Appendices

Water Reclamation Facilities Plan

City Project No. SW0701

VOLUME 2

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VISION ENGINEERING

City of Bend

Water Reclamation Facilities Plan

TECHNICAL MEMORANDUM NO. 1
FLOW AND WASTE LOAD PROJECTIONS

April 2008

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CITY OF BEND

WATER RECLAMATION FACILITIES PLAN

TECHNICAL MEMORANDUM
NO. 1

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FLOW AND WASTE LOAD PROJECTIONS

1.0 INTRODUCTION

This technical memorandum (TM) presents an evaluation of historical wastewater flows and loads at the Bend Water Reclamation Facility (WRF) and establishes flow and load projections associated with future growth. The City's population projections are based upon information developed by the Population Research Center at Portland State University and are based in part upon estimates of the Oregon Office of Economic Analysis average growth rates for Deschutes County. These are consistent with the population projections used for other City planning efforts.

The forecasted growth over the planning period should be reviewed on a regular basis and adjusted consistent with actual population and service connection data. Future flow and pollutant loading estimates should be revised accordingly.

The following terminology is used in characterizing wastewater flows in this analysis:

1. Average Annual Flow (AAF) - the average daily flow for an entire year.
2. Average Day Maximum Month Flow (ADMMF) - the average daily flow for the peak month of the year. Often referred to as "Peak Month."
3. Peak Day Flow (PDF) - the maximum or peak flow recorded over an entire day.
4. Peak Dry Weather Flow (PDWF) - the maximum peak hourly flow during non-storm events.
5. Peak Wet Weather Flow (PWWF) - the maximum peak hourly flow at any one hour period during the year, associated with abnormal and infrequent (i.e. 10 to 20 year return frequency) rainfall events. Often referred to as maximum or peak hydraulic flow rate.

2.0 POPULATION PROJECTIONS

Population projections were provided by the City of Bend extending out to the year 2030. The projections were divided into sewered and unsewered population components. The populations are tabulated in Table 1.

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.

Table 1	Service Area Population Projections Water Reclamation Facilities Plan City of Bend		
Year	**Projected Total Population**	**Estimated Unsewered Population**	**Estimated Sewered Population**
2007	73,948	9,290	64,658
2008	76,551	8,774	67,777
2009	79,245	8,258	70,987
2010	81,242	7,742	73,501
2011	83,135	7,225	75,910
2012	85,075	6,709	78,366
2013	87,054	6,193	80,861
2014	89,083	5,677	83,406
2015	91,158	5,161	85,997
2016	92,981	4,645	88,336
2017	94,841	4,129	90,712
2018	86,738	3,613	93,125
2019	98,673	3,097	95,576
2020	100,646	2,581	98,066
2021	102,337	2,064	100,273
2022	104,056	1,548	102,508
2023	105,804	1,032	104,772
2024	107,582	516	107,066
2025	109,389	0	109,389
2030	119,000	0	119,000

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

3.0 CURRENT FLOWS AND LOADS

Table 2 presents a summary of the current plant influent flows and loadings, based on an analysis of data over the period of 2005-2006, during which influent loadings were reasonably consistent. The exceptions are the influent BOD and TSS concentrations, which are based on sampling results after April 2006, when the influent sampling location was changed to avoid sampling of plant recycle flows.

Influent flows were evaluated by reviewing 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 of change making correlation between flow, load, and population uncertain. Since the end of 2004, flow and load to the WRF represent a more stable trend and, therefore, increase the certainty of estimates.

The City operates a relatively new sewer system with low infiltration and inflow and typically low precipitation events. However, in December 2005 an unusually intense rain event took place that inundated the storm system in Bend. Manhole covers were opened to drain water from streets in an effort to relieve local flooding, resulting in very high flows that overtopped clarifiers and other facilities at the WRF. The flow was much higher than the measurement range of the influent flow meters, but was estimated by City staff at 18 to 22 mgd.

Instead of using the peak wet weather flow (PWWF) that resulted from intentionally draining storm water into the sanitary sewer system, the current PWWF was provided by the City of Bend based upon the collection system hydraulic model that has been recently developed by the City as part of the 2006 Collection System Master Plan. The current PWWF was estimated based upon Peak Dry Weather Flow with additional rain induced infiltration and inflow resulting from a 10-year, 24-hour storm event. The 10-year, 24-hour storm used to estimate peak wet weather flow has a total rainfall depth of 1.3 inches with a Soil Conservation Service (SCS) Type II distribution.

4.0 FLOW AND INFLUENT LOAD PROJECTIONS

4.1 Average Annual Flow Projections

Average Annual Flow projections are based upon the projections of served population and current per capita flow contributions with ratios applied to account for commercial and industrial contributions.

The City provided summaries of previous work from reports (*Collection System Master Plan*, MWH and *Solids Master Plan*, Vision Engineering), analyzing 2004 and 2005 flow and planning data within the Urban Growth Boundary. Pertinent parts of those analyses are reproduced and expanded in this plan.

Unit residential contributions were calculated based on flow and population estimates, as reported in the *Collection System Master Plan*. The average contribution per residential unit was calculated to be 165 gallons per day (gpd), based on estimated 2005 residential flows of 3.90 mgd and a total of 23,694 sewered residential connections at the end of 2004. Planning data provided by the City indicate approximately 2.4 persons per residential unit, yielding a residential contribution of approximately 69 gallons per capita per day (gpcd).

Table 2 Summary of Current Flows and Loads Water Reclamation Facilities Plan City of Bend		
Parameter	**Units**	**Value**
Current Flows		
Average Daily Average Flow (AAF)	mgd	5.9
Average Daily Max Month Flow (ADMMF)	mgd	6.5
Peak Day Flow (PDF)	mgd	7.4
Peak Dry Weather Flow (PDWF)	mgd	11.6
Peak Wet Weather Flow (PWWF)	mgd	16.0
Hydraulic Peaking Factors (HPF)		
ADMMF / AAF	--	1.10
PDF/AAF	--	1.25
PDWF / AAF	--	1.97
Average Influent Concentrations @ AAF		
BOD_5	mg/L	350
TSS	mg/L	344
TKN[5]	mg/L	49
Ammonia-N[5]	mg/L	22
Organic-N[5]	mg/L	27
Alkalinity	mg/L	260
Maximum 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
Temperature and pH		
30 day minimum	°C	13.5
30 day maximum	°C	23
Average annual	°C	17
Average pH	--	7.26

The City provided a check of the residential wastewater contribution amount by examining the average winter water consumption for residential customers in December, January, February, and March of 2004 and 2005. Unit consumption was reported as 177 gpd and 151 gpd in years 2004 and 2005, respectively, for a two-year average of 164 gpd. This correlates well with the WRF influent flow and population data. Therefore, the residential portion of influent flow projection is based upon a contribution of 69 gpcd.

Although this per capita contribution is low compared with text book values, it represents only the residential contribution from a collection system that is relatively new and constructed in an area that receives a small amount of precipitation and has little shallow groundwater that could contribute to baseline infiltration.

Commercial and industrial flow contributions are projected based upon the 2005 ratios of contribution to total flows and the projected population for each year within the planning period. Table 3 summarizes the AAF projections for residential, and commercial and industrial flows for 2010, 2020, and 2030. The total commercial and industrial flow projection (AAF) includes the anticipated contribution from the Deschutes Brewery.

Table 3 Average Annual Flow Projections, mgd
Water Reclamation Facilities Plan
City of Bend

Year	Residential	Deschutes Brewery	Total Commercial & Industrial	Total
2010	5.1	.07	1.7	6.7
2020	6.7	.08	2.2	9.0
2030	8.2	.08	2.7	10.9

4.2 Other Flow Projections

Future Average Day Maximum Month Flows (ADMMF) and Peak Day Flows (PDF) were determined by projecting AAF based upon changes in the served population throughout the planning period and then applying the same peaking factors that are currently observed at the WRF.

Future Peak Dry Weather Flows (PDWF) were determined by projecting AAF based upon changes in the served population throughout the planning period and then applying the same dry weather peaking factor (PDWF/AAF) as is currently observed at the WRF. This calculation resulted in projections of future PDWF.

2030 Peak Wet Weather Flow (PWWF) was projected based upon modeling the anticipated development of the collection system to serve the 2030 population projections. Murray Smith & Associates modeled the system using the model that was developed as part of the 2006 Collection System Master Plan. The 2030 PWWF was estimated based upon the projected 2030 PDWF with additional rain induced infiltration and inflow resulting from a 10-year, 24-hour storm event. The 10-year, 24-hour storm used to estimate peak wet weather flow has a total rainfall depth of 1.3 inches with a Soil Conservation Service (SCS) Type II distribution.

The additional 7.7 mgd of flow resulting from this 10-year, 24-hour storm event was added to the 2030 PDWF to project the 2030 PWWF. Projected PWWF in other planning years were estimated by interpolating the incremental difference between PWWF and PDWF at current conditions and at 2030 conditions and adding that calculated incremental difference to the PDWF to arrive at the PWWF.

5.0 WRF INFLUENT POLLUTANT LOAD PROJECTIONS

WRF influent pollutant load projections of pounds of BOD5, TSS, TKN, and NH4-N are population-based, and were derived by examining the raw treatment plant data and projections of sewered population served by the WRF. The loadings are an aggregate of residential, commercial, and industrial sources and include the anticipated future loadings from the Deschutes Brewery. The influent pollutant loading projections are based on the assumption that the relative contributions of residential and commercial and industrial sources will remain constant throughout the planning period. Therefore, peaking factors, developed based upon current flows and loadings, as presented in Table 2, were used were used to project future WRF influent pollutant load design conditions.

6.0 SUMMARY

Table 4 provides the summary of flow and waste load projections for the WRF up to the year 2030. A detailed year-by-year summary of the projections is provided in Table 5.

Table 4 Flow and Waste Load Projections Summary
Water Reclamation Facilities Plan
City of Bend

Parameter	Year 2010	Year 2020	Year 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

Table 5 Detailed Flow and Loading Projections
Water Reclamation Facilities Plan
City of Bend

Year	Total Population	Estimated Unsewered Population	Estimated Sewered Population	Total Influent Flows, mgd				Total Annual Average Loadings, pounds/day					Total Average Day Maximum Month Loadings, pounds/day				
				AAF	ADMMF	PDF	PDWF	BOD	TSS	TKN	Amm-N	Org-N	BOD	TSS	TKN	Amm-N	Org-N
2007	73,948	9,290	64,658	5.9	6.5	7.4	11.6	17,300	17,000	2,400	1,600	1,334	21,100	23,120	3,100	2,000	1,700
2008	76,551	8,774	67,777	6.2	6.8	7.8	12.2	18,100	17,800	2,500	1,700	1,398	22,100	24,200	3,300	2,100	1,800
2009	79,245	8,258	70,987	6.5	7.1	8.1	12.7	19,000	18,700	2,700	1,700	1,500	23,200	25,400	3,500	2,100	2,000
2010	81,242	7,742	73,500	6.7	7.3	8.4	13.1	19,700	19,300	2,800	1,800	1,500	24,000	26,200	3,600	2,300	2,000
2011	83,135	7,226	75,909	7.0	7.6	8.7	13.6	20,300	19,900	2,800	1,900	1,600	24,800	27,100	3,600	2,400	2,100
2012	85,075	6,710	78,366	7.2	7.8	9.0	14.1	21,000	20,600	2,900	1,900	1,600	25,600	28,000	3,800	2,400	2,100
2013	87,054	6,193	80,861	7.4	8.1	9.3	14.5	21,600	21,200	3,000	2,000	1,668	26,400	28,800	3,900	2,500	2,200
2014	89,083	5,677	83,406	7.6	8.3	9.5	15.0	22,300	21,900	3,100	2,000	1,700	27,200	29,800	4,000	2,500	2,200
2015	91,158	5,161	85,997	7.9	8.6	9.8	15.4	23,000	22,600	3,200	2,100	1,800	28,100	30,700	4,200	2,600	2,300
2016	92,981	4,645	88,336	8.1	8.8	10.1	15.9	23,600	23,200	3,300	2,200	1,800	28,800	31,600	4,300	2,800	2,300
2017	94,841	4,129	90,712	8.3	9.1	10.4	16.3	24,300	23,800	3,400	2,200	1,900	29,600	32,400	4,400	2,800	2,500
2018	96,738	3,613	93,125	8.5	9.3	10.7	16.7	24,900	24,500	3,500	2,300	1,900	30,400	33,300	4,600	2,900	2,470
2019	98,673	3,097	95,576	8.8	9.5	10.9	17.2	25,600	25,100	3,600	2,300	2,000	31,200	34,100	4,700	2,900	2,600
2020	100,646	2,581	98,065	9.0	9.8	11.2	17.6	26,200	25,800	3,700	2,400	2,000	32,000	35,100	4,800	3,000	2,600
2021	102,337	2,065	100,272	9.2	10.0	11.5	18.0	26,800	26,351	3,800	2,500	2,100	32,700	35,800	4,900	3,100	2,700
2022	104,056	1,549	102,508	9.4	10.2	11.7	18.4	27,400	26,900	3,800	2,500	2,100	33,400	36,600	4,900	3,100	2,700
2023	105,804	1,032	104,772	9.6	10.5	12.0	18.8	28,000	27,500	3,900	2,600	2,200	34,200	37,400	5,100	3,300	2,900
2024	107,582	516	107,066	9.8	10.7	12.3	19.2	28,600	28,100	4,000	2,600	2,200	34,900	38,200	5,200	3,300	2,900
2025	109,389	0	109,389	10.0	10.9	12.5	19.6	29,200	28,700	4,100	2,700	2,300	35,600	39,000	5,300	3,400	3,000
2030	119,000	0	119,000	10.9	11.9	13.6	21.4	31,800	31,300	4,500	2,900	2,500	38,800	42,600	5,900	3,600	3,300

City of Bend

Water Reclamation Facilities Plan

TECHNICAL MEMORANDUM NO. 2
FACILITY SITE EVALUATION

April 2008

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FACILITY SITE EVALUATION

1.0 PURPOSE OF TECHNICAL MEMORANDUM

The purpose of this Technical Memorandum (TM) is to present the findings and recommendations of the Facility Site Evaluation conducted for the City of Bend as part of the Water Reclamation Facilities Plan. The major tasks completed as part of this effort are as follows:

- Conduct a condition assessment of the assets at the Water Reclamation Facility (WRF),
- Determine the remaining useful life of each asset,
- Identify potential improvement projects for the WRF through the year 2030, and
- Identify the potential impact of recent building code changes on the use, renovation, and/or replacement of the existing assets.

2.0 OBJECTIVES

The objective of this task is to identify the condition of the WRF assets and to provide an engineering estimate of the assets' remaining useful life. This effort is intended to serve as a basis for the City's long-term planning by identifying the need and recommended timing of replacement of the WRF assets.

3.0 ASSET MANAGEMENT TERMS AND DEFINITIONS

Asset management terms used throughout this TM are summarized in Table 1.

Table 1	Terms and Definitions Facility Site Evaluation City of Bend
Term	**Definition**
Asset	A physical component of a facility that has value and enables service to be provided
Asset Management Program	A program or plan developed for the management of one or more infrastructure assets that combines multi-disciplinary management techniques (including technical and financial) over the lifecycle of the asset in the most cost-effective manner to provide a specified level of service. A significant component of the plan is a long-term cash flow projection for the activities.
Economic Life	The period from the acquisition of the asset to the time when repair of the asset ceases to be the lowest cost alternative to satisfy a particular level of service.
Economic Remaining Useful Life	The remaining period in which the asset value is greater than the cost of repair. When the asset value reaches approximately half of its original value, the cost for maintenance or repair of the asset increases considerably, resulting in an exponentially decreasing investment rate of return. This is the optimal economic point at which to replace the asset.
Evaluated Remaining Useful Life	The remaining number of years until the physical failure of the asset, which incorporates the current condition of the asset.
Remaining Useful Life	The predicted remaining number of years until the physical failure of the asset, independent of the asset's existing condition.

4.0 CONDITION ASSESSMENT

A condition assessment was conducted for each of the major assets at the WRF. These assets were assessed by a multi-discipline engineering team licensed and experienced in the areas of process, mechanical, structural, and electrical engineering. At each facility, the assessment team inspected the aboveground assets and interviewed operations and maintenance (O&M) personnel regarding the operation and maintenance history of the major assets.

The information gathered during the condition assessment provides a standardized record of the asset condition specific to each discipline. Component information such as the manufacturer, asset identification number, and installation year were also noted, when possible. In addition, other relevant information, such as recent performance history, was gathered and the existing condition of all assets was documented with digital photos. To standardize the process of determining an asset's condition, specific discipline-related questions were addressed for each asset.

4.1 Condition

The ranking scale used in the condition assessment of each asset is shown in Table 2. This scale is an internationally accepted, industry-wide standard for designating asset condition. The condition ranking is related to the percentage of the value of an asset needed to repair or rehabilitate the asset to return it to its original condition. The repair percentages associated with each condition ranking are used to calculate both the evaluated remaining useful life and economic remaining useful life of all evaluated assets. The condition of the major assets at each facility is presented in Appendix A. The assets in the worst condition are listed in Table 3.

Table 2 Asset Condition Ranking Scale [1]
Facility Site Evaluation
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 Assets in Poor Condition (Condition Rankings 4 and 5)
Facility Site Evaluation
City of Bend

Process	Asset	Condition	Comments
Headworks	Lime Feeder	5	Gearbox has been rebuilt multiple times because of poor quality lime (rocks present). Screw is too small.
Headworks	Electrical Room	5	Original construction. Corroded conduit. Abandoned electrical panels should be removed.
Headworks	MCC-H	4	Original construction, past its useful life.
Septage Receiving	Rotary Screw Air Compressor	5	Run at maximum capacity. Oil bypasses pickup tube resulting in significant oil leaks.

Table 3 Assets in Poor Condition, continued
Facility Site Evaluation
City of Bend

Process	Asset	Condition	Comments
Septage Receiving	Mini Power Center	5	Corrosion on enclosure and conduit, no expansion for additional loads.
Septage Receiving	Septage Influent Submersible Pump #1	4	Ragging Issues
Septage Receiving	Submersible Pump #2	4	Generally in poor condition. Highly corrosive environment.
Septage Receiving	Submersible Pump #3	4	Generally in poor condition. Highly corrosive environment.
Septage Receiving	Septage Pump Control Panel	4	Some corrosion on enclosures and conduit.
Primary Clarification	Rake Arm #1 / Interior Mechanisms	4	Significant corrosion. Mastic is peeling away. Mechanism was adjusted after poor installation. Skimmer has been rebuilt. Scum trough clogs. High grease. Drive replaced in 2005.
Primary Clarification	Rake Arm #2 / Interior Mechanisms	4	Significant corrosion. Mastic is peeling away. Mechanism was adjusted after poor installation. Skimmer has been rebuilt. Scum trough clogs. High grease. Drive replaced in 2005.
Primary Clarification	Primary Sludge Pump #1	4	Pumps #1 and #2 don’t run well together. Original progressive cavity pumps were replaced with air diaphragm pumps in 1995.
Primary Clarification	Primary Sludge Pump #2	4	Pumps #1 and #2 don’t run well together. Original progressive cavity pumps were replaced with air diaphragm pumps in 1995.
Primary Clarification	External Lighting, Conduit, and Control Stations	4	Missing cover plates, burnt and abandoned wiring, visible corrosion.
Primary Clarification	MCC-PSP	4	Original construction, near end of expected useful life.
Primary Clarification	DRC Controller Panels	4	Original construction, near end of expected useful life.
Primary Clarification	Sample Pump Panel	4	Original construction, near end of expected useful life.
Primary Clarification	Internal Conduit and Lighting	4	Conduit corroding near leaking overhead drain.

Table 3 Assets in Poor Condition, continued
Facility Site Evaluation
City of Bend

Process	Asset	Condition	Comments
Aeration	Blower #1	5	Needs new motor and blower overhaul.
Aeration	Blower #2	4	Needs complete overhaul. Motor is new from 2003.
Aeration	Blower #3	4	Needs complete overhaul. Motor is new from 2006.
Aeration	Mixed Liquor Pump #1	4	Difficult to maintain (bearing, seal, impeller failure). Difficult to get replacement parts (3-4 months).
Aeration	Mixed Liquor Pump #2	4	
Aeration	Mixed Liquor Pump #3	4	
Secondary Clarification	RAS Sump Pump #1	5	Bearings are gone.
Secondary Clarification	RAS Sump Pump #2	5	Bearings are gone.
RAS/WAS Building	RAS/WAS Indicator Panels	5	Original construction. Many modifications have been made, many open holes visible.
RAS/WAS Building	RAS Pump VFDs	4	Original construction, near end of expected useful life.
RAS/WAS Building	MCC-RAS	4	Original construction, near end of expected useful life.
Blower Building	Lighting	5	Poor lighting. Building reaches up to 109°F in summer.
Blower Building	Switchboard B	4	Original construction. New main breaker and metering in 2001.
Blower Building	MCC-B	4	Original construction. Near end of expected useful life.
Disinfection	External Stations at CCBs	5	Original construction. Corroded conduit and controls.
Dissolved Air Flotation	Recirculation Pump #1	5	Seal is bad; needs to be rebuilt.
Dissolved Air Flotation	Recirculation Pump #2	5	Seal is bad; needs to be rebuilt.
Dissolved Air Flotation	Flowmeter	5	Foxboro flowmeter: Non-functional.
Dissolved Air Flotation	Progressive Cavity Pump #1	4	Difficult to get replacement parts; hasn't been rebuilt in 10 years.

Table 3 Assets in Poor Condition, continued
Facility Site Evaluation
City of Bend

Process	Asset	Condition	Comments
Dissolved Air Flotation	Progressive Cavity Pump #2	4	Difficult to get replacement parts; hasn't been rebuilt in 10 years.
Dissolved Air Flotation	Recycle Sludge Tank	4	Interior inspected in 2006; lots of scale on inside, wall thickness is deteriorating.
Dissolved Air Flotation	Auxiliary Distribution Switchboard A	4	Original construction. Near end of expected useful life.
Dissolved Air Flotation	MCC-W	4	Original construction. Near end of expected useful life.
Dissolved Air Flotation	External Control Stations and Conduit	4	Corrosion visible.
Digestion	Sediment Trap #1	5	Significant deterioration; rotted through.
Digestion	Sediment Trap #2	5	Significant deterioration; rotted through.
Digestion	HVAC Gas Master (Digester 3)	5	System has never worked well. The circulation pumps have been rebuilt, as have the heat exchangers. The controls have been overridden by Ken Hanson at Limited Main Electric.
Digestion	Digester #3 Feed Pump	4	No redundancy. Has had multiple seal failures. Difficult to operate (clogging issues); cannot bypass system. However, new screens at headworks should resolve the clogging problems.

Table 3 Assets in Poor Condition, continued
Facility Site Evaluation
City of Bend

Process	Asset	Condition	Comments
Digestion	Boiler #1	4	Propane gas & air mixer does not work properly - low fuel pressure problems. This causes problems in the burner and control system. If the propane gas and air were replaced with natural gas, it is likely that the problems with the boiler would be resolved, as the boiler and heat exchanger themselves are in fair condition. Boiler efficiency is good.
Digestion	Boiler #2	4	
Digestion	Boiler Conduit	4	Original construction; past its expected useful life.
Digestion	Boiler Instrumentation and Controls	4	Original construction; past its expected useful life.
Percolation Ponds	Percolation Pond #1	4	Rock outcroppings not sufficiently covered by soil, therefore, these provide a direct conduit into the groundwater table.
Degas	Motor Starters and Controls	4	Original construction. Near end of expected useful life.
Plant Water	Plant Water Pump #1	5	Generally in poor condition.

Table 3 Assets in Poor Condition, continued
Facility Site Evaluation
City of Bend

Process	Asset	Condition	Comments
Plant Water	Plant Water Pump #2	5	Running above rated speed; motors need constant rebuilding.
Plant Water	Plant Water Pump #3	5	Has been out of service for the last 3 months for repairs.
Plant Water	Chlorine Residual Analyzer Pump	5	Has been removed, not in use.
Plant Water	Lighting, HVAC	5	Original construction, past its useful life.
Plant Water	MCC-PW	5	Original construction, past its useful life.
Plant Water	Chlorine Residual Analyzer Panel	5	Has been removed; not in use.
Plant Water	PLC Panel	4	Original construction. Near end of expected useful life.
Drinking Water	Deep Well Submersible Pump	4	Was rebuilt in 1988.

The remaining facilities assessed as part of this effort were determined to be, overall, in good to fair condition (Condition Rankings 1 to 3). A complete list of the assets evaluated as part of the condition assessment can be found in Appendix A.

5.0 REMAINING USEFUL LIFE

The remaining useful life of the assets can be determined using either an accounting-based or an engineering-based approach. The accounting-based approach typically utilizes a straight-line depreciation method, which is based on the year of installation and the expected useful life of the asset. The advantage of this approach is its simplicity; however, it does not account for operations and maintenance practices.

The engineering-based approach includes two methods for estimating remaining useful life: evaluated and economic remaining useful life. Evaluated remaining useful life incorporates the effects of operations and maintenance practices, as reflected in the asset's condition, to determine the remaining useful life. Economic remaining useful life expands on this premise, incorporating condition as well as economic considerations regarding the appropriate level of investment in relation to rehabilitation or replacement timing.

To account for operations and maintenance practices, an engineering-based approach was used.

5.1 Evaluated Remaining Useful Life

As previously stated, the evaluated remaining useful life incorporates the condition of the asset in estimating the asset's remaining useful life. The equation for evaluated remaining useful life is as follows:

Evaluated Remaining Useful Life = Original (expected) Useful Life * (1 - Condition Fraction)

Note: Condition fraction is equivalent to the percentage of asset requiring repair (as seen in Table 3).

This metric is often used to determine when to replace an asset, as it represents the "true" remaining life of the asset, incorporating its expected useful life and the existing condition of the asset.

The evaluated remaining useful life of the City's assets can be found in the Appendix.

5.2 Economic Remaining Useful Life

Like evaluated remaining useful life, economic remaining useful life incorporates the asset's existing condition and additionally addresses financial considerations related to the timing of renewal and replacement (R&R) projects. Economic useful life is the time period in which the asset value is greater than the cost of repair. This distinction from the evaluated remaining useful life (which is based solely on an asset's existing condition) is that economic useful life better defines the optimal timing for asset replacement based on cost, a primary objective of asset management. The equation for economic remaining useful life is provided below:

Economic Remaining Useful Life = Original Useful Life / 2 – (Original Useful Life * Condition Fraction)

The premise of economic remaining useful life is that it may be more cost effective to replace an asset prior to the end of its projected life span. For example, even though an asset may have several years of functional service, it may be very costly to operate and maintain during those years of service compared to a new (replacement) asset. Similarly, for highly critical assets, running the asset to failure may have significant cost implications (i.e., high costs for emergency repair), or other non-cost implications (i.e., failure to meet service level objectives).

The economic remaining useful life of the City's assets can be found in the Appendix.

6.0 POTENTIAL CODE IMPACTS

Another factor to consider in the implementation timing of the City's future R&R projects is the impact of recent code revisions and new requirements. These 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*) are presented herein.

6.1 INTERNATIONAL BUILDING CODE 2003[1]

The State of Oregon adopted the *2003 International Building Code* (IBC) in October 2004, and is scheduled to adopt the 2006 IBC in April 2007. Both of these adoptions include amendments to the model code that are specific to the State of Oregon. The model code (IBC) and the State of Oregon amendments make up the Oregon building code, known as the Oregon Structural Specialty Code.

One of the major differences between the IBC and the previous model building code used in Oregon, the Uniform Building Code (UBC), is that the IBC no longer duplicates the design code for major building materials (steel, concrete, masonry, and wood) in its text. Instead, it incorporates the material design codes by reference. This means that the design codes, such as ACI 318 *Building Code Requirements for Structural Concrete*, are considered part of the model code, even though their provisions are not found in the text of the IBC. This method of incorporating by reference also makes it easier to adopt specialized codes, such as ACI 350 *Code Requirements for Environmental Engineering Structures*, into the building code. The UBC had little, if anything to say about the special requirements of a wastewater treatment facility. The IBC specifically requires that design of facilities like the WRF be accomplished using the specialized codes, like ACI 350.

