps	$2,460,000
PAX feed system for filament treatment	Chemical tote storage area and feed pumps	$510,000
Chlorination system improvements	New chlorine contact basin; abandon existing gas chlorine system; expand chlorine building; hypochlorite system	$2,040,000
Solids treatment	Install additional belt filter press	$1,250,000
Site improvements	Allowance for miscellaneous site improvements in support of above projects	$1,520,000
Total Phase 1		**$16,700,000**
<u>Phase 2 - 2011/2013</u>		
Secondary clarification upgrade	Add secondary clarifier; splitter box; site piping modifications	$5,450,000
Support facilities improvements	Add laboratory; renovate admin. building; renovate existing maintenance building; add new maintenance building	$9,380,000
Site improvements	Allowance for miscellaneous site improvements in support of above projects	$1,480,000
Total Phase 2		**$16,310,000**

Table 7.3 Recommended Project Phasing Plan, continued
Water Reclamation Facilities Plan
City of Bend

Phase/Timing	Description	Cost Estimate
Phase 3 - 2014/2016		
Gravity thickeners	Two gravity thickeners and thickened sludge pumps	$3,300,000
Site improvements	Allowance for miscellaneous site improvements in support of above projects	$340,000
Total Phase 3		**$3,640,000**
Phase 4 - 2017/2019		
Primary Clarifier	Add primary clarifier	$2,320,000
New aeration basin	Add fourth aeration basin	$3,930,000
Upgrade blowers	One new blower with piping	$840,000
WAS pumping upgrade	Install additional WAS pump	$1,640,000
Evaporation/percolation pond repairs	Repair leaks in Ponds 1 and 2	$1,310,000
Site improvements	Allowance for miscellaneous site improvements in support of above projects	$1,000,000
Total Phase 4		**$11,040,000**
Phase 5 - 2020/2024		
Upgrade blowers	One new blower with piping	$840,000
Secondary clarification upgrade	Add secondary clarifier	$3,120,000
Site improvements	Allowance for miscellaneous site improvements in support of above projects	$400,000
Total Phase 5		**$4,360,000**