Another major difference between the UBC and the IBC is how lateral loads, specifically wind and seismic loads, are computed. Wind and seismic forces are generally higher for the IBC than those given in the UBC. Wind loads are now computed using a wind speed defined by the fastest 3-second gust. The UBC used a wind speed from the "fastest mile" or the average speed of the wind to cover one mile. This is not necessarily the maximum wind speed, which the 3-second gust more accurately matches. Therefore, design wind speeds used in the UBC are not compatible with the design wind speeds in the IBC. In addition, the IBC has more provisions for wind pressures at wall and roof discontinuities. These discontinuities include such items as corners, eaves, and ridgelines. Studies have shown that the pressure from wind at discontinuities can increase dramatically, anywhere from 15% to 200% depending on the configuration.

1 At the time of the development of this Technical Memorandum, IBC 2006 had not yet been adopted.

For seismic loads, the IBC no longer uses the concept of seismic zones. Instead, a more site-specific approach is used. Under the UBC, the entire area within the Bend city limits was considered Seismic Zone 2b. This means that anywhere in the Bend area, the same seismic force would be computed for a given structure. In contrast, the site-specific IBC approach considers such factors as soil type, soil strata, location of bedrock, and the proximity of known fault lines. Thus, a structure at the WRF may have a lesser or greater seismic load than the same structure located in downtown Bend. The IBC also has more stringent requirements for the inclusion of vertical seismic loads. Under the UBC, it was possible to ignore vertical seismic loads under certain conditions. Under the IBC, this is no longer allowed.

Finally, the last major change in the IBC over the UBC is in the area of quality control during construction. Many items now require special inspection during construction. This includes the installation of anchor bolts, installation of concrete anchors (both expansion bolts and epoxy grouted bolts), reinforcing steel in concrete and masonry, concrete placement, masonry erection, and the grouting of masonry. Special inspection is to be performed by a person who has been trained and certified to inspect the type of construction being built. Thus, it is possible that one person will inspect the anchor bolts, while a different person will inspect the concrete placement. The IBC requires that the special inspector be independent from the contractor and Engineer of Record.

Applicability to Bend WRF Facilities

The code changes identified above 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, as more items require special inspection. The requirement for increased special inspection could also potentially affect the construction schedule.

6.2 NFPA 70 - NATIONAL ELECTRICAL CODE

The National Electrical Code (NEC) defines three categories for application of the Code as listed in Article 80.9:

1. New Installations.
2. Existing Installations.
3. Additions, Alterations, or Repairs.

The NEC allows existing installations that do not comply with the provisions of the current code to continue in use unless the Authority Having Jurisdiction (AHJ) determines that they present an imminent danger to occupants. The NEC also allows Additions, Alterations, or Repairs to existing buildings to take place without requiring that the entire existing building comply with all the provisions of the current Code version provided any changes do not cause an unsafe condition or adversely affect 'building performance' as determined by the local AHJ. Any repair or reconditioning of existing equipment will require that equipment to comply with the current version of the Code and should be reviewed on a case by case basis in coordination with the AHJ.

Applicability to Bend WRF Facilities

When reviewing the existing construction documents and the 2004 load study of the Bend WRF, 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, but in general, the NEC itself has not undergone significant changes in the area of conductor and conduit sizing in the last 25 years; therefore, most systems will likely not require changes to conductors and conduit during refurbishment. Each system should be individually inspected and evaluated for adverse effects due to aging. The final word on acceptability is determined by the AHJ.

6.3 NFPA 820 - STANDARD FOR FIRE PROTECTION IN WASTEWATER TREATMENT AND COLLECTION FACILITIES

The National Fire Protection Association publishes *NFPA 820 - Standard for Fire Protection in Wastewater Treatment and Collection Facilities*. This document provides standards intended to safeguard against fire and explosion hazards in wastewater treatment facilities and related collection systems. The stated purpose is to “reduce or eliminate the effects of fire or explosion by maintaining structural integrity, controlling flame spread and smoke generation, preventing the release of toxic products of combustion, and maintaining serviceability and operation of the facility”. The first version was published in 1990, and the current version is dated 2003.

The standard covers fire and explosion hazards, but not toxic or biological hazards. It applies to new installations, and additions or modifications to existing facilities. The authority having jurisdiction is permitted to apply any portions of the standard retroactively if they determine “that the existing situation presents an unacceptable degree of risk.”

The categories covered by the standard are:

- Ventilation - Electrical classifications and requirements for materials are based on the amount of ventilation that is provided.

- National Electric Code (NEC) Area Classification - This classifies areas under the NEC Class 1, Group D, into either Division 1, Division 2, or unclassified. These result in progressively less restrictive (and less expensive) requirements for electrical equipment located within classified areas.

- Materials of construction - This describes minimum requirements for building materials as noncombustible, limited-combustible, or low flame spread.

- Fire protection measures - Requires fire extinguishers, hydrant protection, and/or combustible gas detector devices under certain circumstances.

These standards are applied to various unit process areas, including liquids and solids processing systems. In liquids treatment areas, the primary risk is from “possible ignition of flammable gases or floating flammable liquids.” This generally refers to floating hydrocarbons (such as gasoline) that can be found in processes up through primary clarification. In solids systems, the risk is either carryover of grease and/or flammable liquids (typically found in scum from primary clarifiers), or methane gas in sludge holding and digestion facilities.

Applicability to Bend WRF Facilities

This standard has retroactivity provisions that provide exceptions to compliance for facilities installed prior to the effective date of the standard, except where determined to present an unacceptable degree of risk by the AHJ. The provisions also allow exceptions where a disproportionate effort or expense is necessary to result in a minor increase in fire protection, again as determined by the AHJ.

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.

Table 4 provides a summary of the provisions of the rule as they apply to various facilities. 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. The primary issue relates to ventilation rates in solids process facilities, and the likelihood of having to provide supply fans in addition to existing exhaust fans. The other significant factor is location of unclassified, or under-classified electrical equipment within classified areas around the digesters.

6.4 AHJ Designation

The AHJ for improvements of the WRF is summarized below:

- Fire: City
- Electrical: County
- Structural: County
- Mechanical: County

7.0 RECOMMENDATIONS

The objective of this task is to provide an estimate of the implementation timing for the City’s future WRF R&R projects. Considering the three methods for estimating remaining useful life, including both accounting and engineering-based techniques, it is recommended that renewal and replacement (R&R) project timing be based on the economic remaining useful life methodology.

1. Use Economic Remaining Useful Life to Identify R&R Timing

By using the economic remaining useful life as the initial trigger for the replacement timing of upcoming R&R projects, further analysis can be completed regarding the total life cycle costs and benefits associated with “just-in-time” replacement of the existing asset (to take advantage of increased technology such as high efficiency equipment) versus continued maintenance of the existing asset (with possible higher long-term operating costs). The recommended implementation timing for each of the 294 assets assessed at the WRF is presented in the Appendix. To summarize these findings, the number of assets recommended for replacement each year through 2030 is presented in Figure 1 and Table 5.

Table 4 Summary of NFPA 820 Code Impacts
Facility Site Evaluation
City of Bend

Process	Area	Requirements - New Installations[1, 2]	Remarks
Headworks			New headworks was designed in compliance with current standards
Primary clarifiers	Tank interior; envelope 18 in above top of tank and extending 18 in beyond wall; envelope 18 in above grade extending to 10 ft from exterior walls	Class 1, Div. 2 electrical equipment NC, LC, or LFS materials H	Existing electrical equipment unknown; no requirements likely unless substantial modifications are made.
Aeration basins Blower building Secondary clarifiers Effluent filters Chlorine contact Plant water pumps Chlorine storage	Unclassified	H	No issues Chlorine storage expansion may trigger review of exhaust scrubbing or other improvements per IFC 2003.
Primary pumping station splitter	10 ft radius around primary splitter box	Class 1, Div. 2 electrical equipment NC, LC, or LFS materials H	No issues.
Primary pumping station	Pumping room	H & FE; none other if vented at > 6 AC/hr	Major modification would trigger review of ventilation rate; supply fan required
WAS/RAS pumping station	Pumping room	H & FE; none other if vented at > 6 AC/hr	Major modification would trigger review of ventilation rate; supply fan required
DAFT	Tank interior; envelope 18 in above top of tank and extending 18 in beyond wall; envelope 18 in above grade extending to 10 ft from exterior walls	Class 1, Div. 2 electrical equipment NC, LC, or LFS materials H	Existing electrical equipment unknown; no requirements likely unless substantial modifications are made.
Solids building	Entire structure	Unclassified NC, LC, or LFS materials	General ventilation only; OK
Digesters 1 & 2 and control building	Envelope extending 10 ft above highest point and 5 ft from exterior walls	Class 1 Div. 1 NC; H & FE	Existing electrical equipment unknown; no requirements likely unless substantial modifications are made.
	Envelope extending an additional 5 ft above and 5 ft outside Div 1 envelope	Class 1 Div. 2 NC; H & FE	Ventilation rates are good (>20 AC/hr), but supply fans would be required if modified
Digester 3 and control building	Same as listed for Digesters 1 & 2	Same as listed for Digesters 1 & 2	Designed in accordance with code

Notes:
1. NC = noncombustible material; LC = limited-combustible material; LFS = low flame spread material
2. H = Hydrant protection; FE = portable fire extinguisher; CGD = combustible gas detector

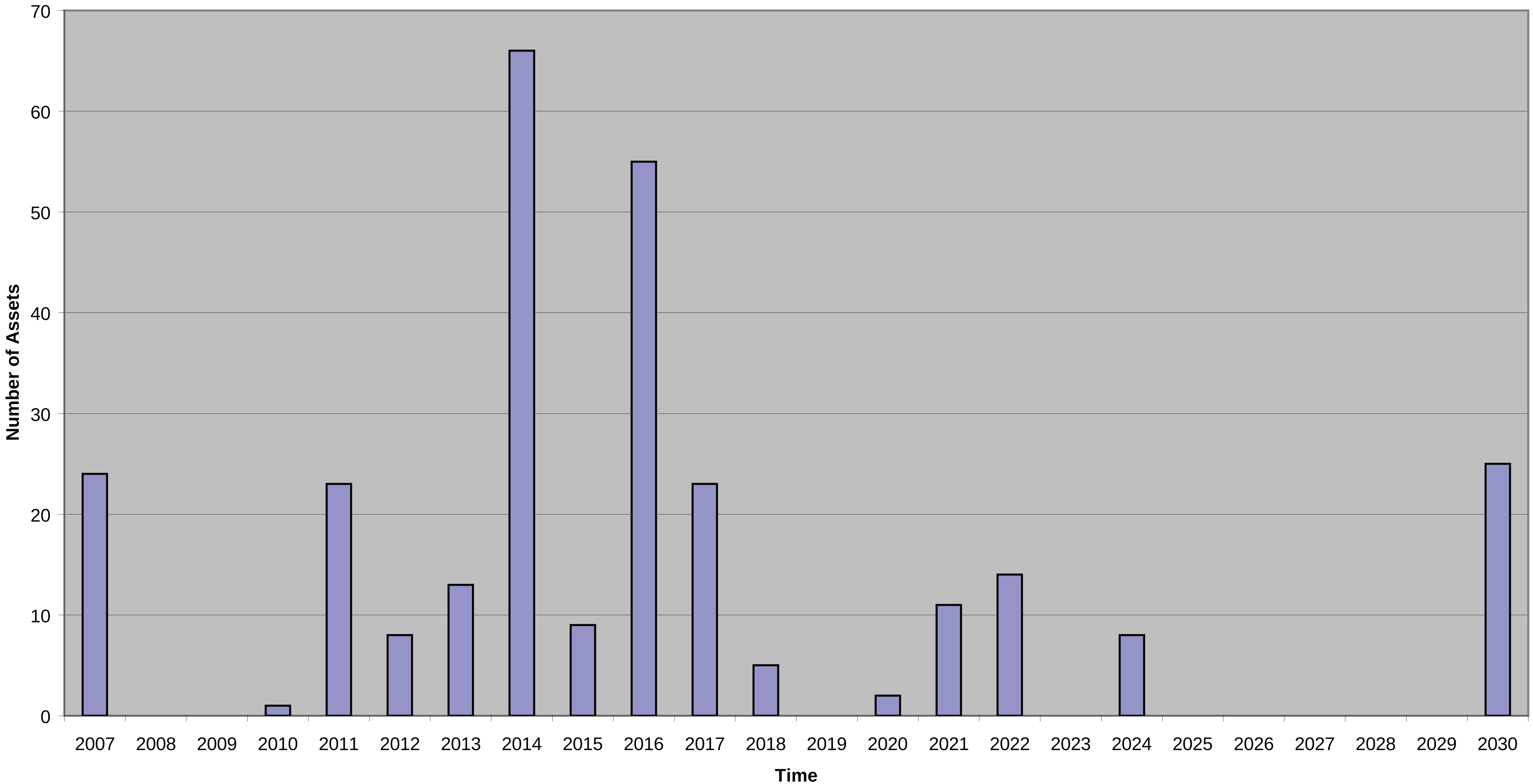

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FIGURE 1
RECOMMENDED REPLACEMENT TIMING OF WRF ASSETS
FACILITY SITE EVALUATION
CITY OF BEND

Table 5 Number of Assets Recommended for Replacement through 2030 Facility Site Evaluation City of Bend		
No. Of Assets	**Economic Remaining Useful Life**	**Implementation Year**
16	<1 year	2007
18	4 years	2011
6	5 years	2012
55	7 years	2014
8	8 years	2015
45	9 years	2016
18	10 years	2017
5	11 years	2018
2	13 years	2020
4	15 years	2022
8	17 years	2024
25	23 years	2030

Note: The timing for the predicted R&R projects does not account for the continued good operation and maintenance of the WRF assets. Therefore, it is recommended that additional condition assessments be conducted every three years to re-evaluate the remaining life of the assets.

2. Develop R&R Project Capital Costs

It is further recommended that the City develop an estimate of the cost to renew or replace each of these assets so that a summary can be developed that identifies the total capital cost expenditures estimated to be needed each year through 2030. This will allow the City to evaluate their financing options (pay-as-you-go versus debt financing) for the recommended R&R projects. Additionally, this effort will enable the City to identify peaks in their expected R&R project needs, and will provide the opportunity to normalize these peaks over a longer time period to develop a more realistic project implementation schedule. For example, if the City identifies that in 2016, $30 million dollars of R&R projects are predicted, the City could phase the implementation of the projects over a five-year period, from 2014-2018, lowering the annual capital costs to $6 million per year. These R&R costs were not further considered within this Facilities Plan. Based upon discussion with City staff, the R&R costs will be budgeted as part of the WRF's annual O&M budget.

3. Conduct Additional Condition Assessments

To incorporate the impacts of sound operations and maintenance techniques on the life of the WRF assets, it is recommended that condition assessments be conducted on a regular basis. Accordingly, it is recommended that assets in poor condition (4 or 5) be assessed annually, and a comprehensive assessment of all of the above ground WRF assets be conducted every three to five years. New assets (installed within the past year) should be evaluated concurrent to the comprehensive assessment. These efforts will enable the City to more accurately predict the remaining life of the WRF assets and more effectively plan for the long-term R&R of the WRF facilities.

Appendix A

CONDITION ASSESSMENT SUMMARY

CLIENT: CITY OF BEND, OREGON
PROJECT: FACILITIES PLAN
PROJECT NO.: 7622A.00

Process	Equipment Name	Condition	Installation Year	Remaining Useful Life	Evaluated Remaining Useful Life	Economic Remaining Useful Life
HEADWORKS	Lime Volumetric Feeder	5	1988	1	10	0
HEADWORKS	Lime Silo	2	2000	18	24	11
HEADWORKS	Electrical Room	5	1978	1	15	0
HEADWORKS	MCC-H	4	1978	1	21	6
HEADWORKS	480V 3Φ Panelboard	2	2000	23	29	14
HEADWORKS	Lime Silo Starters	3	1978	-9	17	7
SEPTAGE RECEIVING	Septage Influent Submersible Pump #1	4	1993	6	14	4
SEPTAGE RECEIVING	Submersible Pump #2	4	1993	6	14	4
SEPTAGE RECEIVING	Submersible Pump #3	4	1993	6	14	4
SEPTAGE RECEIVING	Rotary Screw Air Compressor	5	1993	6	10	0
SEPTAGE RECEIVING	Septage Transfer Pump	3	1981	-6	17	7
SEPTAGE RECEIVING	Septage Scale Building	2	2000	18	24	11
SEPTAGE RECEIVING	General conduit and lighting	4	1993	6	14	4
SEPTAGE RECEIVING	7.5HP AB Motor Starter	4	2000	13	14	4
SEPTAGE RECEIVING	Septage Mini Power Center	5	1993	16	15	0
SEPTAGE RECEIVING	Septage Pump Control Panel	4	1981	4	21	6
SEPTAGE RECEIVING	Septage Scale Building	2	2000	23	29	14
PRIMARY	Primary Clarifier #1	2	1981	24	48	23
PRIMARY	Primary Clarifier #2	2	1981	24	48	23
PRIMARY	Primary Clarifier Rake Arm #1	4	1981	-6	14	4
PRIMARY	Primary Clarifier Rake Arm #2	4	1981	-6	14	4
PRIMARY	Primary Clarifier Drive #1	1	2005	18	20	10
PRIMARY	Primary Clarifier Drive #2	1	2005	18	20	10
PRIMARY	Primary Sludge Pump #1	4	1981	-6	14	4
PRIMARY	Primary Sludge Pump #2	4	1981	-6	14	4
PRIMARY	Primary Air Compressor	2	1995	8	19	9
PRIMARY	Air Dryer	1	2006	19	20	10
PRIMARY	Gates for sludge pumps (3)	3	1981	-6	17	7
PRIMARY	Primary Building	2	1981	24	48	23
PRIMARY	Primary Splitter Box	2	1981	24	48	23
PRIMARY	External Lighting, Conduit and Control Stations	4	1981	-6	14	4
PRIMARY	MCC-PSP	4	1981	4	21	6
PRIMARY	DRC Controller Panels	4	1981	4	21	6
PRIMARY	Sample Pump Panel	4	1981	4	21	6
PRIMARY	Internal Conduit and Lighting	4	1981	-6	14	4
AERATION	Aeration Basin #1	2	1981	24	48	23

Process	Equipment Name	Condition	Installation Year	Remaining Useful Life	Evaluated Remaining Useful Life	Economic Remaining Useful Life
AERATION	Aeration Basin #2	2	1981	24	48	23
AERATION	Aeration Basin #3	3	2001	44	42	17
AERATION	Aeration Floating Mixer #1	2	2001	14	19	9
AERATION	Aeration Floating Mixer #2	2	2001	14	19	9
AERATION	Aeration Floating Mixer #3	2	2001	14	19	9
AERATION	Aeration Blower #1	5	1981	-6	10	0
AERATION	Aeration Blower #2	4	1981	-6	14	4
AERATION	Aeration Blower #3	4	1981	-6	14	4
AERATION	Aeration Blower #4	3	2001	14	17	7
AERATION	Aeration Mixed Liquor Pump #1	4	2001	14	14	4
AERATION	Aeration Mixed Liquor Pump #2	4	2001	14	14	4
AERATION	Aeration Mixed Liquor Pump #3	4	2001	14	14	4
AERATION	Aeration 12" Primary Flow Meter #1	2	2002	10	14	7
AERATION	Aeration 12" Primary Flow Meter #2	2	2002	10	14	7
AERATION	Aeration 12" Primary Flow Meter #3	2	2002	10	14	7
AERATION	Aeration 18" Primary Flow Meter #1	2	2002	10	14	7
AERATION	Aeration 18" Primary Flow Meter #2	2	2002	10	14	7
AERATION	Aeration 18" Primary Flow Meter #3	2	2002	10	14	7
AERATION	Aeration 10" RAS Flow Meter #1	2	2002	10	14	7
AERATION	Aeration 10" RAS Flow Meter #2	2	2002	10	14	7
AERATION	Aeration 10" RAS Flow Meter #3	2	2002	10	14	7
AERATION	Sump Pump to Drain Pit	3	2002	15	17	7
AERATION	Aeration Basin Pipe Gallery	1	2001	44	50	25
AERATION	Blower Building	2	1981	24	48	23
AERATION	480V Panel, Transformer, Lighting	1	2002	15	20	10
AERATION	Control Valves	2	2002	10	14	7
AERATION	Flow Meters	2	2002	10	14	7
BLOWER ROOM	Main Electrical Distribution - SWBD B	4	1981	4	21	6
BLOWER ROOM	MCC-B	4	1981	4	21	6
BLOWER ROOM	MCC-B1	3	2001	24	25	10
BLOWER ROOM	Aeration Basin PLC Panel	2	2001	24	29	14
BLOWER ROOM	Blower Building PLC Panel	2	2001	24	29	14
BLOWER ROOM	480V Panelboard	2	2001	24	29	14
BLOWER ROOM	Lighting, HVAC	5	1981	-6	10	0
BLOWER ROOM	Blower Control Panels	3	1981	4	25	10
BLOWER ROOM	Blower Instrumentation	3	1981	-11	13	5
BLOWER ROOM	Control Valves	3	1999	12	17	7
SECONDARY	Secondary Clarifier #1	2	1981	24	48	23
SECONDARY	Secondary Clarifier #2	2	1981	24	48	23
SECONDARY	Secondary Clarifier #3	1	2003	46	50	25
SECONDARY	Secondary Clarifier Drive #1	2	2003	16	19	9
SECONDARY	Secondary Clarifier Drive #2	2	2003	16	19	9

Process	Equipment Name	Condition	Installation Year	Remaining Useful Life	Evaluated Remaining Useful Life	Economic Remaining Useful Life
SECONDARY	Secondary Clarifier Drive #3	2	2003	16	19	9
SECONDARY	Secondary Clarifier Rake Arm #1	2	2003	16	19	9
SECONDARY	Secondary Clarifier Rake Arm #2	2	2003	16	19	9
SECONDARY	Secondary Clarifier Rake Arm #3	2	2003	16	19	9
SECONDARY	WAS Pump #1	3	2002	15	17	7
SECONDARY	WAS Pump #2	3	1981	-6	17	7
SECONDARY	RAS Pump #1	3	2002	15	17	7
SECONDARY	RAS Pump #2	3	1981	-6	17	7
SECONDARY	RAS Pump #3	3	1981	-6	17	7
SECONDARY	RAS Sump Pump #1	5	1981	-6	10	0
SECONDARY	RAS Sump Pump #2	5	1981	-6	10	0
SECONDARY	RAS Flow Meter #1, Secondary Sludge	3	1981	-11	13	5
SECONDARY	RAS Flow Meter #2, Secondary Sludge	3	1981	-11	13	5
SECONDARY	RAS Flow Meter #3	2	2002	10	14	7
SECONDARY	RAS Sludge Flow Control Valves & Actuator #1	3	1981	-6	17	7
SECONDARY	RAS Sludge Flow Control Valves & Actuator #2	3	1981	-6	17	7
SECONDARY	RAS Building	2	1981	24	48	23
SECONDARY	RAS Scum Pit	2	1981	24	48	23
SECONDARY	Secondary Splitter Box	2	1981	24	48	23
SECONDARY	Tank 1 & 2 Electrical Conduit	3	1978	-9	17	7
SECONDARY	Tank 3 Electrical Conduit	2	2002	15	19	9
RAS/WAS BUILDING	WAS/RAS Indicator Panels	5	1981	4	15	0
RAS/WAS BUILDING	RAS Pump VFDs	4	1981	4	21	6
RAS/WAS BUILDING	WAS Pump VFDs	3	2002	25	25	10
RAS/WAS BUILDING	MCC-RAS	4	1981	4	21	6
DISINFECTION	Chlorine Contact Basins	2	1981	24	48	23
DISINFECTION	Chlorine Rotameter #1	2	1981	-11	14	7
DISINFECTION	Chlorine Rotameter #2	2	1981	-11	14	7
DISINFECTION	Chlorine Rotameter #3	3	2003	11	13	5
DISINFECTION	Chlorine Rotameter #4	2	1981	-11	14	7
DISINFECTION	PCU Rotameter Controller	2	1981	-6	19	9
DISINFECTION	Remote Vacuum System	3	1981	-6	17	7
DISINFECTION	Weight Indicator	2	1995	3	14	7
DISINFECTION	Chlorine Regulator #1	2	2000	8	14	7
DISINFECTION	Chlorine Regulator #2	2	2000	8	14	7
DISINFECTION	Chlorine Regulator #3	2	2000	8	14	7
DISINFECTION	Chlorine Regulator #4	2	2000	8	14	7
DISINFECTION	Chlorine Regulator #5	2	2000	8	14	7
DISINFECTION	Chlorine Regulator #6	2	2000	8	14	7
DISINFECTION	Chlorine Gas Leak Detectors (2)	2	1990	-2	14	7
DISINFECTION	Chlorine Scale	3	1981	-11	13	5
DISINFECTION	Effluent Flow Meter	2	1981	-11	14	7

Process	Equipment Name	Condition	Installation Year	Remaining Useful Life	Evaluated Remaining Useful Life	Economic Remaining Useful Life
DISINFECTION	Water Champ	2	2003	16	19	9
DISINFECTION	Gates (2)	3	1981	-6	17	7
DISINFECTION	Valves (4) (2 per basin)	3	1981	-6	17	7
DISINFECTION	Chlorine Building	2	1981	24	48	23
DISINFECTION	Reuse Building	1	2003	46	50	25
DISINFECTION	Chlorine Contact Basins - External Stations	5	1981	4	15	0
CHLORINE BLDG	HVAC & Lighting	3	1981	-6	17	7
REUSE	Aqua Disc Filter Tank #1	1	2003	21	25	13
REUSE	Aqua Disc Filter Tank #2	1	2003	21	25	13
REUSE	Aqua Disc Filter #1	1	2006	9	10	5
REUSE	Aqua Disc Filter #2	1	2006	9	10	5
REUSE	Plant Water Pump #4	2	2003	16	19	9
REUSE	Drain Pit Pumps (2)	2	2003	16	19	9
REUSE	Low Head Reuse Pump #1	2	2003	16	19	9
REUSE	Low Head Reuse Pump #2	2	2003	16	19	9
REUSE	Filter Feed Pump #1	2	2006	19	19	9
REUSE	Filter Feed Pump #2	2	2005	18	19	9
REUSE	Filter Backwash Pump #1 (Tank 1)	2	2003	16	19	9
REUSE	Filter Backwash Pump #2 (Tank 1)	2	2003	16	19	9
REUSE	Filter Backwash Pump #3 (Tank 2)	2	2003	16	19	9
REUSE	Filter Backwash Pump #4 (Tank 2)	2	2003	16	19	9
REUSE	MCC-FL & 480V/120V Panelboards	2	2003	26	29	14
REUSE	PLC & Instrumentation	2	2003	16	19	9
REUSE	Lighting, HVAC	2	2003	16	19	9
REUSE	External Effluent Control Panel	2	2003	26	29	14
REUSE	Electrical, Instrumentation, Control, Lighting	2	2003	16	19	9
PERCOLATION PONDS	Percolation Pond #1	4	1981	24	35	10
PERCOLATION PONDS	Percolation Pond #2	3	1981	24	42	17
PERCOLATION PONDS	Percolation Pond #3A	3	1981	24	42	17
PERCOLATION PONDS	Percolation Pond #3B	3	1981	24	42	17
PERCOLATION PONDS	Inlet to Perc. Ponds	3	1981	24	42	17
DEGAS	Degas Supernatant Pump #1	3	1981	-6	17	7
DEGAS	Degas Supernatant Pump #2	3	1981	-6	17	7
DEGAS	Degas Sludge Pump #1	3	1981	-6	17	7
DEGAS	Degas Sludge Pump #2	3	1981	-6	17	7
DEGAS	Degas Sump Pump	3	1981	-6	17	7
DEGAS	Degas Beds	2	1981	24	48	23
DEGAS	Degas Vault	2	1981	24	48	23
DEGAS	Motor Starters and Controls	4	1981	4	21	6
GBT	Solids Handling Aquabelt Gravity Belt Thickener	1	2000	13	20	10
GBT	Polymer Bulk Storage Hopper Weigh Cell (4 ea)	1	2007	15	15	8
GBT	Eductor Hopper Weigh Controller	1	2007	15	15	8

Process	Equipment Name	Condition	Installation Year	Remaining Useful Life	Evaluated Remaining Useful Life	Economic Remaining Useful Life
GBT	Eductor Hopper South Weigh Cell (4 ea)	1	2007	15	15	8
GBT	Bulk Storage Hopper Weigh Controller	1	2007	15	15	8
GBT	Headworks Polymer Pump #1	1	2007	20	20	10
GBT	Headworks Polymer Pump #2	1	2007	20	20	10
GBT	Headworks Thickened WAS Cake Pump	1	2007	20	20	10
GBT	Headworks Chemical Solution Pump	1	2007	20	20	10
GBT	Headworks Chemical Solution Mixer	1	2007	20	20	10
GBT	Polymer Loss-In-Weight Feeder	1	2007	20	20	10
GBT	Polymer Transfer Conveyor	1	2007	20	20	10
GBT	Polymer Injection Pump	1	2007	20	20	10
GBT	Polymer Dry Air Dryer	1	2006	19	20	10
GBT	Washwater Booster Pump	2	2000	13	19	9
GBT	GBT Control Panel and Conduit	1	2007	30	30	15
GBT	MCC-SH	1	1981	4	30	15
GBT	480V Panelboard	1	2007	30	30	15
GBT	Solids Handling PLC Panel	1	2007	30	30	15
DAF	DAF Tank	2	1981	24	48	23
DAF	DAF Thickener	3	1981	-6	17	7
DAF	DAF Progressive Cavity Pump #1	4	1981	-6	14	4
DAF	DAF Progressive Cavity Pump #2	4	1981	-6	14	4
DAF	DAF Air Compressor	2	1987	0	19	9
DAF	DAF Recirculation Pump #1	5	1981	-6	10	0
DAF	DAF Recirculation Pump #2	5	1981	-6	10	0
DAF	Recycled Sludge Tank	4	1979	-8	14	4
DAF	Generator	2	2000	23	29	14
DAF - ELECTRICAL	Aux Dist SWBD A	4	1981	4	21	6
DAF - ELECTRICAL	MCC-W	4	1981	4	21	6
DAF - ELECTRICAL	Instrumentation	4	1981	-11	10	3
DAF - ELECTRICAL	External Control Stations & Conduit	4	1981	-6	14	4
DAF - ELECTRICAL	Automatic Transfer Switch	3	2000	23	25	10
DIGESTION	Digester #1	2	1981	24	48	23
DIGESTION	Digester #2	2	1981	24	48	23
DIGESTION	Digester #3	2	2000	43	48	23
DIGESTION	Digester #1-2 Building	2	1981	24	48	23
DIGESTION	Digester #3 Building	2	2000	43	48	23
DIGESTION	Boiler #1	4	1981	-6	14	4
DIGESTION	Boiler #2	4	1981	-6	14	4
DIGESTION	Boiler #3	3	2001	14	17	7
DIGESTION	Heat Exchanger #1	3	1981	-6	17	7
DIGESTION	Heat Exchanger #2	3	1981	-6	17	7
DIGESTION	Heat Exchanger #3	2	2000	13	19	9
DIGESTION	Hot Water Loop Pump	2	2000	13	19	9

Process	Equipment Name	Condition	Installation Year	Remaining Useful Life	Evaluated Remaining Useful Life	Economic Remaining Useful Life
DIGESTION	Sediment Trap #1	5	1981	-6	10	0
DIGESTION	Sediment Trap #2	5	1981	-6	10	0
DIGESTION	Boiler Water Re-circulation Feed Pump	2	2001	14	19	9
DIGESTION	Boiler Water Inlet Feed Pump	2	2001	14	19	9
DIGESTION	Digester #3 Feed Pump	4	2001	14	14	4
DIGESTION	Gas Compressor #1	2	1992	5	19	9
DIGESTION	Gas Compressor #2	2	1992	5	19	9
DIGESTION	Hot Water Circulation Pump #1	2	2001	14	19	9
DIGESTION	Hot Water Circulation Pump #2	2	2001	14	19	9
DIGESTION	Mix Pump #1	3	2001	14	17	7
DIGESTION	Mix Pump #2	3	2001	14	17	7
DIGESTION	Muffin Monster	2	2001	14	19	9
DIGESTION	Sludge Circulation #4	3	2001	14	17	7
DIGESTION	Sludge Circulation #5	3	2001	14	17	7
DIGESTION	Sludge Transfer Pump #1	3	1981	-6	17	7
DIGESTION	Sludge Transfer Pump #2	2	1981	-6	19	9
DIGESTION	Sludge Transfer Pump #3	3	1981	-6	17	7
DIGESTION	Water Circulation Pump #1	2	1981	-6	19	9
DIGESTION	Water Circulation Pump #2	2	1982	-5	19	9
DIGESTION	Waste Gas Burner	3	2001	14	19	9
DIGESTION	HVAC System	5	2000	23	15	0
DIGESTION	HVAC Control Panel	2	2000	23	29	14
DIGESTION	MCC-D	2	1981	4	29	14
DIGESTION	PLC Panel	2	1981	4	29	14
DIGESTION	Gas Pump Room	2	1981	-6	19	9
DIGESTION	Boiler Conduit	4	1981	-6	14	4
DIGESTION	Boiler Intrumentation & Controls	4	1981	-11	10	3
DIGESTION	Heat Exchanger Conduit	3	1981	-6	17	7
DIGESTION	Heat Exchanger Instrumentation & Controls	3	1981	-11	13	5
DIGESTION	Hot Water Circulation Conduit	2	2001	14	19	9
DIGESTION	Hot Water Circulation Instrumentation & Controls	2	2001	9	14	7
DIGESTION	Muffin Monster Conduit & Controls	2	2001	14	19	9
DEWATERING	Belt Filter Press	2	2005	18	19	9
DEWATERING	Belt Press Feed Box Drive	2	2005	18	19	9
DEWATERING	Belt Press Hydro Power Pack	2	2005	18	19	9
DEWATERING	Sharples Decanting Centrifuge	3	2000	13	17	7
DEWATERING	Plant Water Booster Pump	2	2005	18	19	9
DEWATERING	Belt Press Pressure Section	2	2005	18	19	9
DEWATERING	Discharge Screw Conveyor, Belt Press	2	2000	13	19	9
DEWATERING	Belt Press Cake Pump	2	2005	18	19	9
DEWATERING	Slide Gate Hydro. Power Pack	1	2007	20	20	10
DEWATERING	Cake Pump Weigh Controller	2	2005	13	14	7

Process	Equipment Name	Condition	Installation Year	Remaining Useful Life	Evaluated Remaining Useful Life	Economic Remaining Useful Life
DEWATERING	Cake Hopper Weigh Cells (4 ea)	0	2007	15	15	8
DEWATERING	Cake Hopper Weigh Controller	0	2007	15	15	8
DEWATERING	Cake Pump Weigh Cells (4 ea)	2	2005	13	14	7
DEWATERING	Digested Sludge to Belt Press Flow Meter	1	2007	15	15	8
DEWATERING	Solids Building	2	1998	41	48	23
DEWATERING	Crane	2	1998	11	19	9
DEWATERING	Belt Filter Press Electrical	1	2005	28	30	15
DEWATERING	Sharples Decanting Centrifuge Electrical	1	2000	23	30	15
DEWATERING	Belt Press Pressure Section	1	2005	28	30	15
DEWATERING	Discharge Screw Conveyor Electrical	1	2000	23	30	15
DEWATERING	Belt Press Cake Pump Electrical	1	2005	28	30	15
DEWATERING	Slide Gate Hydro. Power Pack Electrical	1	2007	30	30	15
DEWATERING	Cake Pump Weigh Controller Electrical	1	2005	28	30	15
DEWATERING	Cake Pump Weigh Cells (4 ea) Electrical	1	2005	28	30	15
DEWATERING	Digested Sludge to Belt Press Flow Meter	1	2007	15	15	8
DEWATERING	HVAC & Lighting	2	1998	11	19	9
DEWATERING	Crane Disconnect	3	1998	11	17	7
DRYING BEDS	Drying Beds (9)	3	1981	24	42	17
DRYING BEDS	Drying Bed Pump and Pit	3	1981	24	42	17
PLANT WATER	Plant Water Pump #1	5	1981	-6	10	0
PLANT WATER	Plant Water Pump #2	5	1981	-6	10	0
PLANT WATER	Plant Water Pump #3	5	1981	-6	10	0
PLANT WATER	Effluent Flow Meter	0	2006	14	15	8
PLANT WATER	Micro/2000 Analyzer CL2	2	2003	11	14	7
PLANT WATER	Water Champ	2	2005	18	19	9
PLANT WATER	Water Strainer	5	2006	19	10	0
PLANT WATER	CL2 Residual Analyzer Pump	5	1981	-6	10	0
PLANT WATER	Plant Water Building	2	1981	24	48	23
PLANT WATER	Lighting & HVAC	5	1978	-9	10	0
PLANT WATER	MCC-PW	5	1978	1	15	0
PLANT WATER	PLC Panel	4	1981	4	21	6
PLANT WATER	Plant Water Pump VFD's	1	2006	29	30	15
PLANT WATER	Residual Analyzer Panel	5	1981	-11	8	0
DRINKING WATER	Booster Pump #1	1	2006	19	20	10
DRINKING WATER	Booster Pump #2	1	2006	19	20	10
DRINKING WATER	Deep Well Submersible Pump	4	1988	1	14	4
DRINKING WATER	Deep Well Submersible Pump Control Panel	1	2006	29	30	15
DRINKING WATER	Potable Water Reservoir	2	2003	46	48	23
DRINKING WATER	Well Pump Starters	1	2002	15	20	10
DRINKING WATER	Lighting & HVAC	2	2002	15	19	9
PLANT BUILDINGS	Storage Building	2	1995	13	24	11
PLANT BUILDINGS	Wood Shed (Storage Building)	2	1990	8	24	11

Process	Equipment Name	Condition	Installation Year	Remaining Useful Life	Evaluated Remaining Useful Life	Economic Remaining Useful Life
PLANT BUILDINGS	Equipment Storage and Parking	2	1995	13	24	11
PLANT BUILDINGS	Maintenance Building	3	1981	24	42	17
PLANT BUILDINGS	Training Facility	1	2003	46	50	25
PLANT BUILDINGS	Control Building / Laboratory	1	2006	49	50	25

City of Bend

Water Reclamation Facilities Plan

TECHNICAL MEMORANDUM NO. 3
EFFLUENT DISPOSAL EVALUATION

April 2008

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

CITY OF BEND

WATER RECLAMATION FACILITIES PLAN

TECHNICAL MEMORANDUM
NO.3

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EFFLUENT DISPOSAL EVALUATION

1.0 INTRODUCTION

The purpose of this Technical Memorandum (TM) is to evaluate the effectiveness of the current effluent disposal method through the 2030 planning period. This evaluation will include a detailed analysis of the method's ability to protect groundwater quality and meet regulatory requirements.

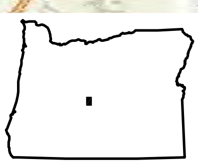
2.0 BACKGROUND

The existing Bend Water Reclamation Facility (WRF) began operation in 1981. The location of the WRF is shown on Map 1. Prior to that time, the City of Bend 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 Bend disposed of sewage individually either by a sewage drain hole or by septic tank and drain field, until the Oregon Environmental Quality Commission determined that continued use of sewage drain holes was a threat to groundwater quality and ordered their elimination and replacement with an area-wide sewerage facility.

Disposal options available at the time the Bend WRF was constructed were few. Discharge to the Deschutes River or via a drill hole was not acceptable to the public. North Unit Irrigation District, which has its main canal near the treatment plant site, was adamantly against the use of its canal as a disposal point. Furthermore, water only flowed in the canal during the irrigation season. Irrigation near the treatment plant site or transport of effluent to a suitable area for irrigation was believed to be not feasible. Seepage ponds, which were considered the only viable and acceptable alternative, were eventually built and ultimately found to be environmentally acceptable and permitted under an Oregon-issued Water Pollution Control Facilities (WPCF) Permit.

Initial operation of the seepage ponds found a few problems. When treated effluent was directed into Pond 1, it almost immediately seeped into the ground without benefit of any soil treatment by controlled seepage. Controlled seepage was desired to provide some final polishing of effluent before it moved into the groundwater. The inlet channel was then lined with shotcrete to cover the high seepage area and allow the effluent to move out into the pond. As Pond 1 began to fill, however, the rising water encountered other high seepage areas. Effluent flow was then diverted to Pond 2. As it filled, rising water leaked rapidly through a rock outcropping on the east end of Pond 2.

Based upon this information, the City concluded that any rock outcroppings within the ponds were potential areas with high risks of rapid leakage. In order to have controlled seepage, areas within the ponds where rock outcroppings were evident would have to be



Base Map:
Mapquest Internet Street Atlas

NEWTON CONSULTANTS INC.
Earth, Water and Rock Specialists
Ph: 541 504-9960 Fax: 541 504-9961

Vicinity Map
City of Bend - Water Reclamation Facility
Deschutes County, Oregon

DESIGNED BY:	DRAWN BY:	DATE:	PROJECT NO.	
M.Perle	S.Schenck	April 2007	1044-101-03	MAP 1

G:\1000\1044\101\03\Cad\Water\W1044101_03_M1_VicMap 15:17 04/17/2007 SS covered with geo-textile fabric and soil. With this knowledge, Pond 2 was partially repaired (the area of the major leak was covered with fabric, soil and riprap) and two new ponds, 3A and 3B, were constructed, all with potential sources of rapid leakage covered with filter fabric and soil and, in some cases, just soil. Since then (circa 1983), virtually all effluent has been disposed into Ponds 3A and 3B with no evidence of rapid seepage or leaks. Pond 2 receives some effluent, but only enough to provide habitat for waterfowl. Pond 1 has not been used at all because it was not reconditioned.

3.0 REGULATORY CONSIDERATIONS

The proposed method for disposal of treated effluent in this TM will only be authorized by the Oregon Department of Environmental Quality (DEQ) when it issues a modified Water Pollution Control Facilities Permit. DEQ has two major regulatory issues within its groundwater quality protection rules that need to be addressed in a permit modification application. These two requirements are categorized as: (1) Anti-degradation, and (2) Protection of the beneficial uses of groundwater. These requirements are set forth in Oregon Administrative Rule (OAR) 340-040, as described below:

OAR 340-040-0020 Anti-Degradation (Highest and Best Practicable Control)

The anti-degradation requirements are established in OAR 340-040-0020, which states, in part:

> (2) Groundwater, once polluted, is difficult and sometimes impossible to clean up. Therefore, the Environmental Quality Commission (EQC) shall employ an anti-degradation policy to emphasize the prevention of groundwater pollution, and to control waste discharges to groundwater so that the highest possible water quality is maintained.
>
> (3) All groundwaters of the state shall be protected from pollution that could impair existing or potential beneficial uses for which the natural water quality of the groundwater is adequate. Among the recognized beneficial uses of groundwater, domestic water supply is recognized as being the use that would usually require the highest level of water quality. Existing high quality ground waters that exceed those levels necessary to support recognized and legitimate beneficial uses shall be maintained except as provided for in these rules.
>
> (11) In order to minimize groundwater quality degradation potentially resulting from point source activities, 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.

OAR 340-040-0030 Groundwater Quality Protection Program

Regulation of point sources to protect beneficial uses of groundwater are set out in OAR 340-040-0030(2), which states:

> The Department shall review and evaluate appropriate technical information and reports submitted by permitted sources to determine the potential for adverse impacts to groundwater quality. Where the above technical information and reports indicate that there is a likely adverse groundwater quality impact, the Department shall require through the permits and rules referred to in OAR 340-040-0020(12), and other appropriate statutory and administrative authorities, the following groundwater quality protection program:
>
> (a) Groundwater Monitoring Requirements. The permittee or permit applicant shall submit to the Department for approval a groundwater monitoring plan for the uppermost aquifer and any other potentially affected aquifers. The groundwater monitoring plan shall be capable of determining rate and direction of groundwater movement, and monitoring the groundwater quality immediately upgradient and downgradient from the waste management area;
>
> (b) Reporting Requirements. The facility permit shall specify monitoring and assessment reporting requirements;
>
> (c) Background Monitoring Point(s) Requirements. The permittee shall monitor the background water quality of the uppermost aquifer. The background monitoring point(s) shall be located where water quality is unaffected by facility operation;
>
> (d) Downgradient Detection Monitoring Point(s) Requirements. The permittee shall monitor the aquifer directly downgradient from the waste management area to ensure immediate detection of waste released to groundwater. This shall be known as the down-gradient detection monitoring point(s);
>
> (e) Compliance Point(s) Requirements. The Department shall specify the location at which groundwater quality parameters must be at or below the permit-specific concentration limits. Unless otherwise specified by the Department, that location will be defined by a vertical plane located along the waste management area boundary. Any monitoring point on that plane is a compliance point. The compliance point(s) may not necessarily be the same as the downgradient detection monitoring point(s).

The operating phrase in OAR 340-40-0030(2) is “likely adverse groundwater quality impact.” If DEQ determines that the expanded use of the seepage ponds will not have a likely adverse impact on groundwater quality, a groundwater quality protection program will not be required and will not be inserted into the City's WPCF permit.

In the City of Bend's current WPCF permit evaluation report, the DEQ determined that the current treatment and disposal method employed by the City did not have the potential to cause an adverse effect on groundwater quality. Consequently, the current permit does not contain a groundwater quality protection program. This determination by DEQ was limited to the impacts of nitrate-nitrogen in the groundwater.

This document will demonstrate that the expanded use of seepage ponds will not have a likely adverse impact on groundwater quality, and that the City is providing highest and best practicable control of the wastewater that is being disposed in the seepage ponds.

4.0 EFFECTIVENESS OF EXISTING DISPOSAL SYSTEM

4.1 Disposal Capacity

The disposal capacities of the seepage ponds were evaluated based on WRF records of total annual average flow of treated effluent and observed seepage/evaporation rates. The current, calculated seepage rates were compared to the original seepage rate estimates made when the four ponds were designed. The calculated area capacity curves were then used to determine available capacity (areal and volumetric) in each pond to store and slowly evaporate/seep additional effluent.

4.1.1 Current Seepage Rates in Ponds 3A and 3B

In 2005, the WRF treated an annual average of 5.0 million gallons per day (MGD) or approximately 5,600 acre-feet per year. Of these 5,600 acre-feet, 260 acre-feet were used by a nearby golf course for irrigation water and 460 acre-feet were discharged to Pond 2. The remaining 4,880 acre-feet were discharged into Ponds 3A and 3B.

In 2005, the area covered by water in Ponds 3A and 3B was approximately 60 acres. Assuming the area covered by Ponds 3A and 3B held constant at 60 acres, for each acre inundated about 26.5 million gallons per year or 81 acre-feet per year were disposed either by seepage or evaporation. This is equivalent to 81 feet of seepage or a seepage rate of approximately 81 acre-feet per acre of pond for Ponds 3A and 3B.

4.1.2 Comparison to Original Predicted Rates

Seepage rates were originally estimated in the City of Bend Ultimate Effluent Disposal Alternative Analysis Report dated January 1982. These seepage estimates were then further revised in subsequent reports in January and March of 1983. These seepage rate estimates were made for Ponds 1 and 2 as Ponds 3A and 3B had not yet been built. The goal of the reports and making seepage rate estimates was to determine the ultimate effluent disposal strategy and more specifically determine if additional ponds (3A and 3B) would need to be built.

Seepage rate was estimated based the following equation:

$$S = I + P - \Delta V - E$$

Where:

S	=	seepage volume in acre-feet
I	=	inflow volume in acre-feet
P	=	total volume added to pond by precipitation
ΔV	=	change in pond volume in acre-feet
E	=	total pond evaporation in acre-feet (73% of measured pan evaporation multiplied by the average pond surface area for the time period)

An average seepage rate was calculated by dividing the seepage volume calculated above by the average pond surface area and the elapsed time for the measurement period. In order to estimate future pond performance, the seepage rate was assumed to stabilize at 0.96 inches per day. Monthly total losses were then calculated based on an average seepage rate of 0.96 inches per day, and by adding average monthly pond evaporation and subtracting average monthly precipitation.

The disposal capacity of Ponds 1 and 2 was estimated by taking the December total loss value (minimum on a per day basis) and multiplying it by the high water line surface area. Using these methods, it was estimated that Ponds 1 and 2 had a disposal capacity of 3.76 MGD or approximately 4,206 acre-feet per year based on a total inundated area of 153 acres. This is equivalent to a seepage rate of approximately 27.5 acre-feet per acre for Ponds 1 and 2.

These estimates were further revised in subsequent reports entitled “Performance Monitoring On City of Bend Interim Effluent Seepage/Filtration Pond” in January 1983 and “Design Definition Memorandum No. 15: Ultimate Effluent Disposal System Pre-design Report” in March of 1983. In the January 1983 report the seepage rates in Ponds 1 and 2 were found to have stabilized at 0.89 inches per day (as opposed to 0.96 inches per day assumed previously). Therefore, the disposal capacity for Ponds 1 and 2 was revised to 3.46 MGD or 3,876 acre-feet per year based on a total inundated area of 153 acres. This is equivalent to a seepage rate of approximately 25 acre-feet per acre for Ponds 1 and 2.

In the March 1983 report the seepage rates were further refined based on projected long term seepage rates. The disposal capacity for Ponds 1 and 2 was revised to 3.57 MGD or 4,000 acre-feet per year based on a total inundated area of 153 acres. This is equivalent to a seepage rate of approximately 26 acre-feet per acre for Ponds 1 and 2.

These estimated seepage rates for Ponds 1 and 2 (25 to 27.5 acre-ft per acre) are different than those measured in Ponds 3A and 3B (81 acre-ft per acre). The disparity in the two estimates can potentially be explained by the fact that seepage estimates for Ponds 3A and 3B are based on a longer term record. These two ponds have been the primary ponds used for disposal of effluent since they were constructed in 1984 and, therefore, have had many years for seepage rates to equilibrate. In addition, seepage rates in Ponds 3A and 3B could be different given variations in sub-surface geology, change in hydraulic heads as the ponds change in volume, variation in soil texture and sealing caused by algae, aquatic vegetation, and solids buildup.

4.2 Resistance to Rapid Leaks

The pond site locations are in basalt lava terrain that forms most of the plateau area of Central Oregon. Basalt lavas bring risk of rapid leak potential through fractures, rubbly zones with high void content, and lava tubes. Rapid leaks can occur where soils overlying permeable sections of basalt are carried downward from within by water into rock fractures, rubble zones, or tubes. Rapid leak events can develop a short time after inundation, or after a very long time, depending on water depth and thickness and composition of soils overlying permeable rock zones. Clay soils with sticky, cohesive properties are resistant to this type of soil erosion. Silt and sand soils of Central Oregon are prone to this type of erosion. On this basis, a general expectation is that rapid leak events can occur relatively soon after ponding.

Specific pond areas were identified as being areas with risks of high seepage losses during the initial design of Ponds 1 and 2. Placement of geo-fabrics, additional soil cover, or combinations of the two were recommended in these high risk areas. However, due to the unknown nature of how exactly the ponds would respond to filling, Ponds 1 and 2 were constructed without addressing the potential high risk. After the leak occurred in Pond 2, the area where the leak had occurred was overlain with fabric and rip rap according to the original sealing guidelines. Pond 2 was filled once again without any noticeable leaks occurring.

Given the experience with the construction and filling of Ponds 1 and 2, it was decided that all potential high seepage rate areas noted in Ponds 3A and 3B should be covered according to recommendations. Ponds 3A and 3B have been in use since 1984 without any high seepage areas being noted in either field water level measurements or monitoring well records.

Based upon the experience with the seepage ponds, future use of Ponds 1 and 2 should not be undertaken until the ponds have been reconditioned by identifying potential areas for high rate leaks and covering these areas with geotextile fabric, soil, and rip rap.

4.3 Description of Monitoring Wells

The seepage ponds are located over the Deschutes Formation. This formation ranges from 7.5 to 4.0 million years in age and covers an extensive area of the upper basin. The formation is comprised of inter-layered sedimentary and volcanic materials reflecting basin-filling sedimentation combined with episodic volcanic eruptions. The formation contains an extensive aquifer system that is capable of supplying high-capacity wells, and is the most extensively used water-bearing unit in the upper Deschutes basin. High-capacity wells are commonly installed in the formation for municipal and irrigation water supply. Water-bearing units within the Deschutes Formation are highly transmissive and yield water to pumping wells with very little to low draw down of the static water level at the well. In general, high capacity wells can be installed in this formation with reasonably high probability they will yield water at flow rates ranging from several hundred to more than 1,500 gpm.

In order to assess the effectiveness and efficiency of the containment and disposal of effluent, a series of monitoring wells were installed around the seepage ponds in 1979. The monitoring well system presently consists of 4 deep and 13 shallow monitoring wells. Each of the 13 shallow monitoring wells was designed to monitor a specific geologic stratum at a specific location. Five of the 13 monitoring wells are up-gradient monitoring wells (M-1S, M4-S, M6-S, M7-S and M13-S), while the remaining eight monitoring wells are down-gradient (M8-S, M9-S, M10-S, M11-S, M12-S, M14-S, M15-S, M16-S) of the ponds. Monitoring wells M15-S and M16-S are down-gradient of Ponds 3A and 3B. Shallow monitoring well M3-S was abandoned before the construction of Pond 3A and 3B, as it was located in the inundated area. Monitoring well locations are shown on Map 2, and described below.

4.3.1 Shallow Monitoring Wells

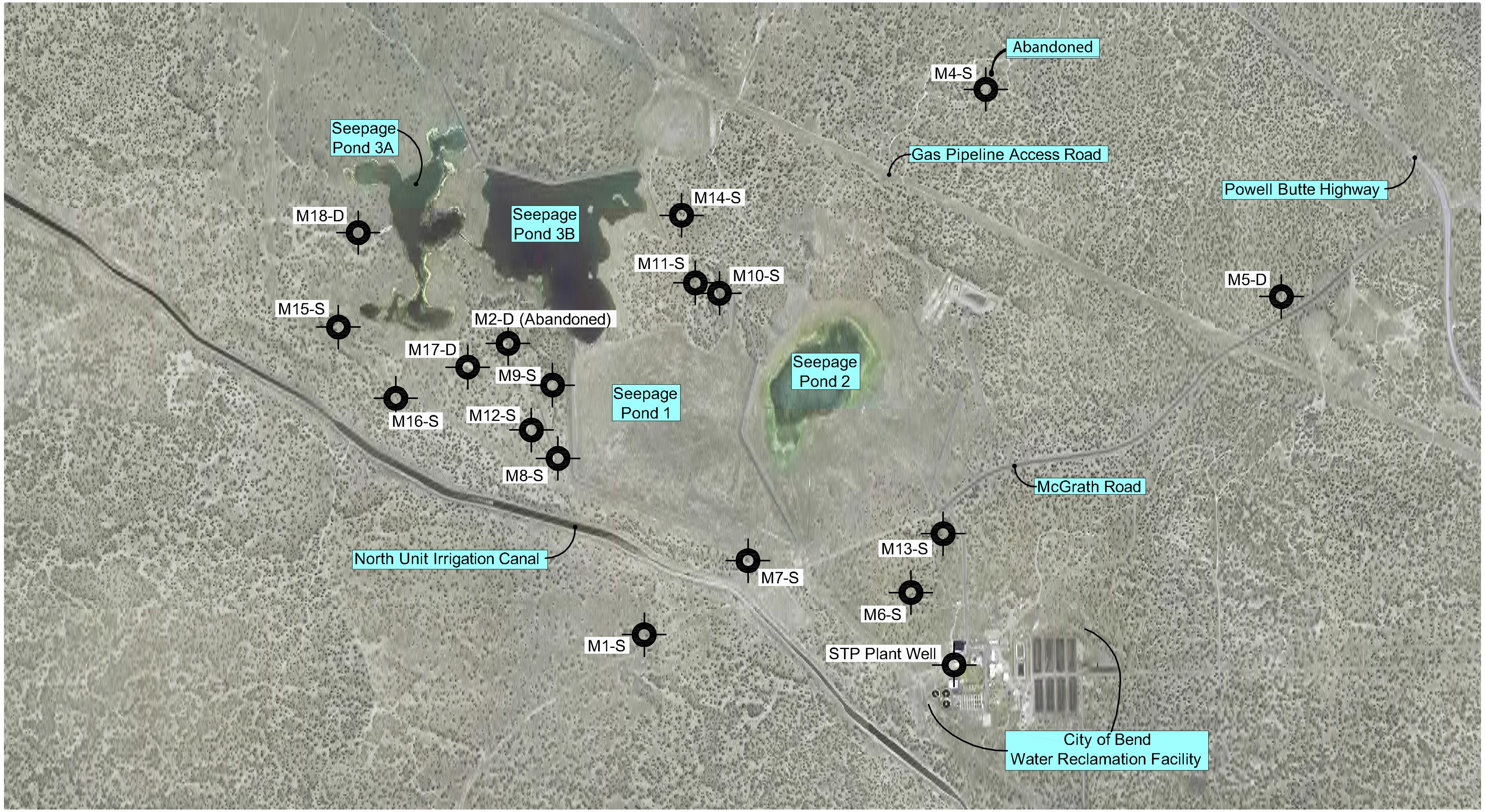
The shallow monitoring wells monitor four zones with the highest relative permeability found in the subsurface materials adjacent to the ponds. The monitoring well locations are shown on Map 2. Ground surface elevations surrounding the seepage ponds range from 3,310 to 3,350 feet above mean sea level. The monitoring wells are screened in the four high permeability zones described below:

1. The first highly fractured lava zone encountered (3,304 ft to 3,331 feet). This first fractured zone represents a lateral extension of fractures associated with a northward trend in surficial lava flow structures located along the western boundary of the seepage ponds.

2. The first interflow deposit and fracture zone (3,211 feet to 3,275 feet). Unconsolidated volcaniclastic sedimentary deposits such as pumice characterize this first interflow deposit.

3. The second interflow deposit of pumice (3,270 feet to 3,291 feet). This second interflow deposit is pyroclastic pumice lapilli deposit found to be continuous beneath the seepage ponds.

4. A cavernous rubbly basalt zone of highly fractured caverns and voids (3,015 feet to 3,046 feet).



LEGEND

M2-D Monitoring Well ID#

Approximate Location of Monitoring Well

1,200' 0' 1,200' 2,400'

SCALE: 1" = 1,200'

Monitoring Well Locations

City of Bend - Water Reclamation Facility

Deschutes County, Oregon

MAP 2

PROJECT NO. 1044-101-03

DATE: April 2007

DRAWN BY: S.Schenck

DESIGNED BY: J.Newton

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The first fracture zone is monitored primarily along the west and northwest sides of the containment Ponds 1 and 2. The first interflow deposit is monitored to the north of containment Ponds 1, 2, 3A and 3B. The second interflow deposit (pumice) is monitored on all but the south side of the containment Ponds 1 and 2 and the cavernous fractured zone is monitored on the west of Ponds 3A and 3B.

The shallow wells consist of 12-inch diameter boreholes that penetrate the zone selected for monitoring. A cement grout was placed on the well bottom and a 6-inch slotted casing was placed in each well. The slotting of the casing was restricted to the zone being monitored and a gravel pack was placed in the annular space for the entire thickness of the monitoring zone plus two feet above. A concrete grout seal to the surface was used in the annular space of each monitoring well.

4.3.2 Deep Monitoring Wells

Deep monitoring wells M5D, M17D, and M18D are in the Deschutes Formation aquifer. The City also routinely monitors the water supply well that serves the treatment plant and which is located at the treatment plant site. This well is termed “STP” well, and is also completely in the Deschutes Formation aquifer. The M5D and STP monitoring wells serve as up-gradient wells; M17D and M18D are down-gradient wells. Deep well M2-D was abandoned in 2000 due to problems with the original well construction and replaced by M18D. Construction of the deep wells is described below:

- Well STP was completed to a depth of 680 feet below the surface with a 10 inch casing from the land surface to 622 feet below the surface. The cement grout seal extended from the land surface to 39 feet below the surface. Well STP was screened from 522 to 622 feet below the surface.

- Well M5D was completed to a depth of 603 feet below the surface with a 6 inch casing from the land surface to 563 feet below the surface. The cement grout seal extended from the land surface to 570 feet below the surface. Well M5D was screened from 565 to 604 feet below the surface.

- Well M17D was completed in 1984 to a depth of 673 feet below the surface with a 6 inch casing from the land surface to 673 feet below the surface. The cement grout seal extended from the land surface to 606 feet below the surface. Well M17D was screened from 613 to 673 feet below the surface.

- Well M2D was completed in 1981 to a depth of 680 feet below the surface with a 6 inch casing from the land surface to 595 feet below the surface. The cement grout seal extended from the land surface to 596 feet below the surface. Well M2D was screened from 596 to 633 feet below the surface.

- Well M18D was completed in 1999 to a depth of 595 feet below the surface with a 6 inch casing from the land surface to 595 feet below the surface. The cement grout seal extended from the land surface to 570 feet below the surface. Well M18D was screened from 575 to 595 feet below the surface.

Monitoring wells M5D, M17D, and STP wells have been monitored for various constituents since they were installed in the early 1980s. M18D has been monitored since it was installed in 1999. The primary parameters monitored are nitrate-nitrogen, sulfate, chloride, temperature, pH, total dissolved solids (TDS), conductivity, and water elevation.

4.3.3 Discussion of Monitoring Wells M2D and Subsequent Abandonment

An investigation was undertaken in 1998 to determine why monitoring well M2D groundwater samples contained elevated concentrations of nitrates compared to the levels found in M17D, which is located 300 feet to the west and is screened in the same general zone. Results of the study indicated that the casing broke at 400 feet during the construction of monitoring well M2D, allowing well seal grout to enter the casing. Although this grout was later drilled out, it was still uncertain whether there was any seal placed in the annular space between the casing break at 400 feet below the ground surface and the beginning of the gravel pack at 680 feet below the surface.

The lack of well seal could lead water moving through the unsaturated zone to enter the annular space between the casing and the boring. This would create a preferential pathway for waters to reach the water table more rapidly and could explain why nitrate levels in monitoring well M2D were higher. This preferential pathway in monitoring well M2D would not allow shallower waters higher in nitrate concentrations to be diluted or be naturally attenuated as they move through the unsaturated zone, as was suspected to be occurring in monitoring well M17D.

The uncertainties related to monitoring well M2D include unreliable construction, potential for rapid downward migration of nitrates through borehole, and doubts that groundwater samples would be representative of surrounding groundwater conditions. Due to these conditions, monitoring well M2D was abandoned in August of 2000.

4.4 Impact on Groundwater Quality

This impact analysis will demonstrate that there is no likely adverse impact on groundwater quality by first showing the effluent quality for specific parameters is better than federal drinking water standards or maximum contaminant levels (MCLs). If effluent quality is better than the MCLs, the effluent cannot cause a violation of the MCLs in the groundwater. Secondly, water quality down-gradient wells will be compared with MCLs.

4.4.1 <u>Groundwater Nitrate Nitrogen</u>

Figure 1 shows the monthly average effluent concentration for total nitrogen from December 2004 to December 2005. All values are less or equal to the MCL for nitrate-nitrogen of 10 mg/L. If the total nitrogen in the effluent is less than 10 mg/L, then the effluent cannot cause a violation of the 10 mg/L nitrate-N MCL. The annual average effluent total nitrogen concentration was 6.85 mg/L. (Note: the higher concentrations that occurred in August and September were the result of a temporary process imbalance that is not expected to recur.)

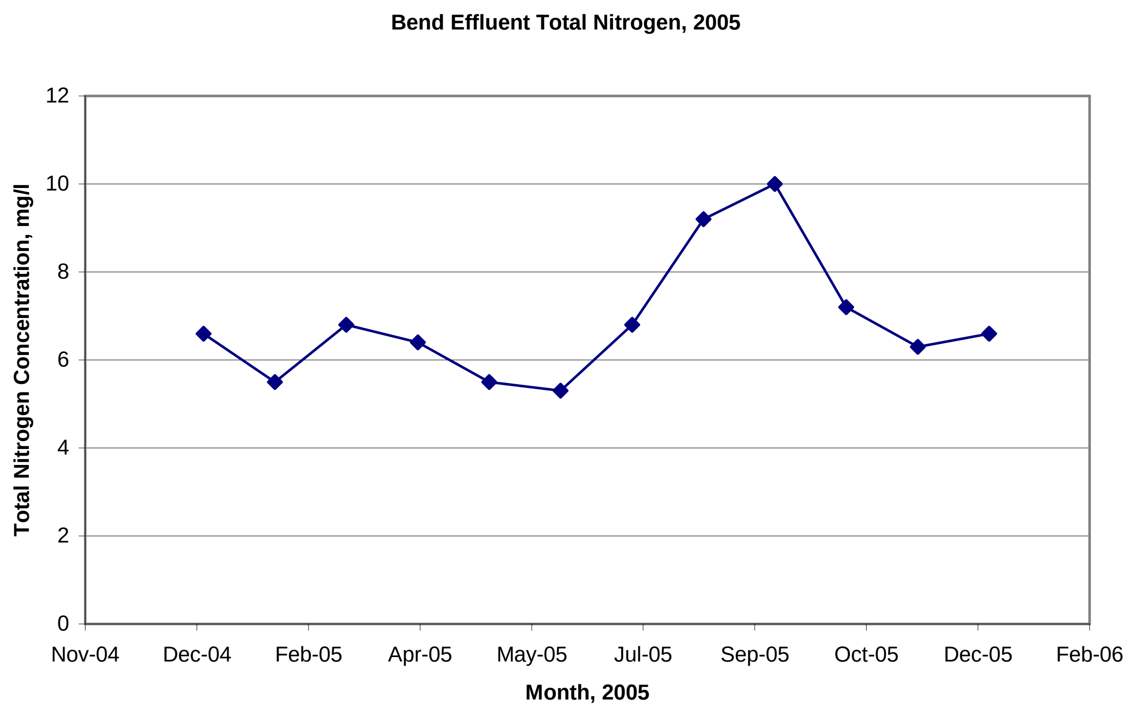

Figure 1 Bend WRF Effluent Total Nitrogen, 2005

Figures 2 and 3 show the concentrations of nitrate/nitrite nitrogen and chloride in the monitoring wells. These graphs show two notable points. First, after 25 years of using the seepage ponds to dispose of effluent, nitrate/nitrite nitrogen concentrations in the two down-gradient wells are still less than 1.0 mg/L. Second, both the chloride and the nitrogen graphs seem to show a very slight upward trend in the down-gradient wells beginning around the year 2000. Considering the general scatter of data over twenty-five years, this may not be a trend at all. However, it also could be a manifestation from lining the North Unit main canal that runs just west of the wastewater facility and the monitoring wells. The lining could have stopped canal leakage that was diluting groundwater in the vicinity of the monitoring wells. Part of the canal was lined in 1999, and another part was completed in 2002. Further data collection is necessary to verify whether or not an actual trend is occurring.

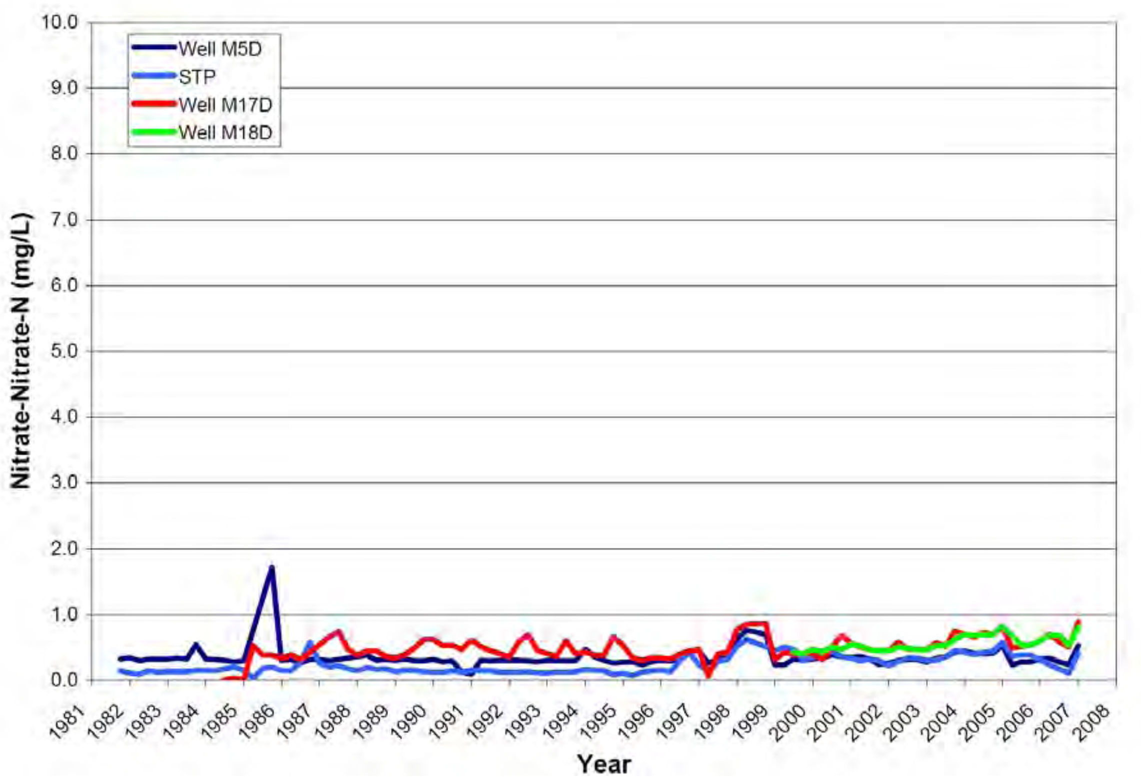

Figure 2 Monitoring Well Nitrate-Nitrite-N Levels

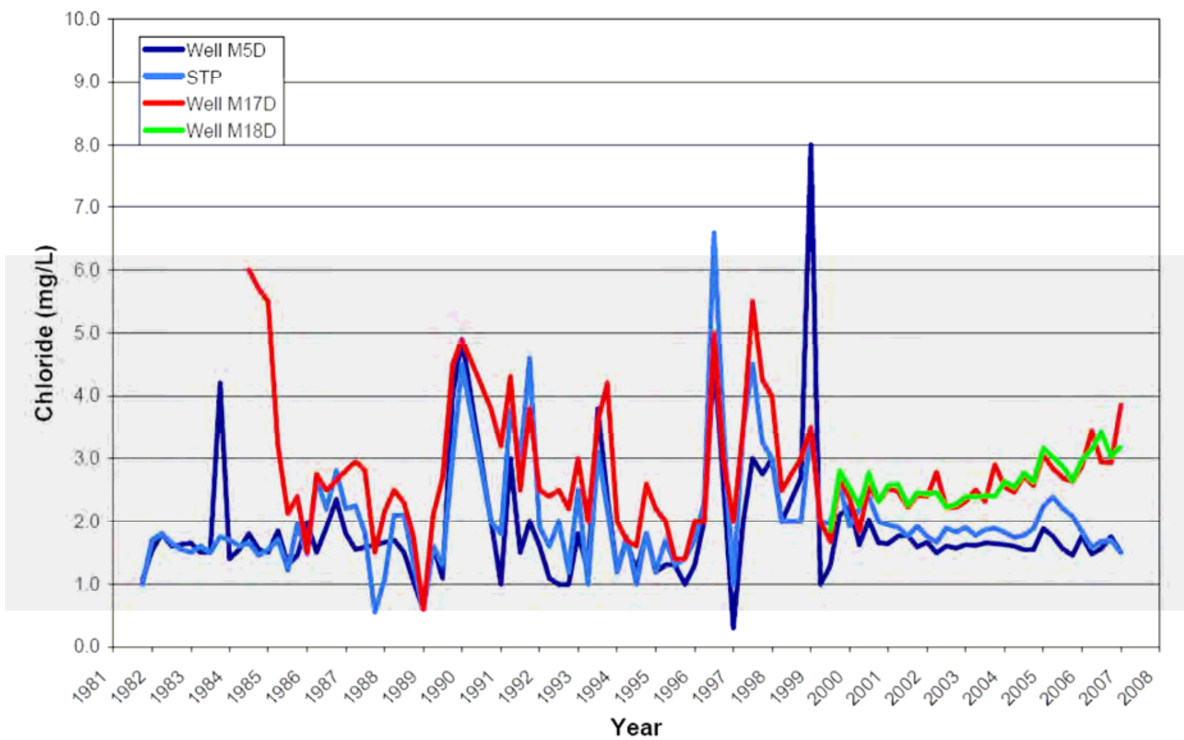

Figure 3 Monitoring Well Chloride Levels

Figure 4 shows the sulfate and chloride concentrations, along with the groundwater elevation in monitoring well M18D. In addition, the graph includes a mass regression analysis trend line for each data set. The graph indicates a possible relationship between increased anion concentrations and dropping groundwater elevation. The drop in groundwater elevation could be a verification that dilution from canal leakage is no longer occurring.

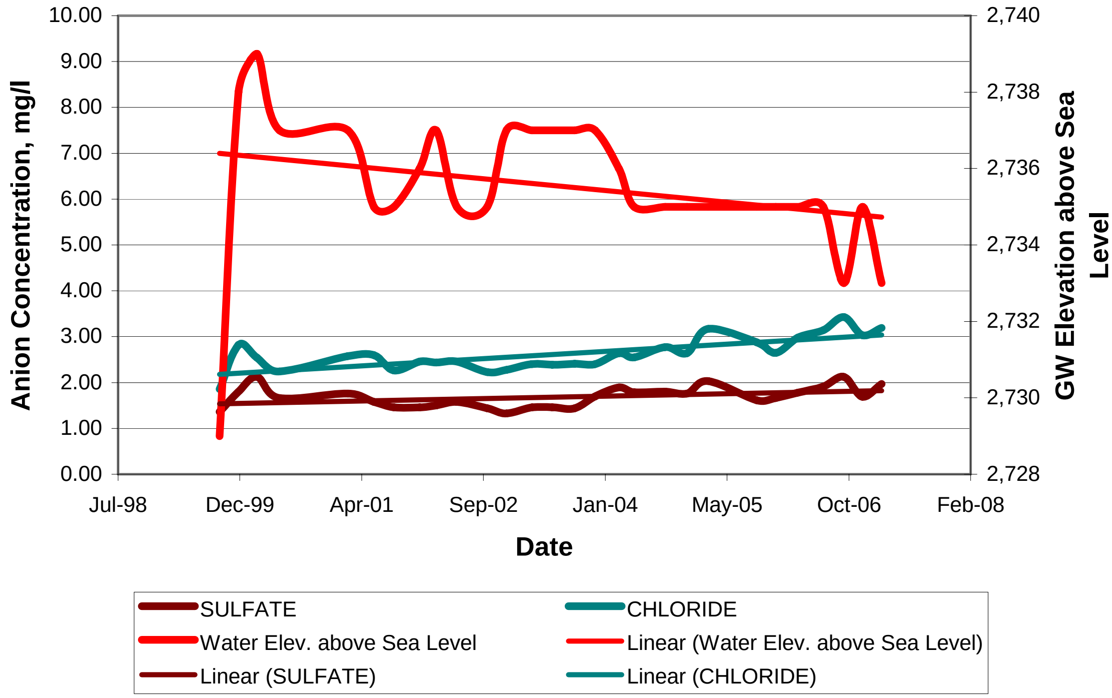

Figure 4 M18D Anions and Water Elevation

Metals

Table 1 summarizes available effluent data from four separate sampling events conducted in 2006. Each event consisted of one 24-hour composite sample collected on each of three consecutive days for a total of twelve samples. Except for copper, arsenic, lead, and zinc, much of the data indicates that contaminants were below method detection limit (MDL). Where values were given as below the MDL, a value of half of the MDL was used to calculate the average.

Table 1 Summary of Effluent Metals Data 2006
Bend Water Reclamation Facility
City of Bend

Contaminant	Number of Samples Collected	Percentage of Non Detects	Method Detection Limit, µg/L	Average[1] Concentration, µg/L	Maximum Concentration, µg/L	Minimum Concentration, µg/L
Arsenic	12	0%		1.51	1.78	1.03
Cadmium	12	75%	0.07/1	0.65	1.00	0.07
Chromium	12	42%	1.0/0.8	0.73	1.00	0.15
Cyanide	12	100%	5.00	2.50	2.50	2.50
Copper	12	0%		11.60	26.30	5.22
Lead	12	0%		1.96	4.12	0.90
Mercury	12	92%	0.20	0.15	0.20	0.06
Molybdenum	12	50%	5.0/4.0	3.47	5.00	1.29
Nickel	12	33%	2.0/1.6	2.05	3.01	1.45
Selenium	12	67%	2.0/1.6	1.56	2.00	0.30
Silver	12	50%	1.0/0.8	0.86	2.85	0.16
Zinc	12	0%		80	120	54

Note:

1. In calculating the average concentration, one half of the MDL was used when samples were Reported below MDL.

Table 2 compares the effluent data against the federal drinking water (DW) standard or MCL. A review of the data shows that effluent concentrations of these metals were all less than 27% of their respective MCL. If effluent concentrations are less than their respective MCL, the effluent cannot cause a violation of the MCLs in groundwater.

Table 2	Comparison of Effluent Values to Federal Drinking Water Standard (MCL) Bend Water Reclamation Facility City of Bend				
Contaminant	**Effluent Maximum Value, µg/L**	**Effluent Average Value[1] µg/L**	**Federal Drinking Water Standard (MCL), µg/L**	**Ratio Max Effluent to MCL**	**Ratio Avg. Effluent to MCL**
Arsenic	1.78	1.51	10	0.18	0.15
Cadmium	0.50	0.34	5	0.10	0.07
Chromium	0.86	0.54	100	0.01	0.01
Copper	26.3	11.6	1300	0.02	0.01
Cyanide	2.5	2.5	200	0.01	0.01
Lead	4.12	1.96	15	0.27	0.13
Mercury	0.10	0.08	2	0.05	0.04
Molybdenum	5	3.47	N/S*	N/A	N/A
Nickel	3.01	2.05	**	N/A	N/A
Selenium	1.30	0.94	50	0.03	0.02
Silver	2.85	0.86	N/S	N/A	N/A
Zinc	120	80.3	N/S	N/A	N/A

Notes:

1. In calculating the average concentration, one half of the MDL was used when samples were reported below MDL.

* N/S means no standard.

** The MCL for nickel is being re-evaluated.

Tables 3, 4, 5, and 6 provide a summary of the groundwater quality data for monitoring wells M5D, STP, M17D, and M18D. Numbers in **bold** indicate that there was no detection above the MDL, and the number shown is the MDL. These tables are provided to show that many of the analytes were below MDLs. Furthermore, the data are very limited. Only three samples have been collected from the deep monitoring wells and only two samples from the STP well. Conclusions drawn upon analyses that include assumptions about values where results are below MDL may be misleading. Therefore, additional data should be collected before any significant decision is made relative to additional controls on metals.

Table 3 Metals Data for MW M5D
Bend Water Reclamation Facility
City of Bend

Sample Date	3/15/2006	9/19/2006	12/5/2006
	µg/L	µg/L	µg/L
Arsenic	1.72	2.000	1.740
Cadmium	**0.0779**	**0.020**	**0.0571**
Chromium	0.932	**0.100**	0.888
Copper	**0.133**	**0.300**	**0.107**
Cyanide	**5.0**	**2.000**	**2.000**
Lead	2.55	1.000	2.150
Mercury	0.181	0.800	**0.0637**
Molybdenum	1.53	5.000	**0.0623**
Nickel	**0.180**	**2.000**	**0.144**
Selenium	**0.284**	**0.300**	**0.227**
Silver	**0.121**	**2.000**	**0.097**
Zinc	332	424	358

Table 4 Metals Data for STP Well
Bend Water Reclamation Facility
City of Bend

Sample Date	3/15/2006	9/19/2006	12/5/2006
		µg/L	µg/L
Arsenic	No sample collected	3.000	2.960
Cadmium	No sample collected	**0.020**	**0.0571**
Chromium	No sample collected	2.000	1.060
Copper	No sample collected	**0.300**	**0.107**
Cyanide	No sample collected	**2.000**	**2.000**
Lead	No sample collected	**0.500**	**0.0443**
Mercury	No sample collected	**0.100**	**0.0637**
Molybdenum	No sample collected	2.000	**0.0623**
Nickel	No sample collected	**2.000**	**0.144**
Selenium	No sample collected	**0.300**	**0.227**
Silver	No sample collected	**2.000**	**0.097**
Zinc	No sample collected	39.000	25.900

Table 5	Metals Data for MW M17D Bend Water Reclamation Facility City of Bend		
Sample Date	**3/15/2006**	**9/19/2006**	**12/5/2006**
	µg/L	µg/L	µg/L
Arsenic	2.920	2.000	2.740
Cadmium	0.0779	0.200	**0.0571**
Chromium	1.160	2.000	1.180
Copper	**0.133**	**0.300**	**0.107**
Cyanide	**5.0**	**2.000**	**2.000**
Lead	0.424	**0.500**	**0.0443**
Mercury	0.105	0.900	**0.0637**
Molybdenum	0.971	4.000	**0.0623**
Nickel	**0.180**	**2.000**	**0.144**
Selenium	**0.284**	**0.300**	**0.227**
Silver	**0.121**	**2.000**	**0.097**
Zinc	226	343	271

Table 6	Metals Data for MW M18D Bend Water Reclamation Facility City of Bend		
Sample Date	**3/15/2006**	**9/19/2006**	**12/5/2006**
	µg/L	µg/L	µg/L
Arsenic	2.400	2.000	2.380
Cadmium	**0.0714**	**0.020**	**0.0571**
Chromium	0.123	2.000	1.140
Copper	0.827	**0.300**	**0.107**
Cyanide	**5.0**	**2.000**	**2.000**
Lead	0.388	**0.500**	**0.0443**
Mercury	0.0863	0.900	**0.0637**
Molybdenum	0.732	2.000	**0.0623**
Nickel	0.426	**2.000**	**0.144**
Selenium	**0.284**	**0.300**	**0.227**
Silver	**0.121**	**2.000**	**0.097**
Zinc	233	386	146

Tables 3 and 4 indicate that the up-gradient or background wells (M5D and STP) are inconsistent for some parameters. For instance, zinc is ten times as high in M5D as the STP well. The average lead concentration in M5D was 1.9 µg/L while it was undetected in the STP well. On the other hand, chromium in the STP well is five times that in M5D. This matter will be addressed in a later section of this technical memorandum.

Table 7 shows the average metals concentrations for monitoring wells M5D, STP, M17D, and M18D, and the ratios of M17D and M18D (the down-gradient monitoring wells) to the federal drinking water standards or MCLs. As with the effluent data, where values were given as below the MDL, a value of half of the MDL was used to calculate the average. The highest ratio is for arsenic and is about one quarter.

Table 7 Comparison of 2006 Average[1] Monitoring Well Metals Data Against MCL
Bend Water Reclamation Facility
City of Bend

Contaminant	MCL, µg/L	Up-Gradient Wells		Down-Gradient Wells		Ratio of M17D to MCL	Ratio of M18D to MCL
		M5D Well, µg/L	STP Well, µg/L	M17D Well µg/L	M18D Well, µg/L		
Arsenic	10	1.304	2.980	2.553	2.260	0.255	0.226
Cadmium	5	0.039	0.019	0.196	0.025	0.039	0.005
Chromium	100	0.623	1.530	1.447	1.457	0.014	0.015
Copper	1300	0.090	0.102	0.090	0.344	0.000	0.000
Cyanide	200	1.50	1.000	1.500	1.500	0.008	0.008
Lead	15	1.900	0.136	0.232	0.220	0.015	0.015
Mercury	2	0.338	0.041	0.346	0.321	0.173	0.170
Molybdenum	N/S*	2.187	1.016	1.667	0.921		
Nickel	**	0.387	0.536	0.387	0.499		
Selenium	50	0.135	0.132	0.135	0.135	0.003	0.003
Silver	N/S	0.370	0.524	0.370	0.370		
Zinc	N/S	371	32	280	255		

Notes:
1. In calculating the average concentration, one half of the MDL was used when samples were reported below MDL.
* N/S means no standard.
** The MCL for nickel is being re-evaluated.

The data for the down-gradient wells indicates that groundwater quality is still well below the federal maximum contaminant levels set in the federal Safe Drinking Water Act. Therefore, based upon the following observations the current level of effluent disposal does not appear to have an adverse impact on groundwater quality:

Total nitrogen concentrations in the groundwater down-gradient from the seepage ponds as represented by nitrate-nitrite are less than 1.0 mg/L. The federal drinking water standard is

10 mg/L. Furthermore, concentrations of toxic metals and other constituents are significantly less than the federal drinking water standards.

4.4.2 Effectiveness of Wells on Monitoring Groundwater Quality

Figure 5 (background nitrate) and Figure 6 (background chloride) show nitrate-nitrogen and chloride concentrations in the two up-gradient monitoring wells: M5D and STP. In general, the data appear to demonstrate similar water quality for these parameters.

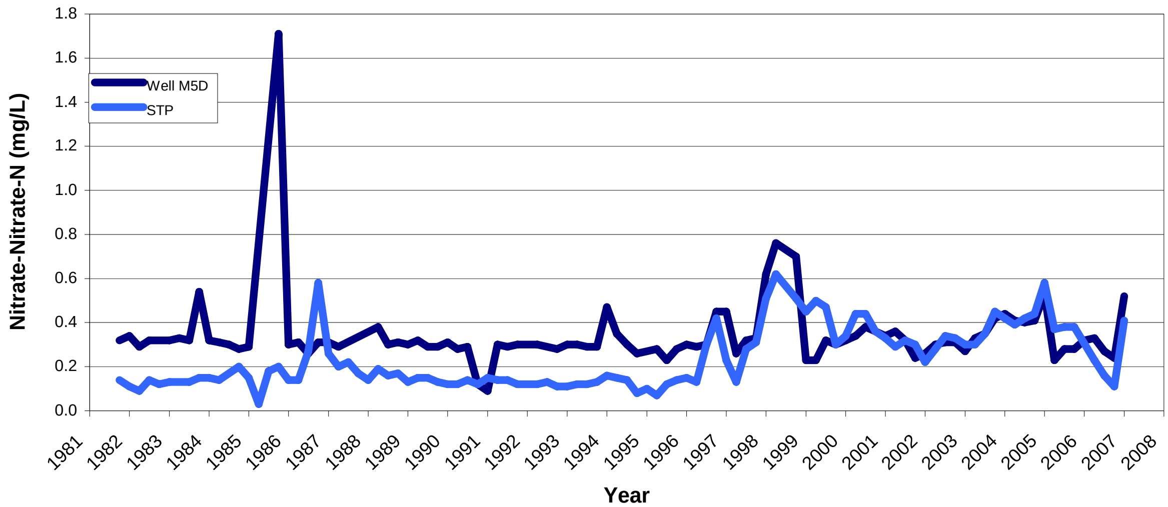

Figure 5 Background Well Nitrate-Nitrite-N Levels

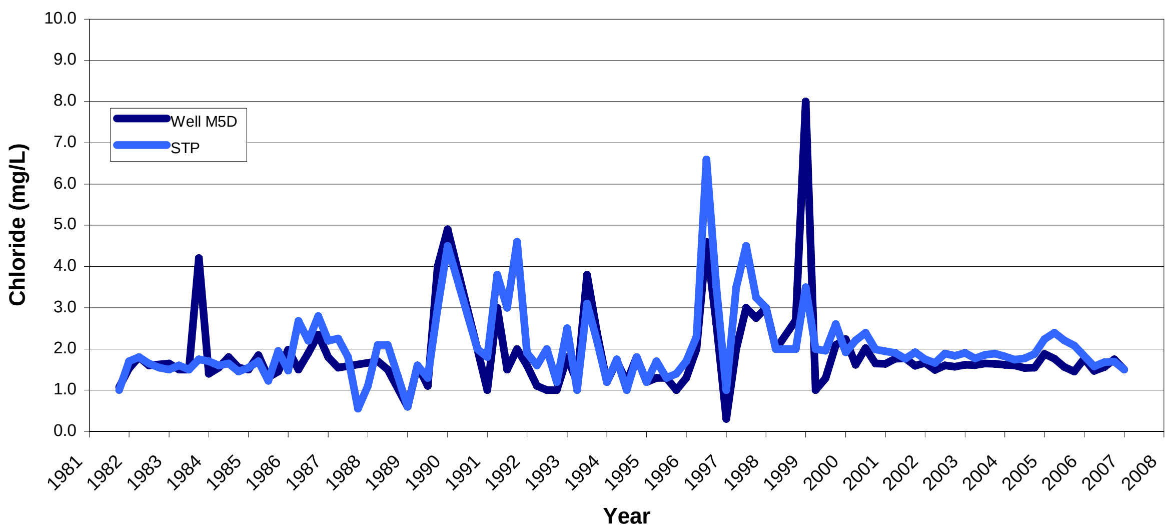

Figure 6 Background Well Chloride Levels

A review of Table 7 indicates the levels of both lead and zinc in monitoring well M5D appear elevated over those levels in the STP well. Well M5D is located relatively close to an abandoned municipal dump and may be affected by its leachate. The STP well shows elevated chromium levels compared to M5D. These differences provide some concern about the ability of the two up-gradient monitoring wells to represent background groundwater quality. On the other hand, the data comes from a limited set of samples (three sets for M5D and only two sets for the STP well). In addition, a significant amount of the values were reported as less than minimum detection levels. Additional data needs to be collected and analyzed before conclusions can be drawn about the background data.

The shallow monitoring wells are intended to monitor various zones beneath the ponds where water is most likely to appear. The shallow wells do not penetrate any water bearing zones and as such are mainly used to monitor the presence or absence of water up-gradient and down-gradient of the ponds. Monitoring results can be used to confirm the presence of seepage water in a particular zone and the quality of the water that is present. This water quality data can also be compared to that of the deep monitoring wells. Monitoring records of the shallow wells indicated, for example, that water levels increased notably in well M10S as a result of a leak that occurred in Pond 2 in late 1982 to early 1983. Once the leak was fixed however, water levels in well M10S declined. Deep wells M5D and M2D were also sampled during this period with only a slight increase in nitrate noted in monitoring well M2D.

5.0 PROPOSED EXPANSION OF SEEPAGE POND USE

The annual average flow projected from the Bend WRF in 2030 is 10.9 MGD or 12,210 acre-feet per year. Therefore, approxmately 5.9 MGD or 6,609 acre-feet per year of effluent will need to be disposed of. The current method of discharging effluent into containment Ponds 3A and 3B has proven to be effective and safe. Therefore, expanded use of the seepage ponds is the recommended approach to increase effluent disposal capacity through the 2030 planning period.

Pond 1 is currently not being used and Pond 2 is only intermittently used. These two ponds can provide additional capacity, as well as provide redundant systems should Ponds 3A or 3B fail or need maintenance for any reason.

5.1 Seepage Capacity of Existing Ponds

Assuming that additional seepage areas will seep/evaporate at the same rate (81 acre-feet per acre) as in 2005 in Ponds 3A and 3B, approximately 87 additional acres of area will be needed to accommodate the 2030 annual flow. This also assumes that the nearby golf course will continue to use 260 acre-feet of effluent each year.

Area capacity curves created for Ponds 3A and 3B indicate that an additional 30 acres in Pond 3A are available for inundation. This means that another 57 acres will be needed in addition to Ponds 3A and 3B, assuming an average seepage rate of 81 acre-feet per acre.

Area capacity curves for Pond 1 and Pond 2 show approximately 74 and 79 available acres, respectively, at the normal high water surface of 3,337 ft MSL. Assuming a seepage rate of 81 acre-feet per acre, either pond could accommodate the needed additional flow in conjunction with Ponds 3A and 3B.

5.2 Assumptions for Predicting Seepage Capacity of Ponds 1 and 2.

The primary assumption is that the seepage/evaporation rates in Ponds 1 and 2 will be the same as that in Ponds 3A and 3B (81 acre-ft per acre). This also assumes that the seepage/evaporation rate for the 30 acres of the unused portion of 3A will also be 81 acre-ft per acre. However, as previously described, when Ponds 1 and 2 were designed the estimated seepage/evaporation rate was 27.5 acre-ft per acre. If the actual seepage/evaporation rate for Ponds 1 and 2, is 27.5 acre-ft per acre, then 168 acres of seepage area would be needed at the 2030 annual average effluent flow rate. The total area of Ponds 1 and 2 (153 acres) are about 10% less than the area needed if Ponds 1 and 2 operate at the lower seepage/evaporation rate. This report recommends that the City monitor seepage/evaporation rates as Ponds 1 and 2 are brought back on line. If seepage rates are equal to or greater than approximately 30 acre-feet per acre, then Ponds 1 and 2 would accommodate the additional projected 2030 flow. If the actual seepage/evaporation rates are found approaching the original estimated rates and are less than 30 acre-feet per acre, action can be taken to locate and construct an additional seepage/evaporation pond.

5.3 Pond 1 and 2 Reconditioning Needs and Costs

In order to effectively use Ponds 1 and 2, they will need to be reconditioned to reduce the risk of high rate leakage in potential high-risk areas.

Contract documents (Ultimate Effluent disposal System: Contract No. 39) for the construction of Ponds 1 and 2 identified areas, as shown in Map 3, that required modifications to take into account potential risks of high seepage rates. These modifications included removal of loose coarse basalt and large rubble material, installation of filter fabric, and placement of new embankment fill material to a minimum depth of 2 feet. In areas exposed to wave action or areas of bedrock near the maximum water surface an additional 6 to 12 inch layer of rip-rap was recommended. The new embankment and rip-rap was recommended to carry to one foot above the maximum water surface.

Areas Originally Identified for Reconditioning

City of Bend - Water Reclamation Facility
Deschutes County, Oregon

EXPLANATION

- Areas Identified in Contract No.39 Document Recommending Soil and Fabric Cover
- Areas Identified in Contract No.39 Document Recommending Soil Cover

0' 400' 800'
SCALE: 1" = 400'

MAP	3
PROJECT NO.	1044-101-03
DATE:	April 2007
DRAWN BY:	S.Schenck
DESIGNED BY:	J.Newton

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Additional surveys of Ponds 1 and 2 were conducted in March 2007 to assess these mapped potential high risk leakage areas, and to determine if any additional areas could pose a risk of high leakage rates. Map 3 shows the areas that were originally identified in the contract documents, and Map 4 shows these areas along with additional areas of exposed bedrock identified during a field reconnaissance survey. The extent of pond reconditioning could expand during construction if construction activities uncover additional high risk areas. Repairs would include removal of loose coarse basalt and large rubble material, installation of filter fabric, and placement of new embankment fill material to a minimum depth of 2 feet. In areas exposed to wave action or areas of bedrock near the maximum water surface, an additional 6 to 12 inch layer of rip-rap is also recommended. Areas identified for reconditioning are shown in Map 5.

The aerial extent of the areas identified in Ponds 1 and 2 are approximately 9.15 acres and 8.5 acres respectively. Estimated project costs to perform the reconditioning of the above areas in Ponds 1 and 2 are approximately $734,000 and $574,000, respectively. This assumes that embankment fill material needed to cover the filter fabric will be procured on site.

EXPLANATION

Bedrock exposures

Surface material (boulder-cobble float) where shallow bedrock is likely.

NOTES

1. Location where Rip Rap berm has been damaged. Berm repair is required.
2. Small sink hole depression.
3. Bedrock exposed in ditch and suspect of bedrock between -2 identified locations for repair.
4. Bedrock exposed in discharge ditch.

0' 400' 800'

SCALE: 1" = 400'

Site Reconnaissance

City of Bend - Water Reclamation Facility
Deschutes County, Oregon

MAP 4

PROJECT NO. 1044-101-03

DATE: April 2007

DRAWN BY: S.Schenck

DESIGNED BY: J.Newton

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Earth, Water and Rock Specialists
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EXPLANATION

Reconditioning Areas

Reconditioning Areas	
Pond 1 Area	Pond 2 Area
9.15 Acres	8.50 Acres

0' 400' 800'

SCALE: 1" = 400'

Pond 1 and Pond 2 Reconditioning Areas

City of Bend - Water Reclamation Facility
Deschutes County, Oregon

NEWTON CONSULTANTS INC.
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DESIGNED BY: J.Newton
DRAWN BY: S.Schenck
DATE: April 2007
PROJECT NO. 1044-101-03
MAP 5

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5.4 Projected Impact on Groundwater Quality

5.4.1 Relative Aquifer Flow at Down-gradient Wells, M17D and M18D.

The current relative aquifer flow occurring in the groundwater can be determined using the conservative anions, chloride and sulfate. Note that nitrogen was not used for determining dilution, in part, because it is not a conservative constituent. To determine dilution, the following equation was used:

Aquifer flow, $Q_A = Q_P(C_A' - C_P)/(C_A - C_A')$ (Equation 1)

Where
Q_P = Seepage pond discharge flow, MGD
C_P = Plant discharge concentration, mg/L
Q_A = Aquifer flow, MGD
C_A = Up gradient aquifer concentration, mg/L
C_A' = Down gradient aquifer concentration, mg/L

For 2005, the annual average discharge flow from the sewage treatment plant was 5.0 MGD. It is recognized that some of the 5.0 MGD effluent flow is evaporated in the seepage ponds, but this portion is very small (≈ 3-4%) and deemed insignificant to that portion which seeps into the ground. The 2005 average concentrations of sulfate and chloride in the effluent and up and down gradient monitoring wells are summarized in Tables 8 and 9. Sulfate and chloride values for monitoring well M5D were used for the up-gradient groundwater concentration. Chloride and sulfate values for M5D and the STP well (both considered up-gradient monitoring wells) are similar. Figure 6 shows the similarity of chloride values in M5D and the STP well.

Table 8 2005 Calculated Aquifer Flow in Monitoring Well M18D
Bend Water Reclamation Facility
City of Bend

	Chloride	Sulfate
Effluent, C_P , mg/L	48.0	18.9
M5D, C_A , mg/L	1.66	1.25
M17D, C_A', mg/L	2.81	1.57
Calculated Dilution	39.3	54.1
Aquifer Flow, Q_A MGD[1]	197	253

Notes:
1. Based on annual flow of 5 MGD.

Table 9	2005 Calculated Aquifer Flow in Monitoring Well M17D Bend Water Reclamation Facility City of Bend

	Chloride	Sulfate
Effluent, C_P, mg/L	48.0	18.9
M5D, C_A, mg/L	1.66	1.25
M18D, C_A', mg/L	2.18	1.82
Calculated Dilution	88.1	29.96
Aquifer Flow, Q_A MGD[1]	441	150

Notes:

1. Based on annual flow of 5 MGD.

The resulting assumed aquifer flows were 225 and 296 mgd in Wells 17D and 18D, respectively, based on the average calculated values for the two conservative constituents.

5.4.2 Predicted Nitrate Nitrogen in Groundwater at Expanded Seepage Flows

The increase in concentration of groundwater constituents can be predicted with the following equation:

$$C_{A2}' = (Q_P' C_P + Q_A C_A)/(Q_P' + Q_A) \quad \text{(Equation 2)}$$

Where
Q_P' = Expanded Seepage pond discharge flow, MGD
C_P = Plant discharge concentration, mg/L
Q_A = Aquifer flow, MGD
C_A = Up gradient aquifer concentration, mg/L
C_{A2}' = Projected down gradient aquifer concentration, mg/L

Derivation of equation (2) and equation (1) used to determine current dilution is in Appendix A. projected down-gradient concentrations for monitoring wells M17D and M18D summarized in Table 10 are based upon this equation, up-gradient nitrate concentration of 0.34 mg/L at MW M5D, and the projected 2030 annual average effluent flow of 10.9 MGD.

Table 10	Predicted 2030 Nitrate Concentrations as Projected from MW M17D and M18D Bend Water Reclamation Facility City of Bend

Monitoring Well	Aquifer Flow, MGD	Projected 2030 Average Nitrate Concentrations	
		@ 10 mg/L permitted effluent concentration	@ 2005 annual average effluent concentration, 6.85 mg/L
M17D	225	0.79	0.64
M18D	296	0.70	0.59

5.4.3 Predicted Metals in Groundwater at Expanded Seepage Flows

Projected 2030 metal concentrations in down-gradient wells can be predicted using the same approach used to predict down-gradient nitrate concentrations. The equation used to make these predictions is a function, in part, on the up-gradient concentration as well as effluent concentrations. For these predictions, 2030 effluent concentrations were assumed to be similar to those concentrations found in 2006. Because the metals concentrations are significantly different in M5D and the STP well, predictions were made using data from both wells. The predictions are summarized in Table 11 and Table 12. Table 11 used data from M5D for up-gradient concentrations and Table 12 uses the STP well data. Predictions were made only for those contaminants for which the preponderance of the data was from actual detected levels. For M5D, predictions are provided for arsenic, lead and zinc; for the STP well, predictions are provided for arsenic, chrome and zinc.

Table 11 Predicted 2030 Down-gradient Groundwater Metals Concentrations as Projected from MW M5D

Contaminant	2006 M5D, μg/L	2006 effluent, μg/L	2006 M17D Well (Down-Gradient). μg/L	2006 M18D Well (Down-Gradient), μg/L	Projected 2030 M17D, μg/L	Projected 2030 M18D, μg/L	MCL, μg/L
Arsenic	1.82	1.51	2.55	2.26	1.80	1.81	10
Lead	1.90	1.96	0.232	0.220	1.90	1.90	15
Zinc	371	80	280	255	354	361	N/A

Table 12 Predicted 2030 Down-gradient Groundwater Metals Concentrations as Projected from STP Well

Contaminant	2006 STP, μg/l	2006 effluent, μg/l	2006 M17D Well (Down-Gradient). μg/l	2006 M18D Well (Down-Gradient), μg/l	Projected 2030 M17D, μg/l	Projected 2030 M18D , μg/l	MCL, μg/l
Arsenic	2.96	1.51	2.55	2.26	2.89	2.91	10
Chromium	1.53	0.54	1.447	1.457	1.48	1.49	100
Zinc	32	80	280	255	34	34	N/A

The results are mixed. In Table 11, arsenic decreases because the current levels of arsenic in the down-gradient monitoring wells are higher than both up-gradient and effluent concentrations. Lead increases in the down-gradient wells, but much of the increase is due to the relatively high levels in well M5D. Similarly, zinc increases, but only because of the high levels in M5D.

In Table 12, arsenic increases in the down-gradient wells, but only because of the higher levels in the up-gradient STP well. Chromium increases in the down-gradient wells, but very little. Zinc is predicted to decrease in the down-gradient wells.

While this report attempts to predict future impacts for metal discharges, the results are based upon very limited data. Fortunately, current and projected concentrations of metals are well below MCLs. This should provide confidence that groundwater is not being degraded beyond use and allows time for additional data to be collected.

5.4.4 Conclusions for Groundwater Quality Impacts

The following conclusions are derived from the preceding analyses:

1. Projected concentrations of nitrate nitrogen in down-gradient monitoring wells will still remain quite low compared to federal MCLs.
2. There is insufficient data to confidently predict future groundwater quality with respect to metals. Current levels, however, are quite low in the down-gradient wells and in plant effluent and there is no indication that groundwater quality is at risk. It is recommended that additional data should be collected and analyzed over the next several years.
3. There is no reason to believe that increased use of the seepage ponds for effluent disposal will have an adverse impact on groundwater quality.
4. Monitoring well M5D and the potential impact of the abandoned landfill should be further investigated.

5.5 Compliance with Regulatory Issues

5.5.1 Basis for Concluding that Highest and Best Practicable Control of Wastewater is achieved.

The phrase “highest and best practicable methods” is a subjective term. In very simplistic terms, highest and best practicable control would be one that achieves the lowest impact on the environment at a reasonable cost including secondary environmental effects. A control strategy that achieves a high level of treatment and minimal impact on the environment at a reasonable cost should meet the definition of “highest and best.” On the other hand, a control strategy that achieves a high level of treatment at a high cost, but with insignificant improvement in the environment would seem impracticable.

Currently, the WRF utilizes a Modified Ludzack Ettinger (MLE) process to control total nitrogen discharge into the seepage ponds. This process was installed and began operating in September 2000. In 2005, the annual average total nitrogen discharged to the seepage ponds was 6.85 mg/L. Figure 7 shows the total mass load discharge of total nitrogen to the seepage ponds from 1998 to 2006, indicating a significant reduction over this period despite an increasing effluent flow. The MLE process also provides enhancedBOD-5 and TSS removal beginning in September, 2000, as indicated in Figure 8.

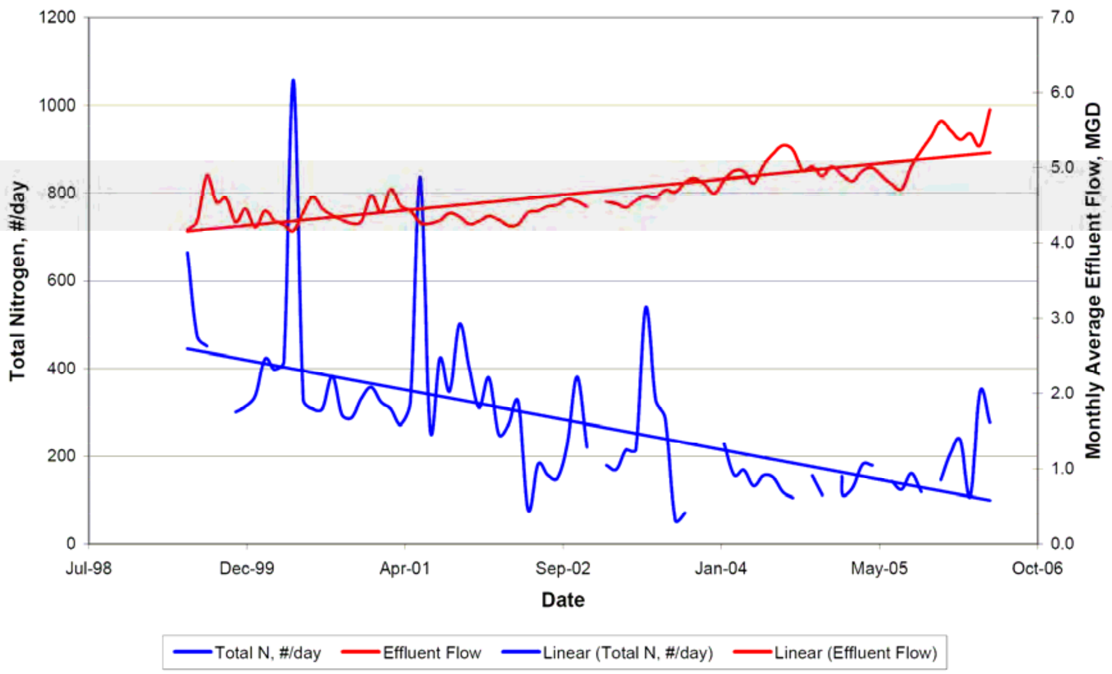

Figure 7 Monthly Average Total Nitrogen Mass Discharge, 1998-2006

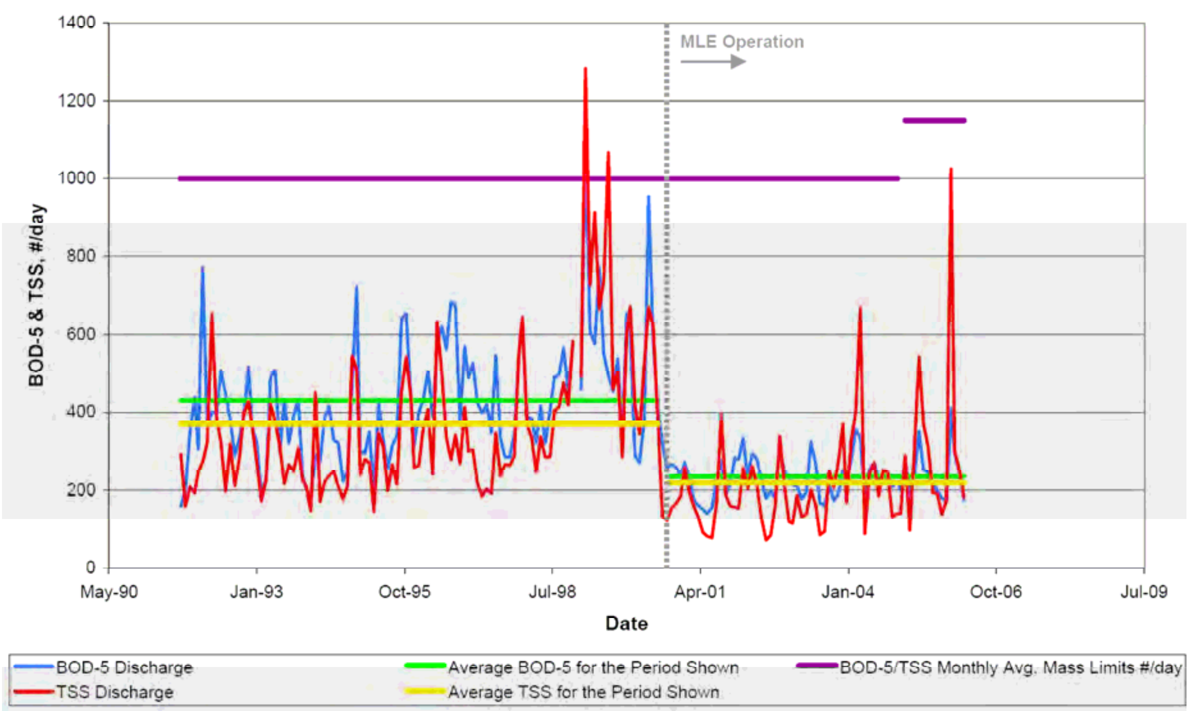

Figure 8 Bend WRF Monthly Average BOD-5 and TSS Mass Load Discharge

As shown in previous sections, nitrate concentrations in down-gradient monitoring wells remain well 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. Based upon this, an expanded wastewater facility providing current levels of treatment for total nitrogen should be considered to represent highest and best practicable control.

Table 12 shows the current level of metals removal through the existing treatment plant. Although the existing treatment plant was not designed to remove these metals, removal efficiency is quite good for many contaminants. As previously stated, many of the metals were not detected above the method detection limit (MDL). Table 12 indicates the amount of non-detects. The percent removal is based upon average 2006 concentrations. In calculating the average, half of the MDL was used when the reported concentration was below MDL. For those contaminants where the number of non-detects was significant, the calculated removal efficiency is an estimate based on very limited data and should not be considered representative. For arsenic, chromium, copper, lead, nickel, silver, and zinc, however, the removal efficiency is reasonably accurate. Note that cyanide is not included in the table, as there were no samples found above MDL in either the influent or the effluent.

Removal efficiencies for metals in 2030 are expected to be equivalent to current removals. Although much additional groundwater data needs to be collected to better define groundwater impacts, current metals concentrations in down-gradient wells are well below federal MCLs. Based upon this, this analysis concludes that highest and best practicable control of metals will be provided with the expanded treatment and disposal system.

Table 13	**Metals Removal Through Existing Treatment Process Bend Water Reclamation Facility City of Bend**			
DATA	**Influent/ Effluent Non-detects**	**Influent Annual Average[1], *u*g/L**	**Effluent Annual Average[1], *u*g/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).

In addition to the current level of treatment, each year the City of Bend provides Pronghorn Resort with 260 acre-feet of effluent for use on its golf course. The City expects this to continue through 2030.

Discharge of treated effluent into the Deschutes River or the nearby North Unit Canal was not considered in this report. A discharge to the river was not considered because it is highly disfavored by the general public. 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. When the City approached North Unit in 1980 to seek a canal discharge, the District was not receptive. Furthermore, the canal only flows between April 15 and October 15.

The City of Bend is receptive to reusing its treated effluent. Reuse within the City of Bend, however, is not practicable as the cost to return treated effluent to areas within the urban growth boundary (UGB) is quite high (>$3,100/acre-foot in 2003 dollars). The cost is high because of distance and because the elevations with the UGB are between 120 feet and 500 feet higher than the treatment plant. As reuse opportunities near the treatment plant arise, however, the City of Bend will be willing to provide reclaimed water for reuse.

The City of Bend believes that the expanded use of its current method of wastewater management represent highest and best practicable control for the following reasons:

1. Current and projected concentrations of nitrate-nitrogen in down-gradient monitoring wells are, and will remain, very low. The concentration will not exceed 1 mg/L, well below the federal maximum contaminate level for drinking water of 10 mg/L.

2. 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.

3. Although based upon very limited data, concentrations of metals in the effluent are well below the federal maximum contaminate levels for drinking water. Enhanced treatment of effluent to further reduce effluent metals concentrations would be impracticable considering that groundwater is still well protected as a drinking water source.

4. To the extent practicable, effluent reuse is practiced.

5.5.2 Basis for Concluding Compliance with Groundwater Quality Protection Program Requirements

The City of Bend also believes that expanded use of the seepage ponds for effluent disposal will not adversely affect groundwater quality, and that a formal groundwater quality protection program is not justified. The bases for this conclusion are:

1. Projected nitrate concentrations in down-gradient wells will be less than 1.0 mg/L, which is well below the federal maximum concentration limit for drinking water of 10 mg/L.

2. Although based upon very limited data, concentrations of metals in the effluent are well below the federal maximum concentration limits for drinking water.

3. The City will continue to monitor groundwater quality and report the information on its discharge monitoring reports.

6.0 SUMMARY CONCLUSIONS

1. Based upon the information set forth in Section 5.0, using existing Ponds 1 and 2 for effluent disposal should provide sufficient seepage capacity to dispose of the projected 2030 effluent flow. The ponds, however, will need to be reconditioned similarly to Ponds 3A and 3B during their construction.

2. Groundwater quality should not be adversely affected with the expanded use of the seepage ponds and, therefore, no groundwater quality protection program pursuant to Oregon Administrative Rules (OAR) 340-040-0030 is warranted.

3. Considering the minor projected impacts to groundwater quality, the current level of wastewater control and treatment if extended to 2030 should be considered highest and best practicable control pursuant to OAR 340-040-0020.

City of Bend

Water Reclamation Facilities Plan

TECHNICAL MEMORANDUM NO. 4
LIQUIDS PROCESS ASSESSMENT

April 2008

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CITY OF BEND

WATER RECLAMATION FACILITIES PLAN

TECHNICAL MEMORANDUM
NO. 4

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LIQUIDS PROCESS ASSESSMENT

1.0 INTRODUCTION

The Bend Water Reclamation Facility (WRF) currently consists of the following liquid treatment processes:

- Preliminary treatment;
- Primary clarification;
- Activated sludge using a Modified Ludzack Ettinger (MLE) process;
- Secondary clarification;
- Tertiary filtration (seasonal usage for production of Level IV reclaimed water); and
- Chlorine disinfection.

This Technical Memorandum (TM) summarizes the evaluation of the preliminary, primary, secondary, and tertiary processes. The evaluation of the disinfection facilities is developed in TM No. 6.

An evaluation of the existing facilities was completed to determine the current capacity for treating peak wet weather flows, as well as monthly, weekly and daily permit limits for TSS and BOD and the annual monthly average permit limit for total nitrogen (TN). Alternatives for increasing the process capacity were developed based on the existing permit limits and the potentially lower TN limits developed in TM No. 3.

2.0 BASIS OF DESIGN

The following sections summarize the projected flows and loads, regulatory requirements, reliability and redundancy requirements, and design criteria used in establishing the existing capacity and developing the recommended alternatives for expansion.

2.1 Flows and Loads

Evaluations of the alternatives for future expansion were based on the projected flows and loads developed in TM No. 1, which are summarized in Table 1.

Table 1	**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

2.2 Regulatory Requirements

Design criteria were developed based on meeting the current permit limits outlined in Table 2, as well as potential future permit limits. Based on the permit evaluation presented in TM No. 3, it is assumed that future permit limits for BOD and TSS will not change, but that the TN permit limit may be reduced from 10 mg/L to either 6 mg/L or 3 mg/L. Process alternatives were developed to meet each of the three potential TN limits.

Table 2 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			
<u>Other Parameters:</u>					
Total Nitrogen	Annual monthly average of 10 mg/L				
pH	Shall be within range of 5.5 to 9.0				

<u>Notes:</u>

1. Based on average dry weather design flow of 7.0 mgd

2. FC = Fecal coliform

In addition to 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.

2.3 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 3 presents a summary of the relevant criteria for the liquid processes for both classes. Note that although the EPA has requirements for filters, they are not applicable for the Bend WRF because the filters are only needed for reuse and the ponds have the capacity to take all flows if the filters are out of service.

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 are 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.

Table 3 Component Reliability Standards
Water Reclamation Facilities Plan
City of Bend

Component	Class I	Class II
Screening	Backup screen required for peak flow.	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.	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.	Minimum of two of equal volume; no backup required.
Secondary clarifiers	Multiple basins; with largest unit out of service, remaining basins have capacity for at least 75% design flow.	Multiple basins; with largest unit out of service, remaining basins have capacity for at least 50% design flow
Filters	Multiple units; with largest unit out of service, remaining basins have capacity for at least 75% design flow.	No back-up.

3.0 PRELIMINARY TREATMENT

3.1 Background and Design Criteria

Table 4 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, which will provide a total firm capacity of 45 mgd. 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 4	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 2.3, 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 due to the following factors:

- A relatively small amount of grit is received at the facility as compared to plants on the west side of the Cascade Mountains.
- The majority of this grit is the result of lime addition for alkalinity control. The fine screens will remove a portion of this grit.
- Digester No. 3 is designed so that grit can be removed periodically from the bottom of the digester and passed on to dewatering.
- The recently installed belt filter press is not affected by the presence of grit in the feed sludge.
- Grit in the final dewatered biosolids does not degrade the quality for land application.
- Eliminating the grit removal step improves the hydraulic profile by saving the 3 feet of head it takes to get through this unit process.

Provisions have been made in the design of the new headworks for the addition of grit removal in the future, if necessary.

3.2 Existing Capacity

The capacity of the new headworks with one screen out of service is 30 mgd. As shown in Table 5, the existing capacity is adequate for flows through 2030.

Table 5 Capacity of Existing Preliminary Treatment Facilities Water Reclamation Facilities Plan City of Bend					
		Current Capacity (mgd)	Required Capacity (mgd)		
Criteria	**Redundancy Criteria**		**2010**	**2020**	**2030**
PHF	One unit out of service	30	17.9	24.0	29.1

3.3 Recommended Upgrades

Based on existing capacity, there is not a 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 capacity requirements with one unit out of service.

4.0 PRIMARY TREATMENT

4.1 Background and Design Criteria

The sizing of the existing primary clarifiers is presented in Table 6.

Table 6 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 7 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 7 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.

4.2 Existing Capacity

As illustrated in Table 8, 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 8 Capacity of Existing Primary Clarifiers Water Reclamation Facilities Plan City of Bend				
		Required Capacity (mgd)		
Condition	**Current 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

4.3 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 9, adding one new clarifier by 2009 and a second by 2020 will provide sufficient capacity for all scenarios through 2030.

Table 9	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	20.6	30.9	30.9

5.0 SECONDARY TREATMENT

5.1 Background and Design Criteria

The existing secondary process consists of three aeration basins and three secondary clarifiers, which are described in Table 10. The current configuration of the aeration basins is shown in Figure 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 10	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	1.08
Total aerobic volume	MG	2.07
Total volume	MG	3.15

Table 10	Sizing of Existing Secondary Facilities Water Reclamation Facilities Plan City of Bend	
Parameter	**Unit**	**Value**
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
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

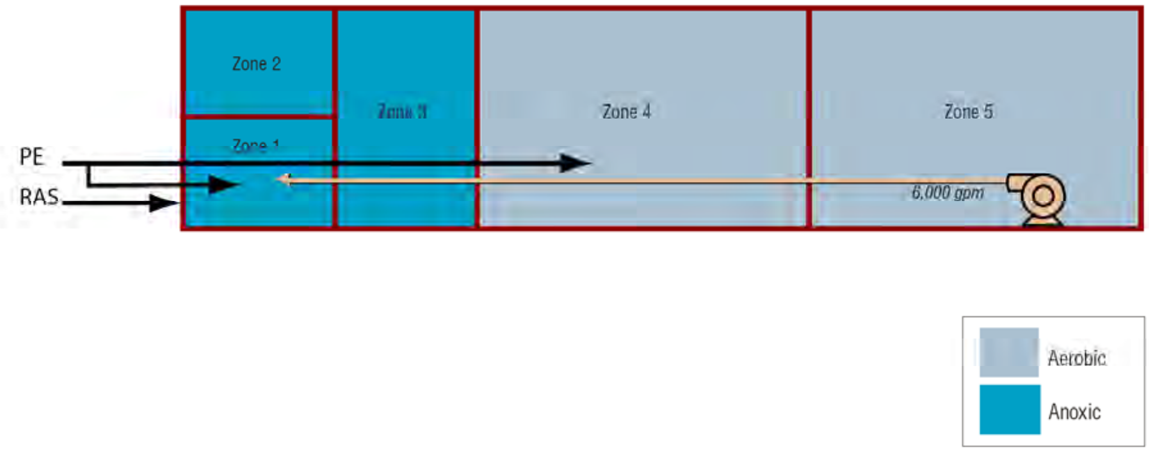

Figure 1 Existing Aeration Basin Configuration and Flow Distribution

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).

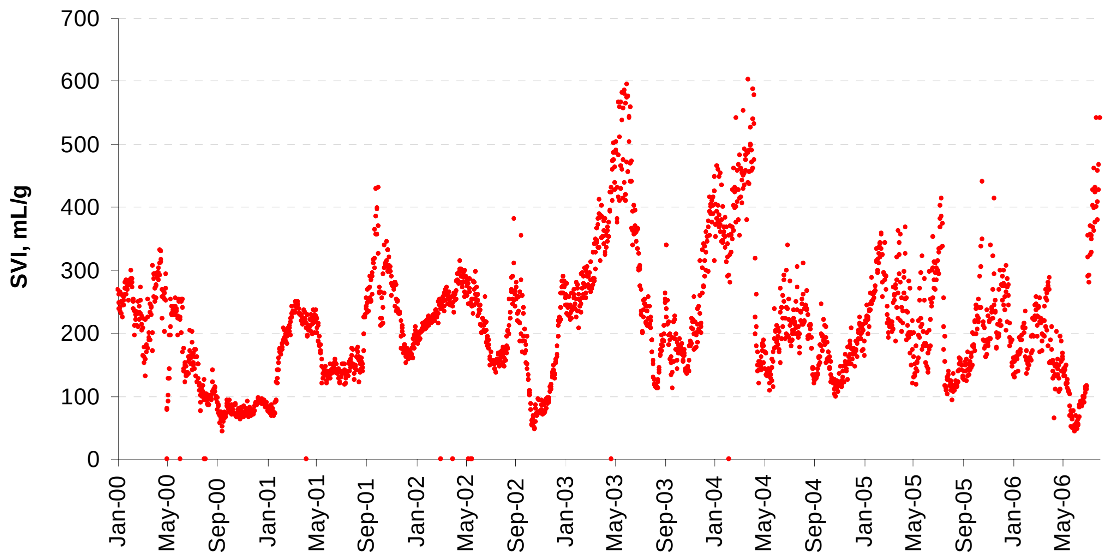

Figure 2 Sludge Volume Index

Figure 2 shows the variation in historical SVI values. According to information from the plant staff, the uncommonly high values (>300 mL/g) are due to bulking that is due to 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. For example, the current capacity rating of the existing MLE process at an SVI of 200 mL/g is approximately 16% higher than the capacity at an SVI of 300 mL/g, and approximately 30% higher than the capacity at an SVI value of 400 mL/g. A more cost effective approach is to control the filamentous bacteria growth, and design for lower SVI values.

Successful control of bulking problems associated with filamentous organisms has been achieved through the addition of chemicals such as disinfectants (mainly chlorine) to the aeration basin or the RAS stream. M. *parvicella* bulking impacting Bend, however, 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 (Roels et al. 2002; Jenkins et al. 2003). At full scale, PAX has been dosed at concentrations between 1.5 and 4.5 g Al^{3+}/kg MLSS/d to successfully reduce SVI values greater than 400 mL/g to less than 100 mL/g.

The LOTT Alliance (Lacey-Olympia-Tumwater-Thurstan County) WWTP in Olympia, WA has been controlling a previously unsolvable M. *parvicella* bulking problem over the past two years through a seasonal PAX dosing schedule coupled with scum removal. By adding approximately 1.5 g Al^{3+}/kg MLSS/d as PAX to the aeration basin over a nine-week period of problematic bulking, SVI values have been successfully reduced from 250 mL/g to 150 mL/g. In addition, utilizing scum removal strategies has allowed the LOTT Plant to reduce PAX consumption over the past year and minimize the duration of the annual bulking problem.

For the purposes of this evaluation, it is assumed that the implementation of appropriate bulking control strategies at the Bend 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.

5.2 Existing Secondary Treatment Process Capacity

Table 5 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 11 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 11 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				

The capacities listed in Table 11 are based upon the current requirement to nitrify, and are lower than the previous non-nitrifying (permitted) plant capacity rating of 7 mgd.

5.3 Alternatives Evaluation

The alternatives evaluation section include 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, for the recommended alternative were also developed.

5.3.1 Near Term Upgrades

5.3.1.1 Dry Weather Operation

As previously discussed, sludge bulking due to filamentous bacteria needs to be addressed. A pilot-scale evaluation of PAX addition is recommended to determine its effectiveness in controlling bulking.

5.3.1.2 Peak Wet Weather Operation

The current facilities cannot treat current PWWF when operating in the MLE configuration. To increase the wet weather flow capacity of the existing plant, it is essential to protect the secondary treatment system from losing solids through washout under high flows. One way to achieve this is by operating in a step feed mode. The step feed mode of operation requires routing part of the incoming PE to the aerobic zone during wet weather events through the existing lines that feed the aerobic zone. The plant is currently operating under this mode to accommodate peak wet weather flows.

5.3.2 Future Expansions with 10 mg/L TN Permit Limit

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 3). 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 4. 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.

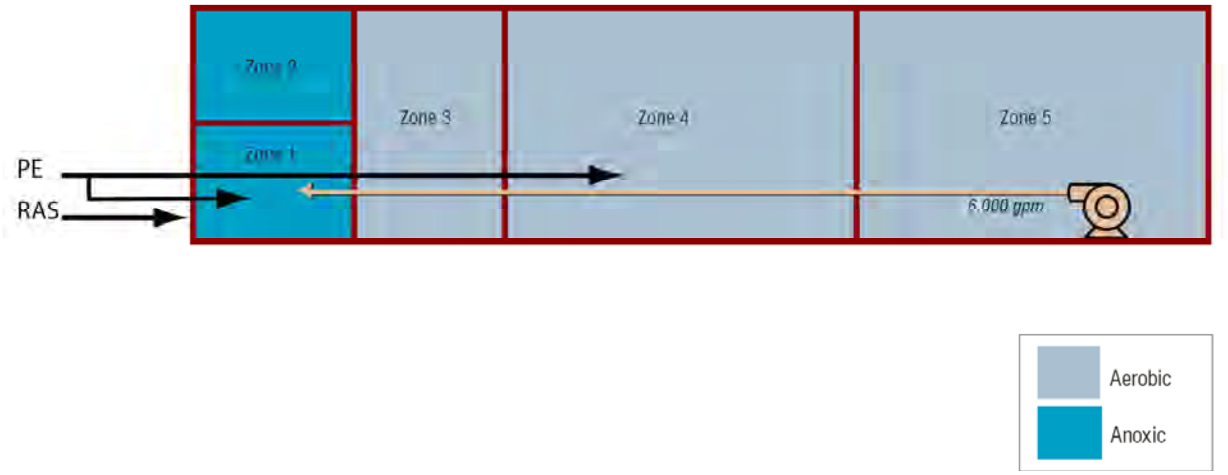

Figure 3 Alternative 2: Reduced Anoxic Zone

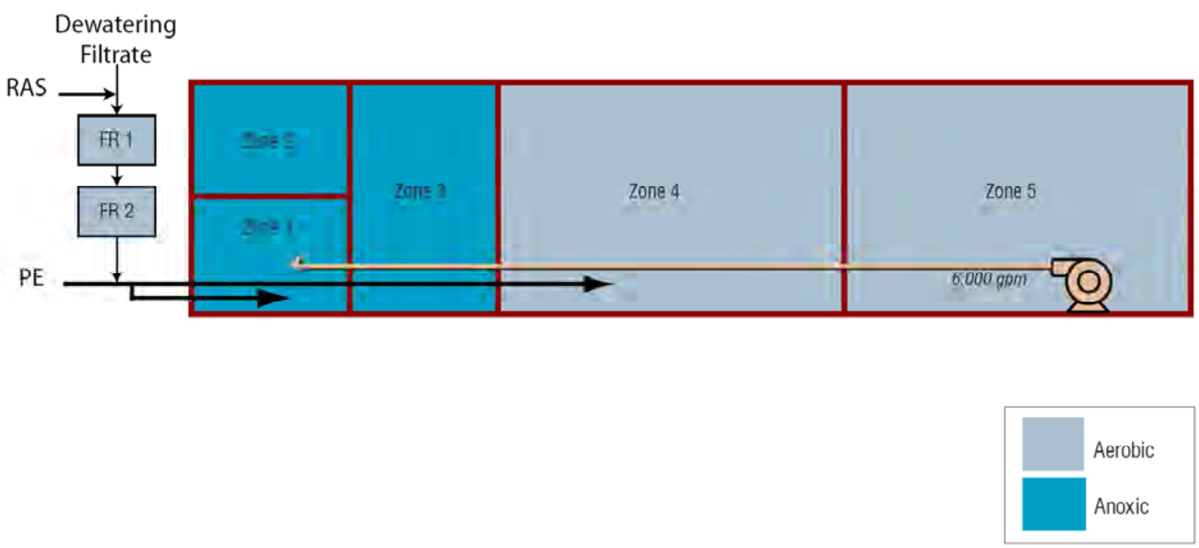

Figure 4 Alternative 3: Filtrate Reaeration

Process modeling was completed for all three alternatives. Estimated capacity for normal and peak wet weather for each aeration basin for each alternative is summarized in Table 12.

Table 12 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 12 indicates that the capacity of the existing MLE configuration is 5.5 mgd ADAF. Alternative 2 can use the same basin volume and achieve a 0.5 mgd increase in ADAF 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 the following benefits:

- Lower effluent TN concentrations.
- Reducing filtrate ammonia loads prior to returning back to the main activated sludge process.

- Increasing the overall SRT for a given MLSS concentration entering the secondary clarifiers, by achieving a solids tapering effect (this is similar to a step feed approach).

- Seeding of the main activated sludge process with nitrifiers from the filtrate reaeration basin.

- Increased nitrate return to the anoxic zones without having to increase the mixed liquor return flow. With the traditional MLE process, nitrate return to the anoxic zones can only be increased by returning more mixed liquor from the end of the aerobic zone. Because this adversely impacts the flow regime inside the tank, it becomes counter-productive to increase MLR flow after a certain point. With filtrate reaeration, a significant amount of nitrate can be returned to the anoxic zones via the nitrified mixture of RAS and filtrate leaving the reaeration basin. This eliminates the need to significantly increase MLR flow to achieve improved denitrification.

Tables 13 - 15 summarize expansion requirements for each of the three alternatives. 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 by requiring 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 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.

**Table 13 Alternative 1: Existing MLE / Process Expansion and Design Criteria
Water Reclamation Facilities Plan
City of Bend**

Parameter	Unit	2006	2010	2020	2030
Aeration Basins					
Number of basins	-	3	4	5	6
MLSS concentration (all clarifiers in service)	mg/L	3,260	3,300	3,140	3,120
MLR, total	mgd	26	35	43	43
Aeration					
Peak air requirements	scfm	8,400	10,500	14,200	19,000
Aeration Blowers					
Number in service	-	3	3	4	5
Standby units	-	1	1	1	1
Capacity each	scfm	3,800	3,800	3,800	3,800
Firm Capacity	scfm	11,400	11,400	15,200	19,000
Secondary Clarifiers					
Number of clarifiers	-	3	4	5	6

**Table 14 Alternative 2: Reduced Anoxic Zone / Process Expansion and Design Criteria
Water Reclamation Facilities Plan
City of Bend**

Parameter	Unit	2006	2010	2020	2030
Aeration Basins					
Number of basins	-	3	4	5	5
MLSS concentration (all clarifiers in service)	mg/L	3,250	2,670	2,950	3,160
MLR, total	mgd	26	35	43	43
Aeration					
Peak air requirements	scfm	9,200	11,300	15,300	19,700
Aeration Blowers					
Number in service	-	3	3	4	5
Standby units	-	1	1	1	1
Capacity each	scfm	3,800	3,800	3,800	3,800
Firm capacity	scfm	11,400	11,400	15,200	19,000
Secondary Clarifiers					
Number of clarifiers	-	3	4	5	6

**Table 15 Alternative 3: Filtrate Reaeration / Process Expansion and Design Criteria
Water Reclamation Facilities Plan
City of Bend**

Parameter	Unit	2006	2010	2020	2030
Main Aeration Basins					
Number of basins	-	3	3	4	4
MLSS concentration (all clarifiers in service)	mg/L	2,000	2,500	2,600	2780
MLR, total	mgd	26	35	43	43
Aeration					
Peak air requirements	scfm	7,820	9,520	13,770	17,830
Side Stream Aeration Basins					
Number of basins	-	2	2	2	2
Basin Volume, each	MG	0.21	0.21	0.21	0.21
Aerobic, total	MG	0.42	0.42	0.42	0.42
MLSS concentration	mg/L	5,600	5,500	7,200	7,900
Aeration					
Peak air requirements	scfm	3,300	3,210	3,990	5,200
Total Aeration Blowers Needs					
Total peak air demand	scfm	11,120	12,730	17,760	23,030
Number blowers in service	-	3	4	5	6
Standby units	-	1	1	1	1
Capacity each	scfm	3,800	3,800	3,800	3,800
Firm capacity	scfm	11,400	15,200	19,000	22,800
Secondary Clarifiers					
Number of clarifiers	-	3	3	4	5

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 16 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.

Cost estimates were developed by first estimating total direct costs (based on recent project experience, project bids, and vendor quotes), then applying factors for contingencies, engineering, and electrical, instrumentation and control (EI&C). A contingency factor is often used to compensate for lack of detailed information, oversights, anticipated changes, and imperfection in the estimating methods used. As the project design progresses and elements become better defined, smaller contingencies may be applied. Percentages (as opposed to discrete dollar amount allowances) are typically used for contingencies as well as other elements in an estimate. Percentages (typically part of total direct costs) used in the development of this cost estimate include the following:

- Electrical, Instrumentation & Control: 35%
- Construction Contingency: 35%
- Engineering, Legal and Administration: 25%

The accuracy of a cost estimate depends on the quantity and quality of the information available to prepare that estimate. Typically, as a project progresses from master planning studies, to conceptual design, to final design, the project elements become better defined, thereby providing more and better information for development of progressively more accurate estimates. The Association for Advancement of Cost Engineers (AACE) has suggested a level of accuracy for planning of +30 to -15 percent.

In order to develop net present worth (in 2007$) for the secondary treatment alternatives, interest (6%), inflation (3%), and construction cost escalation (ranging from 9% in 2009 to 4% in 2030) were considered. Individual expansion components were sequenced based on flow projections in the years 2010, 2020, and 2030.

Table 16 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.

5.3.3 Peak Wet Weather Capacity Expansion

As shown in Table 17, 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 17 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 have been 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 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.

Note that for all alternatives, it is assumed that the tertiary filters are used to filter up to 6 mgd of secondary effluent. By 2030, this will be required to meet the daily mass limits for BOD and TSS of 2,300 lb/d. It will not require an increase in filtration capacity.

Alternative 3a will allow for 100% of the PE to be routed to the first aerobic zone under PWWF conditions. The existing 12" pipe feeding this zone does not have enough capacity. Therefore, a second parallel pipe would need to be added. Control of flows to the different zones could be manual or automated based on flows. Each basin will have a capacity of 7 MGD in contact stabilization made.

In the contact stabilization mode, return activated sludge (RAS) would continue to be directed to the first anoxic zone. Therefore, the first three anoxic zones will contain high solids concentrations representative of RAS return. The solids concentrations in the subsequent aerated zones of the aeration basin would be significantly lower, as a result of dilution with primary effluent. The resulting tapered solids concentration profile in the basin effectively reduces the solids loading on the secondary clarifiers, thereby increasing capacity.

Alternative 3b does not require any modifications to the design of the existing aeration basins. It will require that a diversion structure be built which allow plant to bypass PE based on either flow or level in the aeration basins. To meet daily mass limits, the aeration basins will need to be operated in the step feed mode and flows to the secondary process will need to be maximized.

Alternative 3c will allow for full secondary treatment of all flows without going into the step feed mode and without modifying the aeration basin design; however, it will require changes to how the degasification basins are operated and significant capital improvements.

Table 18 presents estimated net present worth costs for implementing each of the three alternatives. Cost estimates are based on the same assumptions as described in section 5.3.2. 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 18 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. The total NPW cost for the recommended secondary improvements, including contract stabilization and filtrate reaeration, is approximately $15.1 million.

5.3.4 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.

For the case of a permitted effluent TN limit of 3 mg/L, it is recommended that the plant convert to a 4-stage Bardenpho process, including two-stage denitrification and methanol addition. 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 5, 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.

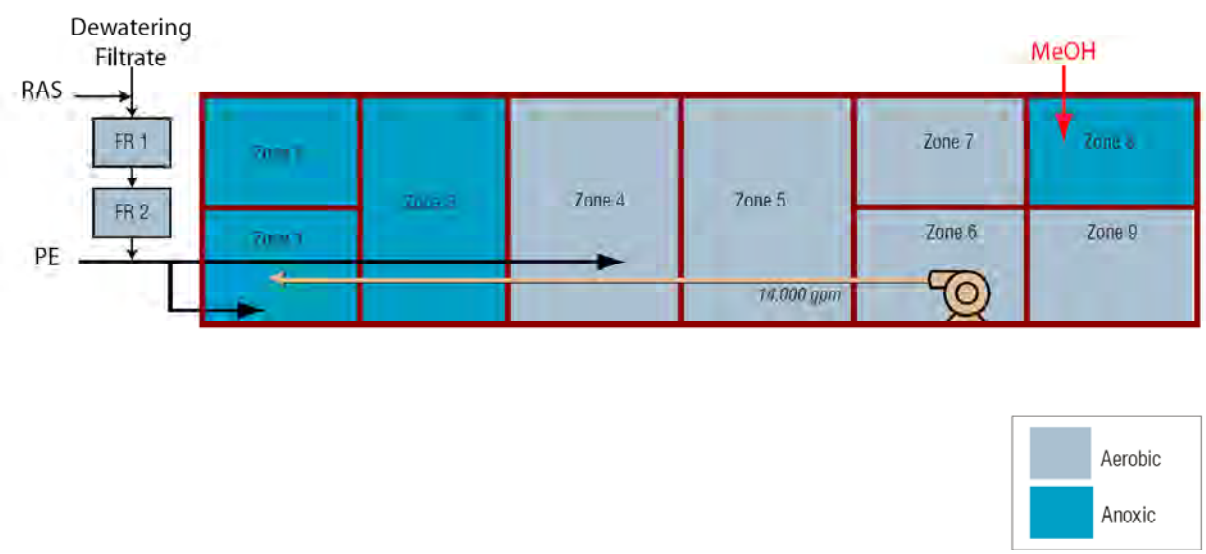

Figure 5 Layout of the aeration basins in the 4-Stage Bardenpho / Filtrate Reaeration configuration (TN = 3 mg/L)

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.

5.4 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.

6.0 TERTIARY FILTRATION

As outlined in Table 19, 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, SE 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.

Table 19 Sizing and Capacity of Existing Tertiary Filtration System
Water Reclamation Facilities Plan
City of Bend

Parameter	Unit	Value
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
Disc area, total	sf	1,290
Area per disk	sf	53.8
Hydraulic Loading Rate		

Table 19 Sizing and Capacity of Existing Tertiary Filtration System Water Reclamation Facilities Plan City of Bend		
Parameter	**Unit**	**Value**
@ ADMMF	gpm/sf	2.7
@ PHF	gpm/sf	9.5
Filter Feed Pumps		
Number	-	2
Type	-	Submersible, VFD
Capacity, each	mgd	5
Horsepower, each	HP	50
Reuse Pumps		
Number	-	2
Type	-	Horizontal screw centrifugal, VFD
Capacity, each	mgd	2.5
Horsepower, each		50

7.0 SUMMARY

The phasing plan for the recommended improvements is summarized below:

- Near term:
  - Complete study of solids bulking problems and implement necessary improvements to reduce SVI
  - Utilize step feed operation under PWWF conditions
- 2009
  - Construct one new primary clarifier
  - Construct two filtrate reaeration basins
  - Add piping to existing aeration basins to allow for operation in contact stabilization mode
  - Add one blower
  - Upgrade RAS/WAS Pump Station
- 2013
  - Construct one new secondary clarifier and secondary clarifier splitter box
- 2019
  - Construct one new primary clarifier
  - Construct one new aeration basin
  - Add one blower
- 2024
  - Construct one new secondary clarifier
  - Add one blower

Figure 6 presents the recommended liquids process flow schematic for 2030.

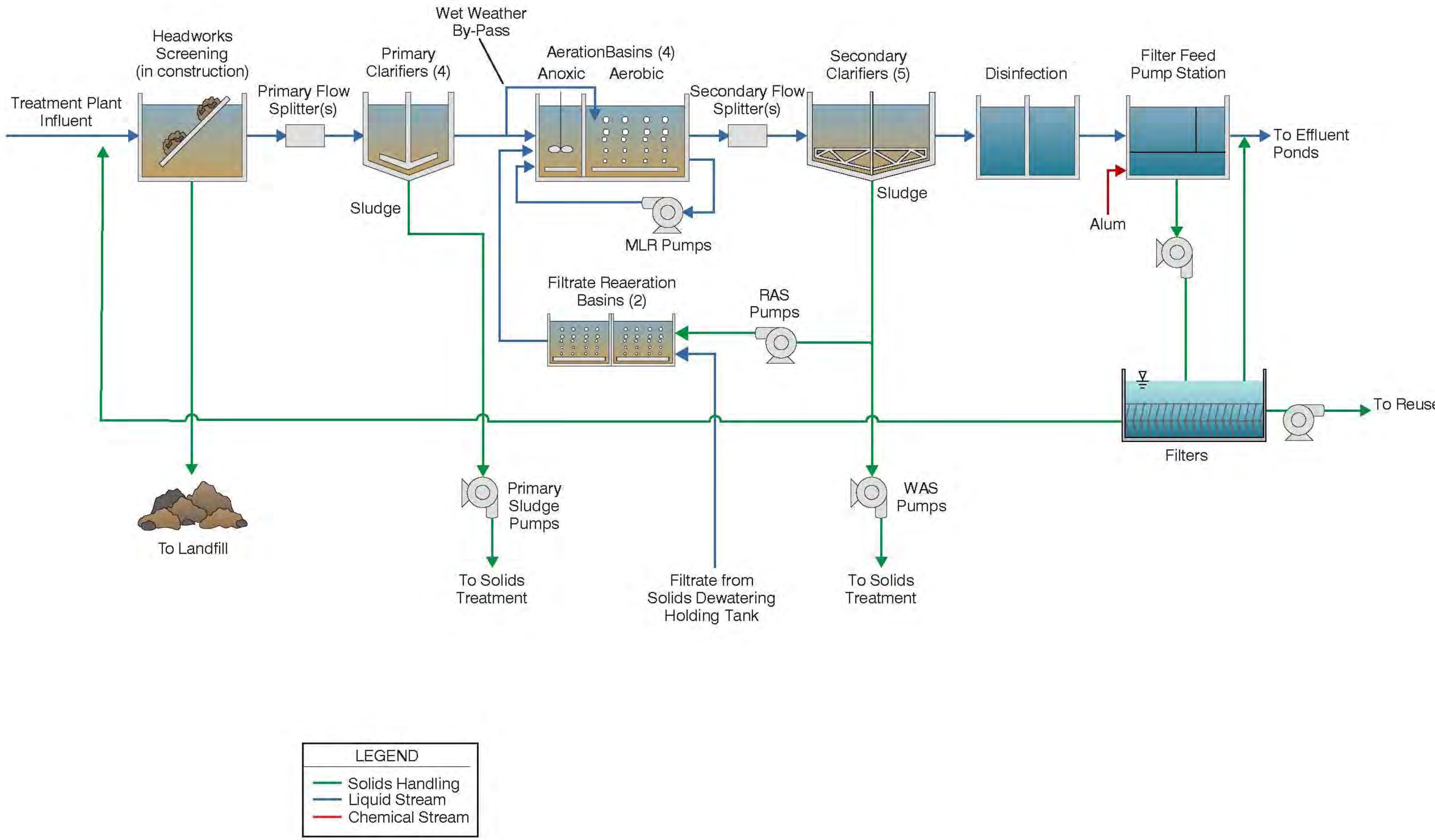

Figure 6 **Process Flow Schematic for 2030**

City of Bend

Bend Water Reclamation Facilities Plan

TECHNICAL MEMORANDUM NO. 5
MBR ALTERNATIVES

April 2008

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CITY OF BEND

BEND WATER RECLAMATION FACILITIES PLAN

TECHNICAL MEMORANDUM
NO. 5

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MBR ALTERNATIVES

1.0 INTRODUCTION

Two alternatives were evaluated for the use of a membrane bioreactor (MBR) at the City's facility. Both alternatives are retrofits into the existing aeration basins. Retrofits were evaluated because they have the greatest potential for being financially competitive with conventional treatment technology expansion alternatives, as each is feasible without constructing new aeration basins or dedicated membrane tanks. The expansion alternatives and process simulation were developed based on information presented in TM1 "Flow and Waste Load Projections". The MBR alternatives considered included:

- MBR Alternative 1 (MBR 1) - An MBR with a net treatment capacity of 16 mgd. This capacity is adequate for diurnal peaks during maximum month in the year 2030. Flows in excess of this treatment capacity (including peak wet weather flows) would be stored in a new earthen lined lagoon. It is assumed in this alternative that bypass blending is not permitted.

- MBR Alternative 2 (MBR 2) - An MBR with a net treatment capacity of 30 mgd, designed to treat the peak wet weather flow event in 2030.

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. 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.

1.1 MBR Process Description

A process flow diagram common to both MBR alternatives is presented in Figure 1. Raw wastewater enters the plant through the headworks. Fine screening (1.0 mm) takes places here to remove larger particles that may otherwise damage the membrane fibers. Screened water then passes through primary clarifiers and into the aeration basins. A modified MLE process (with membrane filtration) was evaluated. The aeration basins are divided into five zones:

- Zones 1-3 - Anoxic
- Zone 4 - Aerobic
- Zone 5 - Aerobic Membrane Basins

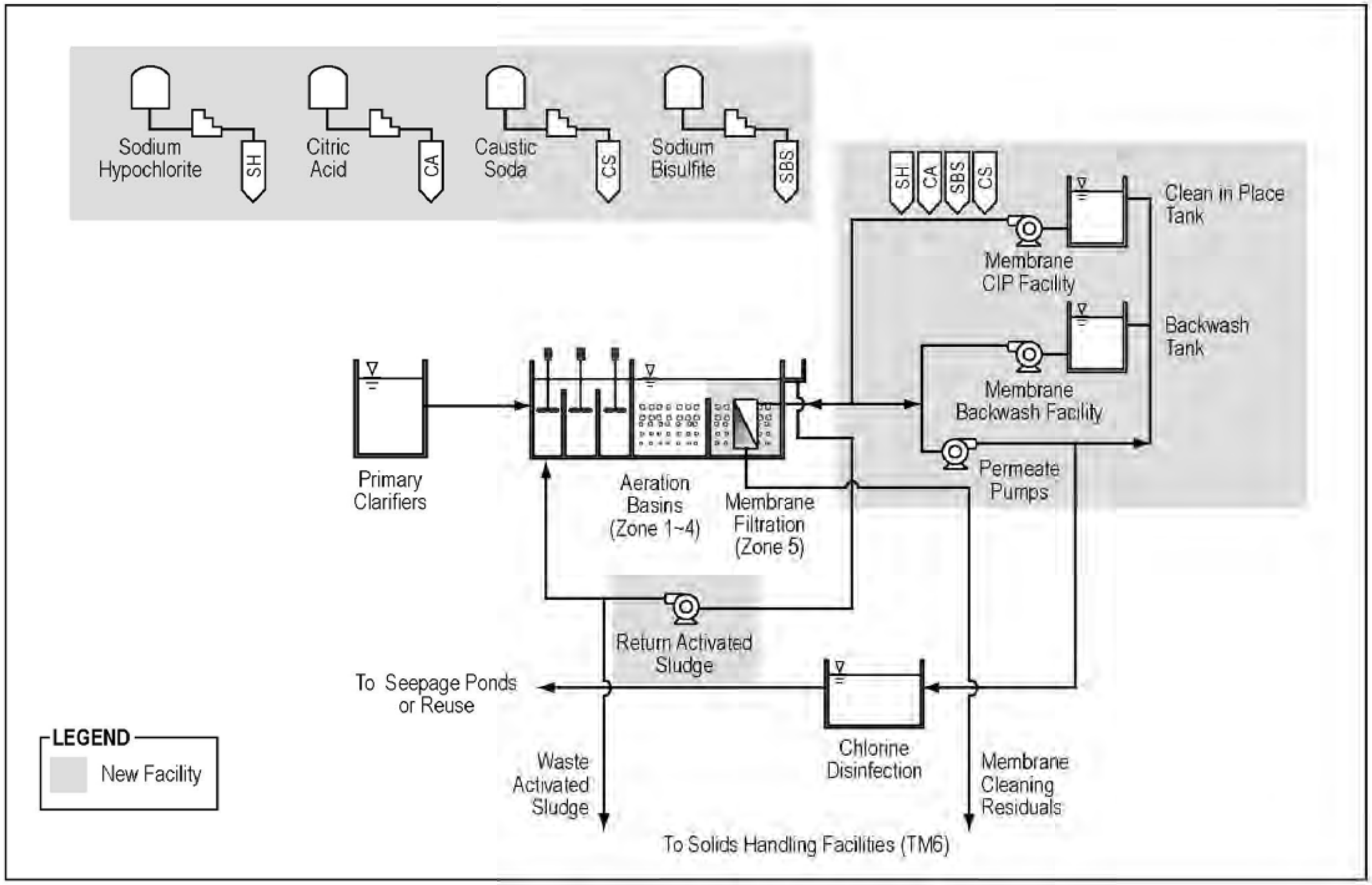

Figure 1
MBR Alternatives - Process Flow Diagram
BEND WATER RECLAMATION FACILITIES PLAN
CITY OF BEND

The MBR process is similar to the conventional alternatives except the MLSS concentration is increased and the membranes eliminate the use of the secondary clarifiers.

The membranes rely on a vacuum system and permeate pumps to pull water across the membranes (filtration). The permeate pumps also provide head required to convey filtrate from the membrane zone to the chlorine contact basins. Disinfected water would then flow either to seepage ponds or pumped for reuse. There would be no need for the existing cloth disk filters.

The membrane system relies on a series of cleaning procedures to sustain production. By separating the MLSS completely from the influent flow, solids are concentrated in the membrane zone. In order to maintain solids at levels that can be handled by the membrane system, a relatively high return activated sludge (RAS) to influent flow is maintained. For the alternatives developed for Bend, these recycle ratios are between 4.1 and 4.6. In addition to RAS flows, the membrane relies on cyclic aeration, backwashes (once every 10-20 minutes), short chemically-intensive cleans (approximately 1/week), and extended chemically intensive cleans (approximately one every one to three months). Due to elevated free chlorine concentrations in cleaning solutions, residuals from extended chemical cleaning events may require chemical neutralization prior to recycle. Chemicals used are:

- Sodium Hypochlorite (SH) - cleaning chemical
- Citric Acid (CA) - cleaning chemical
- Caustic Soda (CS) - for neutralization as required
- Sodium Bisulfite (SBS) - for neutralization as required

2.0 SPECIAL CONSIDERATIONS FOR MBR ALTERNATIVES

A number of specific membrane process considerations would need to be addressed prior to making a decision to implement an MBR process. These can be loosely grouped as design, start up and construction, and maintenance and operation issues.

2.1 Design Considerations

The condition of the concrete aeration basins will influence the cost of an MBR retrofit at Bend.

- The aeration basin walls and floors must be in adequate condition to allow construction of new interior walls for the membrane basins and a special coating to separate process water and membrane cleaning chemicals must be applied to the concrete surfaces of the membrane basins themselves.

There is limited space available for construction of a permeate pump station and pipe gallery on the north side of the basins. The north side was selected for evaluation because it minimized modifications to the existing aeration basins. A more detailed preliminary engineering predesign study is recommended to compare specific alternatives for:

- Constructing a pipe gallery on the north side of the existing basins.
- Feasibility and costs of constructing a pipe gallery on the west side of the existing aeration basins where more space is available.

Membrane equipment and the membranes themselves are sensitive to ambient winter air temperatures that are likely to be experienced in Bend. As a result, a protective structure would need to be built over the membrane basin portion of the aeration tanks. This will address the freezing issue.

Chlorinated solutions, combined with aeration, can create an environment corrosive to equipment, piping, and some structural components. To help protect equipment from this environment, a membrane tank cover and an active ventilation system applied to the headspace between the membrane tank cover and water surface is necessary.

Because membrane systems have frequent starts and stops for cleaning operations, flow through the aeration basins will be interrupted for short periods of time on a regular basis. This will cause some fluctuation in tank water levels. A detailed hydraulic analysis will determine if additional freeboard will be required to accommodate these fluctuations at peak flow conditions.

Large particles and fibrous materials can cause damage to membrane fibers. In order to prevent damage from these materials, a fine screen (1 mm) is recommended by the membrane manufacturers. We assumed the new 3 mm screens would be retrofitted with 1 mm screens. Additional headloss for these screens is assumed to be available in the system upstream of the headworks. Screenings require dewatering and disposal.

2.2 Startup and Construction

Membranes are transported with preservatives, including glycerine, that have elevated BOD. Once installed into a properly constructed and coated tank, these solutions are rinsed from the membranes, producing several tank volumes (>100,000 gallons) of rinsate. This solution will require storage and recycling through the treatment process until the BOD has been reduced. Construction sequencing will need to consider approaches to handling these solutions. Additionally, these solutions will be generated whenever new modules are added to the membrane system.

2.3 Maintenance and Operations

The operation of membrane facilities are highly automated due to the frequent cycling of valves for cleaning operations and precise control required for proper operation and maximizing useful system life. These systems typically rely on a large number of sensors, switches and actuators. Additional training for operation staff and/or additional maintenance staff are often required to maintain control systems and mechanical equipment used in MBR facilities.

3.0 FULL CONVERSION TO AN MBR PLANT

Biotran was used to model the MBR process. The processes presented herein were configured to achieve the estimated effluent water quality shown in Table 1.

Table 1 Effluent Water Quality for MBR Process
Bend Wastewater Facilities Plan
City of Bend

Parameter	Unit	Value
Total Nitrogen as N	mg/L	<10
BOD	mg/L	<1
TSS	mg/L	<1

3.1 Alternative MBR 1 - MBR Capacity of 16 mgd

3.1.1 Process description

In this alternative, all flows would be provided primary treatment. Flows in excess of 16 mgd be diverted to dedicated lined earthen basins (diverted water storage basins) and then pumped back to the inlet of the aeration basins when influent flow rates drop below 16 mgd.

Criteria developed for MBR Alternative 1 (MBR 1) is presented in Table 2. This alternative allows all biological treatment to be accomplished in the existing basins for flows to 16 mgd. MLSS in the aeration basins will be as high was 6,900 mg/L. Required basin modifications include increasing diffuser floor coverage to 27 percent and creating membrane basin compartments. Required yard piping modifications include piping to and from the storage facility, a new RAS line, and piping between the membrane system and CT basin.

Table 2	MBR Alternative 1 Process Configuration Bend Wastewater Facilities Plan City of Bend			
Parameter	**Unit**	**2010**	**2020**	**2030**
Flows				
Aeration Basin Influent including Recycle Streams	mgd	10.0	13.3	15.9
Fine Screening				
Type			1 mm, Band Screens	
Main Stream Aeration Basins (Zones 1-5)				
Number of basins	-	3	3	3
1 AB out of service	-		No	
Basin Volume, each	MG	1.03	1.03	1.03
Aerobic, total	MG	2.1	2.0	2.0
Anoxic, total	MG	0.9	0.8	0.8
Reduction for Membrane Cassettes	MG	0.10	0.12	0.14
All Basins	MG	2.98	2.96	2.95
Aeration Blowers				
Peak Air Requirements (AB)				
Aeration Basins	scfm	8,000	12,500	18,400
Membrane System	scfm	5,700	6,700	7,600
Total		13,700	19,200	26,000
Blowers				
Number in service	-	4	6	8
Standby units	-	1	1	1
Capacity, each	scfm		3,500	
Motor Horsepower, each	HP	150	150	150
Firm Capacity	scfm	14,000	21,000	28,000
Membrane System (Zone 5)				
Membrane Mfr./Model	-		Zenon 500d	
Number of Membrane Trains (basins)	-	6	6	6
Trains, In Service	Ea.	5	5	5
Trains, Redundant (to MMF)	Ea.	1	1	1

Table 2 MBR Alternative 1 Process Configuration, continued
Bend Wastewater Facilities Plan
City of Bend

Parameter	Unit	2010	2020	2030
Train Dimensions				
Length, each	Ft		42	
Width,each	Ft		21.5	
Volume, each	MG		0.08	
Train Design				
Cassettes/Train, Equipped	Ea.	8	11	12
Cassette slots/Train, Spare	Ea.	4	1	0
Module/Cassette, Design	Ea.	48	48	48
Module/Cassette, Max	Ea.	48	48	48
Spare Module Slots/Train	%	33	8.3	0
Permeate Pumps				
Number	Ea.		6	
Redundant Pumps	Ea.		0	
Motor Horsepower, each	HP		40	
Est. Time in Service	%		75-90	
Backwash Pumps				
Number in Service	Ea.		2	
Redundant Pumps	Ea.		1	
Motor Horsepower, each	HP		40	
Est. Time in Service	%		75-90	
Drain Pumps				
Number	Ea.		3	
Redundant Pumps	Ea.		1	
Motor Horsepower, each	HP		5	
Est. Time in service	%		< 5	
Net flux rate				
Max. Month Flow	gfd	11.2	10.9	12.1
Max. Month, Diurnal Peak	gfd	14.5	14.2	15.8
Backpulse Storage Tank				
No.	Ea.		1	
Volume	gallons		16,700	

Table 2 MBR Alternative 1 Process Configuration, continued
Bend Wastewater Facilities Plan
City of Bend

Parameter	Unit	2010	2020	2030
CIP Storage Tank				
No.	Ea.		1	
Volume	gallons		40,000	
Sodium Hypochlorite Storage				
Concentration	%		10.5	
Storage Volume	gallons		12,400	
Citric Acid Storage				
Concentration	%		50	
Storage Volume	gallons		4,300	
Sodium Bisulfite				
Concentration	%		40	
Storage Volume	gallons		1,100	
Caustic Soda Storage				
Concentration	%		25	
Storage Volume	-		7,500	
MLR Properties				
MLR Ratio	-	4.13	4.66	4.12
MLR rate, Total	mgd	32	48	51
Mixed Liquor Recycle Pumps				
Type	-		Submersible	
Number	-		3	
Horsepower, each	HP		25	
Capacity, each	mgd		20	
Aerobic solids retention time				
Design minimum	days		5.0	
All basins in service	days	6.0	6.1	6.1
MLSS concentration	mg/L	3,800	5,100	6,900
Diverted Water Storage Basins				
Peak Wet Weather Flow	mgd	21.4	25.2	29.4
Peak Flow to Storage	mgd	11.9	12.4	14.0
Event Duration	hr	3	3	3

Table 2 MBR Alternative 1 Process Configuration, continued Bend Wastewater Facilities Plan City of Bend				
Parameter	**Unit**	**2010**	**2020**	**2030**
Estimated Storage Volume (Event Volume +25%)	MG	1.9	1.9	2.2
Depth	ft	8	8	8
Min. Basin Area Required	Acres	0.72	0.75	0.84
Min No. of Basins	Ea.	2	2	2
Diverted Water Return Pumps				
Number	Ea.	3	3	3
Redundant Pumps	Ea.	0	0	0
Motor Horsepower, each	HP	15	15	15
Est. Time in Service	%	<1	<1	<1

3.1.2 Modifications to Accommodate MBR 1

A conceptual layout for the MBR process is presented in Figure 2. Major modifications to the existing facilities to accommodate an MBR system treating a maximum flow of 16 mgd include:

- 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, cleaning chemicals, chemical cleaning and backwash storage tanks, process pumps, and electrical equipment.
- Installation of membrane tank covers and concrete coating systems to minimize corrosion of the enclosure, membrane system ancillary equipment, and stainless steel piping.

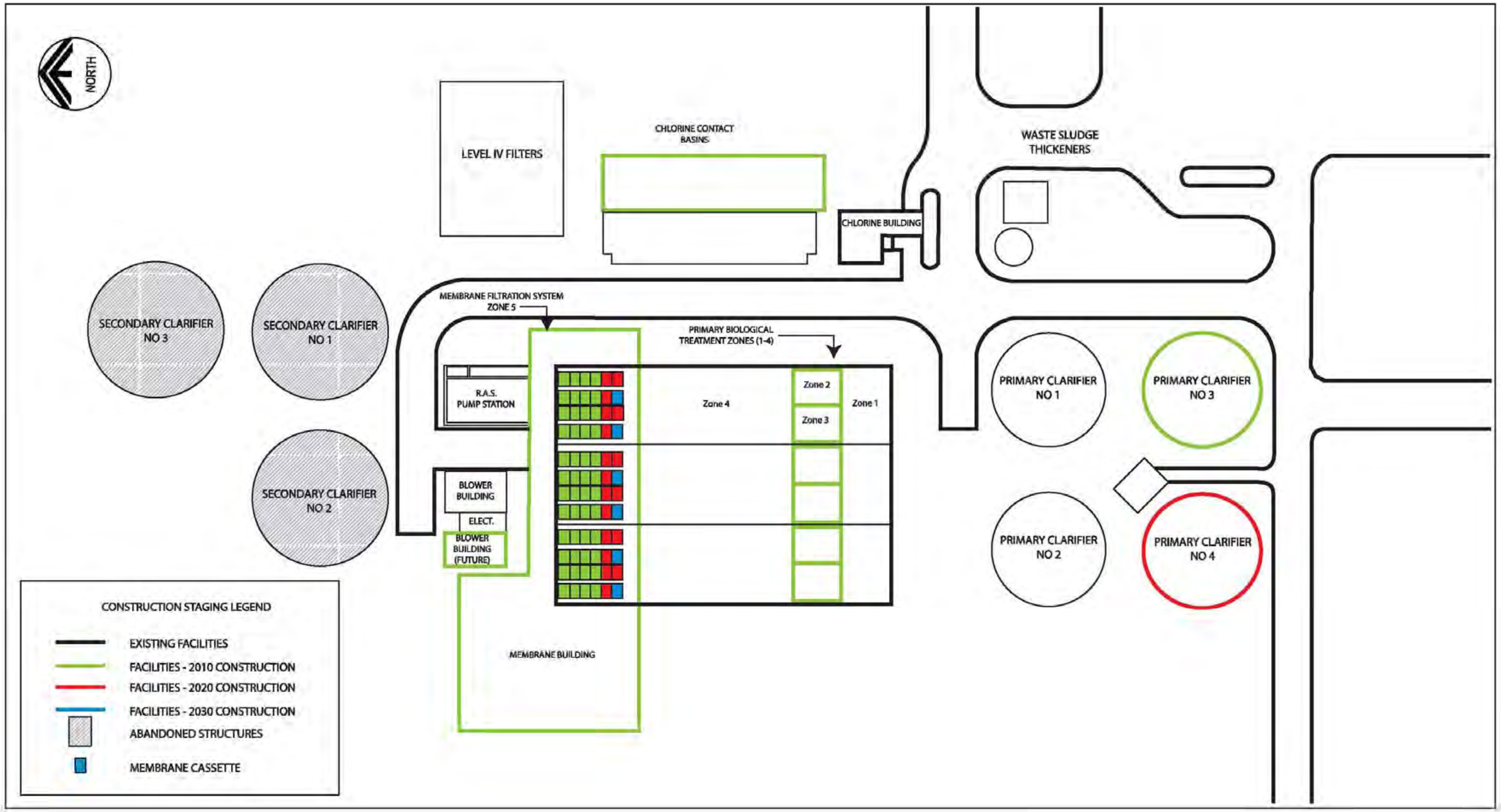

Figure 2
Alternative MBR 1
BEND WATER RECLAMATION FACILITIES PLAN
CITY OF BEND

- 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.

- Construction of new chemical facilities for membrane cleaning. Chemical storage and feed facilities for sodium hypochlorite and citric acid are required for weekly chemically enhanced backwashes (CEBs) and monthly to quarterly “clean-in-place” (CIP) events. Neutralization chemicals will also be required.

- 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. Recycle rates are anticipated to be as high as 51 mgd in 2030.

- Installation of additional blowers to accommodate additional oxygen demands and membrane system aeration (cleaning) demands. Blowers would be made common to both the aeration and MBR zones.

- 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.

- Yard piping modifications.

3.2 Alternative MBR 2 - MBR Capacity of 30 mgd

In this alternative, all flows projected through 2030 (including peak wet weather flows) would be provided primary and secondary treatment, and membrane filtration. Because of the higher treatment capacity, membrane zones are larger than in MBR 1.

Criteria developed for MBR Alternative 2 (MBR 2) are presented in Table 3. This MBR alternative allows all biological treatment to be accomplished in existing basins with modifications to basin compartments and yard piping.

Table 3 MBR Alternative 2 Process Configuration
Bend Wastewater Facilities Plan
City of Bend

Parameter	Unit	2010	2020	2030
Flows				
Aeration Basin influent including recycle streams	mgd	21.4	25.2	29.4
Fine Screening				
Type			1 mm, Band Screens	
Main Stream Aeration Basins (Zones 1-5)				
Number of basins	-	3	3	3
1 AB out of service	-		No	
Basin Volume, each	MG	1.03	1.03	1.03
Aerobic, total	MG	2.1	2.0	2.0
Anoxic, total	MG	0.77	0.77	0.76
Reduction for Membrane Cassettes	MG	0.20	0.22	0.27
All Basins	MG	2.87	2.85	2.80
Aeration Blowers				
Air Requirements (AB)				
Aeration Basins	scfm	6,700	10,200	15,000
Membrane System	scfm	11,400	12,400	15,200
Total		18,100	22,600	30,200
Blowers				
Number in service	-	6	7	9
Standby units	-	1	1	1
Capacity, each	scfm		3500	
Motor Horsepower, each	HP	150	150	150
Firm Capacity	scfm	21,000	24,500	31,500
Membrane System (Zone 5)				
Membrane Mfr./Model	-		Zenon 500d	
Number of Membrane Trains (basins)	-	6	6	6
Trains, In Service	Ea.	5	5	5
Trains, Redundant (to MMF)	Ea.	1	1	1

Table 3 MBR Alternative 2 Process Configuration, continued
Bend Wastewater Facilities Plan
City of Bend

Parameter	Unit	2010	2020	2030
Train Dimensions				
Length, each	Ft		56	
Width, each	Ft		21.5	
Volume, each	MG		0.11	
Train Design				
Cassettes/Train, Equipped	Ea.	10	12	14
Cassette slots/Train, Spare	Ea.	6	4	2
Module/Cassette, Design	Ea.	48	48	48
Module/Cassette, Max	Ea.	48	48	48
Spare Module Slots/Train	%	37.5	25	12.5
Net flux rate				
At Max. Month Flow	gfd	8.9	10.0	10.4
At Diurnal Peak, Max. Day	gfd	11.6	13.0	13.5
Peak 4 hr Wet Weather	gfd	26.3	25.7	25.8
Permeate Pumps				
Number	Ea.		6	
Redundant Pumps	Ea.		0	
Motor Horsepower, each	Hp.		75	
Est. Time in Service	%		75-90	
Backwash Pumps				
Number	Ea.		2	
Redundant Pumps	Ea.		1	
Motor Horsepower, each	HP		75	
Est. Time in Service	%		75-90	
Drain Pumps				
Number	Ea.		3	
Redundant Pumps	Ea.		1	
Motor Horsepower, each	HP		5	
Est. Time in service	%		50-90	
Sodium Hypochlorite Storage				
Concentration	%		10.5	

Table 3 MBR Alternative 2 Process Configuration, continued
Bend Wastewater Facilities Plan
City of Bend

Parameter	Unit	2010	2020	2030
Storage Volume	gallons		17,000	
Citric Acid Storage				
Concentration	%		50	
Storage Volume	gallons		5,000	
Sodium Bisulfite				
Concentration	%		40	
Storage Volume	gallons		1,650	
Caustic Soda Storage				
Concentration	%		25	
Storage Volume	-		10,500	
MLR Recycle Ratio	-	4.1	4.7	4.1
MLR rate, Total	mgd	32	48	51
Mixed Liquor Recycle Pumps				
Type	-		Submersible	
Number	-		3	
Horsepower, each	HP		25	
Capacity, each	mgd		20	
Aerobic solids retention time				
Design minimum	days		5.0	
All basins in service	days	7.8	7.8	7.8
MLSS concentration	mg/L	2,900	4,000	5,300

3.2.1 Modifications to Accommodate MBR 2

A conceptual layout for the MBR 2 process is presented in Figure 3. Major modifications to the existing facilities to accommodate an MBR system treating a maximum flow of 30 mgd are similar to MBR 1. Similarities and differences are summarized below.

- Modifications to existing aeration basins - Similar to MBR 1
- Modifications to the band screens - Similar to MBR 1
- Construction of membrane trains - Trains are longer to accommodate additional membrane cassettes associated with the higher treatment capacity.

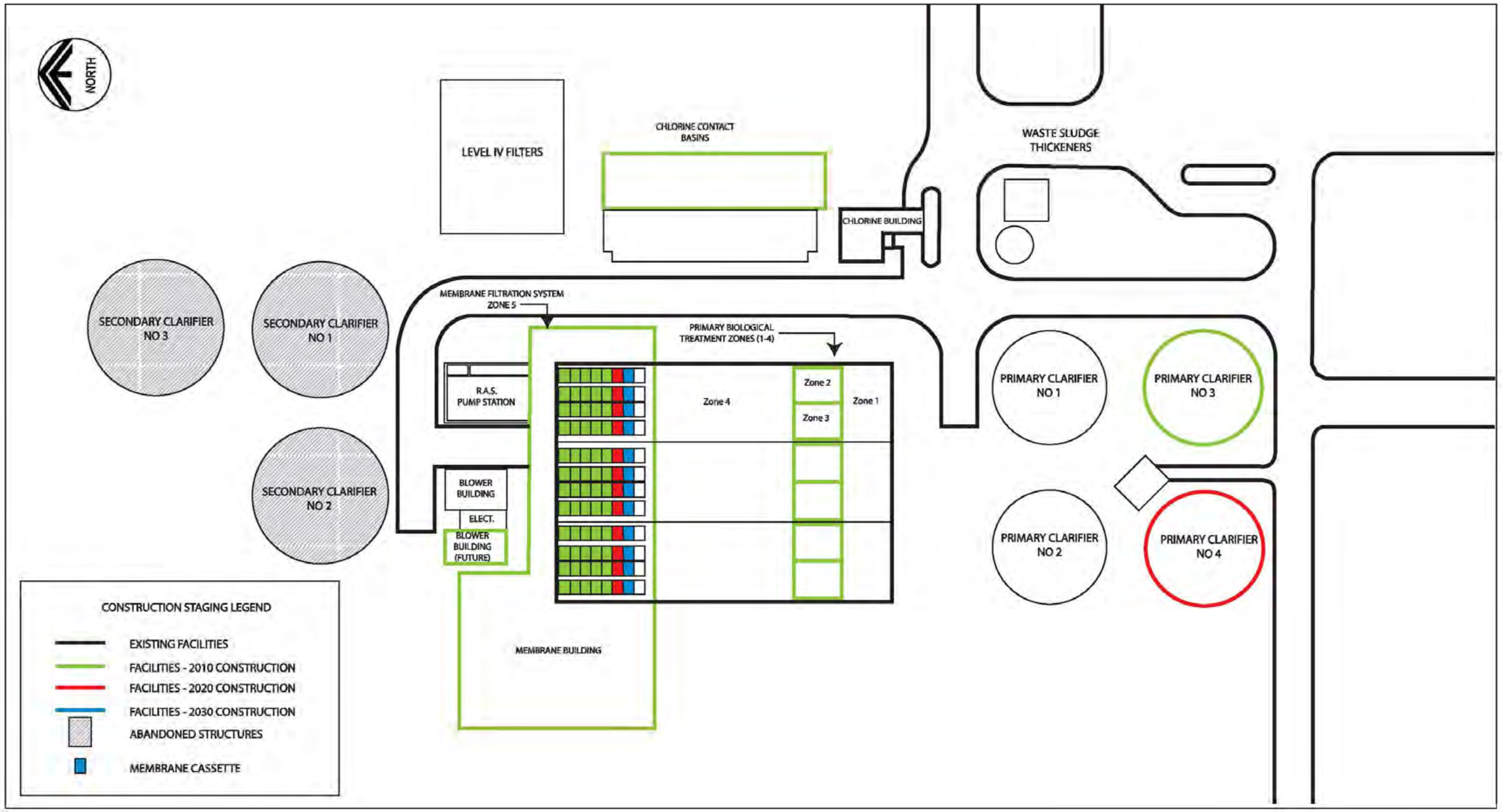

Figure 3
Alternative MBR 2
BEND WATER RECLAMATION FACILITIES PLAN
CITY OF BEND

- Construction of an enclosure over the membrane zone - A larger footprint is required to accommodate larger membrane tank area.
- Installation of membrane tank covers and concrete coating systems - Additional coatings and covers required to accommodate larger membrane tank area.
- Construction of a permeate pump and pipe gallery - Similar to MBR 1
- Installation of cleaning system pumps and piping - Similar to MBR 1
- Construction of new chemical facilities - Increased storage volume due to larger membrane tanks
- Replacement of existing RAS pumps and piping - Similar to MBR 1
- Installation of additional blowers - Similar to MBR 1, but with more required.
- Construction of lined earthen basins - Not required for MBR 2
- Yard piping modifications - Similar to MBR 1, except for piping to and from storage basins.

3.3 Cost Comparison

Costs for the MBR Alternatives are presented in this section. For both alternatives, lifecycle cost is present as a net present worth.

3.3.1 <u>Calculation of Construction Cost Net Present Worth (NPW)</u>

Cost estimates were developed by first estimating total direct costs (based on recent project experience, project bids, and vendor quotes), then applying factors for contingencies, engineering, and electrical, instrumentation and control (EI&C). A contingency factor is often used to compensate for lack of detailed information, oversights, anticipated changes, and imperfection in the estimating methods used. As the project design progresses and elements become better defined, smaller contingencies may be applied. Percentages (as opposed to discrete dollar amount allowances) are typically used for contingencies as well as other elements in an estimate. Percentages (typically part of total direct costs) used in the development of this cost estimate include the following:

- Electrical, Instrumentation & Control: 35%
- Construction Contingency: 35%
- Engineering, Legal and Administration: 25%

The accuracy of a cost estimate depends on the quantity and quality of the information available to prepare that estimate. Typically, as a project progresses from master planning studies, to conceptual design, to final design, the project elements become better defined, thereby providing more and better information for development of progressively more accurate estimates. The Association for Advancement of Cost Engineers (AACE) has suggested a level of accuracy for planning of +30 to -15 percent.

In order to develop net present worth (in 2007$) for the MBR alternatives, interest (6%), inflation (3%), and construction cost escalation (ranging from 8% in 2010 to 4% in 2030) were considered. Individual expansion components were sequenced based on flow projections in the years 2010, 2020, and 2030. A summary of sequencing is presented in Table 4.

Table 4 Schedule of Improvements through 2030
Bend Wastewater Facilities Plan
City of Bend

Improvement Description	Construction Year		
	2010	2020	2030
Primary Splitter Box	X		
Primary Clarifier	X	X	
Fine Screening	X		
Modify Existing Aeration Basins	X		
MBR Equipment	X		
Additional MBR Cassettes		X	X
Untreated Water Storage/Return Pumping	X		
Blower Building	X		
Additional Blowers	X	X	X
Influent Piping Mods	X		
Upgraded WAS Pumps	X		

Note:
1. Improvement sequencing based on flow projections. See TM 1.

3.3.2 Calculation of Net Present Worth of Annual Operating Costs

In order to develop NPW for annual operating costs the following cost components were considered:

- Process energy consumption
- Chemical costs
- Membrane replacement

Labor may be higher with an MBR system, however this piece was not considered in the operation and maintenance costs. Critical data required for these calculations is presented in Tables 5 through 7.

Table 5	Inputs for Annual Energy Cost Estimates[1] Bend Wastewater T Facilities Plan City of Bend						
		Annual Usage[1]					
		MBR1			MBR 2		
Operating Cost Component	Units	2010	2020	2030	2010	2020	2030
Blowers	kWh	3.1E+06	4.3E+06	5.8E+06	4.6E+06	5.6E+06	7.4E+06
Permeate Pumps	kWh	3.8E+05	5.1E+05	6.1E+05	3.8E+05	5.1E+05	6.1E+05
Backwash Pumps	kWh	1.2E+05	1.2E+05	1.2E+05	2.4E+05	2.9E+05	3.4E+05
Energy	$/kWh	$0.08					

Note:
1. Improvement sequencing based on flow projections (TM 1) and process modeling.

Table 6	Inputs for Annual Operating Cost Estimates Bend Wastewater Facilities Plan City of Bend			
			Annual Usage[1]	
Operating Cost Component	Units	Unit Cost	MBR 1	MBR 2
Bulk Sodium Hypochlorite	lbs/yr	$ 1.05	127,027	171,487
Citric Acid	lbs/yr	$ 1.20	11,723	15,826
Sulfur Dioxide	lbs/yr	$ 0.30	9,613	12,977
Caustic Soda	lbs/yr	$ 0.25	8,207	11,080

Note:
1. Differences in annual usage between 16 and 30 mgd scenarios are based on differences in membrane tank size only.

Table 7	Inputs for Membrane Replacement NPW Bend Wastewater Facilities Plan City of Bend	
Input	Units	Value
Replacement Interval[1]	Years	10
Module Replacement Cost	2007$	900
No. of modules replaced	Varies based on alternative and replacement year	
Replacement years	-	2010, 2020, 2030

Notes:
1. Membrane module life varies based on supplier, process, and operation practices. Selection of 10 years produces a replacement cost estimate for membranes with 10 year warranties.
2. Membrane replacement costs based on lump sum payments in 2010 and 2020 expressed as 2007 $.

3.3.3 Net Present Worth of MBR Alternatives

The estimated net present worth costs of the MBR alternatives are presented in Table 8. Since the primary clarifier additions and splitter box are common to all alternatives, these costs were not included in the net present worth costs. This also allows comparison of the construction costs of the MBR alternatives with the construction costs of the conventional secondary treatment costs outlined in TM4. On a net present worth basis, the cost of providing treatment for all wet weather flows is $8.8 M greater than equalization of peak wet weather flows. Approximately 80 percent of the difference in cost is capital expenditures, primarily in the procurement and installation of the membrane equipment and related tank modifications and enclosures. The remaining 20 percent of the difference is in operation and maintenance costs, primarily associated with membrane system aeration to support additional membranes required for MBR 2.

Table 8 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.

4.0 PARALLEL CONVENTIONAL PLANT AND MBR ALTERNATIVE

In this third MBR alternative, approximately half of the 2030 flow will be treated through the existing basins and the remaining flows will be treated through an MBR system, consisting of a new aeration basin and new membrane tanks.

4.1 Design Criteria

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. The flow distribution between the two systems is described in Table 9. Criteria developed for MBR Alternative 3 are presented in Table 10.

Table 9	MBR Alternative 3 Flow Distribution Bend Wastewater Facilities Plan City of Bend			
Parameter	**Unit**	**2010**	**2020**	**2030**
Maximum Month Flows				
Conventional basins	mgd	6	6	6
MBR basin(1)	mgd	1.3	3.8	5.9
Total Maximum Month	mgd	7.3	9.8	11.9
Peak Flows				
Conventional basins(2)	mgd	15	15	15
MBR basin(1)	mgd	4.9	8.8	12.7
Storage or blended flow	mgd	1.5	1.4	1.7
Total Peak	mgd	21.4	25.2	29.4
Required PWWF capacity	mgd	17.9	24	29.1

Notes:

1. Assumes one membrane zone out of service.
2. Assumes that peak flows will be treated through the conventional basins with a step-feed approach.

Table 10	MBR Alternative 3 Process Configuration Bend Wastewater Facilities Plan City of Bend			
Parameter	**Unit**	**2010**	**2020**	**2030**
Flows				
MBR Aeration Basin influent including recycle streams, maximum month	mgd	1.35	3.95	6.09
Fine Screening				
Type			1 mm, Band Screens	
Aeration Basins				
Number of basins	-	1	1	1
1 AB out of service	-		No	
Basin Volume, each	MG	1.04	1.04	1.04
Aerobic, total	MG	0.69	0.69	0.69
Anoxic, total	MG	0.35	0.35	0.35
Aerobic solids retention time	days	8.1	6.0	6.0
MLR Recycle Ratio	-	7.8	6.3	6.6
MLR rate, Total	mgd	11	25	51

Table 10	MBR Alternative 3 Process Configuration Bend Wastewater Facilities Plan City of Bend			
Parameter	**Unit**	**2010**	**2020**	**2030**
MLSS concentration	mg/L	2,050	4,060	7,020
Blowers				
Air Requirements (AB)				
Aeration Basins	scfm	1,300	4,600	10,100
Membrane System	scfm	1,900	3,300	4,700
Total		3,200	7,900	14,800
Blowers				
Number in service	-	1	3	5
Standby units	-	1	1	1
Capacity, each	scfm		3,500	
Motor Horsepower, each	HP	150	150	150
Firm Capacity	Scfm	7,000	14,000	17,500
Membrane System				
Membrane Mfr./Model	-		Zenon 500d	
Number of Membrane Trains (basins)	-	2	4	5
Trains, In Service	Ea.	1	3	4
Trains, Redundant (to MMF)	Ea.	1	1	1
Train Dimensions				
Length, each	Ft		29	
Width, each	Ft		24	
Volume, each	MG		0.05	
Train Design				
Cassettes/Train, Equipped	Ea.	8	7	8
Cassette slots/Train, Spare	Ea.	1	2	1
Module/Cassette, Design	Ea.	48	48	48
Module/Cassette, Max	Ea.	48	48	48
Net flux rate (for 1 membrane tank out of service)				
At Max. Month Flow	gfd	10.2	11.3	11.5
At Diurnal Peak, Max. Day	gfd	13.2	14.7	14.8
Peak 4 hr Wet Weather	gfd	20.0	20.0	20.0
MLSS concentration	mg/L	3,000	6,510	8,980

4.2 Cost Estimate

Costs for the parallel conventional plant and MBR alternative are presented in this section. For this alternative cost are presented as the net present worth of the construction costs, and were developed with the same assumptions as presented in Section 3. The sequencing summary is presented in Table 11.

The estimated net present worth of the construction costs for the parallel MBR alternative is presented in Table 12. Since the primary clarifier additions and splitter box are common to all alternatives, these costs were not included in the net present worth costs. This also allows comparison of the construction costs of the parallel conventional treatment and MBR alternative (MBR 3) with the construction costs of the conventional secondary treatment costs outlined in TM4.

Table 11 Schedule of Improvements through 2030 MBR Alternative 3
Bend Wastewater Facilities Plan
City of Bend

Improvement Description	Construction Year		
	2010	2020	2030
Primary Splitter Box	X		
Primary Clarifier	X	X	
Fine Screening	X		
Additional Aeration Basin	X		
MBR Equipment	X		
Additional MBR Cassettes		X	X
Untreated Water Storage/Return Pumping	X		
Blower Building	X		
Additional Blowers	X	X	X
Influent Piping Mods	X		
Upgraded RAS Pumps	X		
Upgraded WAS Pumps	X		

Note:

1. Improvement sequencing based on flow projections. See TM 1.

Table 12	Summary of Construction Cost NPW for MBR Alternative 3 Bend Wastewater Facilities Plan City of Bend
Cost Component	**NPW of Capital Costs**
Fine Screening	$2,860,000
Aeration Basins	$2,460,000
Membranes	$11,340,000
Blowers	$2,410,000
Piping and Pumps	$2,820,000
NPW of Capital Costs, Total	**$21,900,000**

Notes:

(1) Since the costs of additional primary clarifiers and the primary clarifier splitter box are common to all alternatives, these costs were not included in the capital cost net present worth.

(2) No costs were included for storage and pumping. It was assumed that for this alternative, the peak flow that could not be treated through the MBRs would be blended.

5.0 CONCLUSIONS

As presented in Table 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 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

City of Bend

Water Reclamation Facilities Plan

TECHNICAL MEMORANDUM NO. 6
DISINFECTION EVALUATION

April 2008

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CITY OF BEND

WATER RECLAMATION FACILITIES PLAN

TECHNICAL MEMORANDUM
NO. 6

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1.0 INTRODUCTION

The purpose of this technical memorandum (TM) is to compare upgrading the existing gas chlorination system with the feasibility of effluent disinfection using ultraviolet disinfection or sodium hypochlorite. Disinfection alternatives were evaluated based upon current and projected flows previously defined in TM 1.

2.0 EXISTING SYSTEM

The Bend Water Reclamation Facility (WRF) utilizes a gaseous chlorine system for disinfection. Chlorine is received at the WRF in one-ton horizontal cylinders and is administered through vacuum-driven gas chlorinators. The chlorine solution is delivered to the secondary clarifier effluent at the head of the chlorine contact basins (CCB) and mixed using a Water Champ submerged mixer. Flow is then split between two serpentine contact basins. Each basin is approximately 120 feet long by 15 feet wide with a water depth of approximately 8.5 feet. Volume per basin is approximately 114,400 gallons. The basins are in good condition.

The chlorination building has space for four active one-ton cylinders split into two pairs. The facility is adequately set up to receive and store the cylinders; however, no provisions exist to contain or neutralize a major chlorine leak with a scrubber. The WRF does have a Risk Management Plan, chlorine leak detection, and alarms. The building is in good condition.

3.0 EXISTING DISINFECTION REQUIREMENTS AND USAGE

3.1 Introduction

The WRF uses chlorine for plant effluent disinfection and for control of filamentous organisms. On October 24, 2005, the Oregon Department of Environmental Quality issued a Water Pollution Control Facilities Permit Number (101572) to the WRF detailing four outfalls with varying disinfection requirements. Table 1 lists the method of disposal and disinfection requirements for each outfall.

The majority of plant discharge is through Outfall 001 to the seepage ponds. During a portion of the year, disinfected and filtered effluent is delivered through Outfall 004, as Level IV reclaimed water, to the Pronghorn Resort. 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. Figure 1 depicts the existing chlorine disinfection schematic.

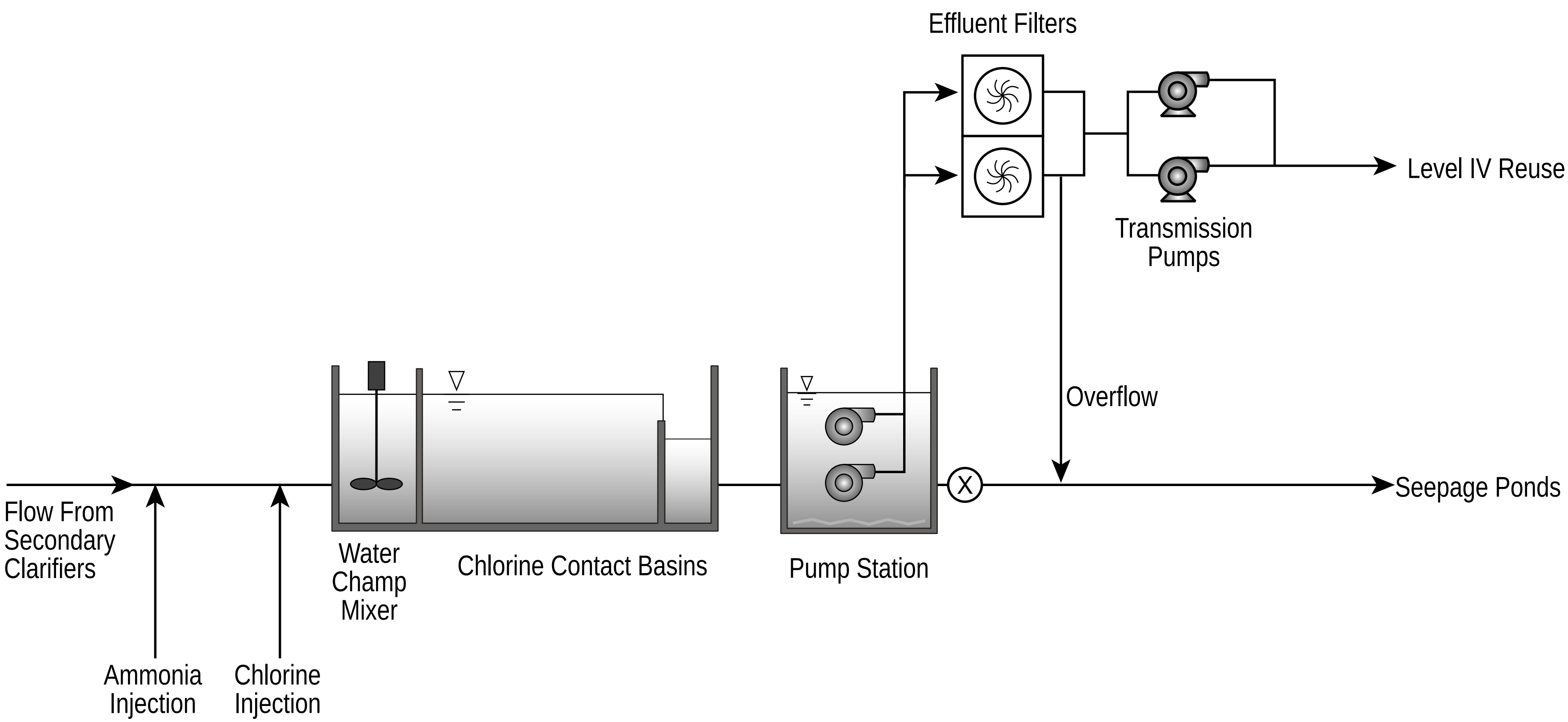

Figure 1
Existing Chlorine Disinfection Schematic
DISINFECTION EVALUATOIN
CITY OF BEND

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3.2 Chlorine Demand

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.

Table 1 Method of Disposal and Disinfection Requirements
Disinfection Evaluation
City of Bend

Outfall	Method of Disposal	Monthly Average	Weekly Average
001	Evaporation/ Seepage Ponds	200 Fecal Coliform/ 100 ml	400 Fecal Coliform/100 ml
002	Land Irrigation Level II	23 Total Coliform/ 100 ml	7 day Median-No two over 240 MPN/100ml
003	Land Irrigation Level III	2.2 Total Coliform/ 100 ml	7 day Median-No single over 23 MPN/100ml
004	Land Irrigation Level IV	2.2 Total Coliform/ 100 ml	7 day Median-No single over 23 MPN/100ml

Examination of chlorine use data from January 2000 to December 2004 indicates that the plant effluent was dosed at an average of 7.53 mg/L of chlorine. This resulted in an average residual of 1.56 mg/L with an average FC count of 13.4. Maximum chlorine usage was reported at 840 pounds per day.

During 2004 and 2005, the average chlorine dose rates were 9.55 mg/L and 10.44 mg/L respectively. However, while producing Level IV effluent in 2005, average fecal counts were lowered to 8.6 MPN/100ml and lowered again in 2006 to an average of 0.49 MPN/100ml. The lower fecal counts are due to chlorine residual levels generally above 2.5 mg/L.

The average chlorine dosage difference between when the plant produced Level IV reclaimed water and prior to that time is approximately 2.9 mg/L. Table 2 indicates the pounds of chlorine that could be reduced by not producing Level IV reclaimed water during the current reuse period.

Table 2	**Chlorine Savings by Not Meeting Level IV Disinfection Evaluation City of Bend**					
			Average Day Reduction by Not Meeting Level IV		**Peak Day Reduction by Not Meeting Level IV**	
Year	**Average Day Flow, mgd**	**Peak Day Wet Weather Flow, mgd**	**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 chlorination” system are described later in this TM.

The WRF has maintained a history of chlorination at levels that produce effluent coliform counts well below permitted limits. Review of the 2000 to 2006 data set yielded only three fecal counts above the 200 MPN/100ml limit. Based upon discussions with plant operators and the long standing operating practice of producing effluent with low fecal counts and a chlorine residual, an average annual dose rate of 10.44 mg/L will be used in this analysis.

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 prior to chlorine results in the formation of chloramines and is governed by the following equation:

$$NH_3 + HOCl \rightarrow NH_2Cl + H_2O$$

Chloramines are a weaker disinfectant than chlorine due to the chemical’s decreased ability to oxidize organic materials. Because of this, the WRF has elected to use chloramines to minimize the impacts resulting from oxidation on its cloth filters. One drawback of this practice is the need to increase the amount of total chlorine dosed to the system. In order to produce chloramines, chlorine is added at a 5:1 weight ratio 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 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. Most recently, operations has dosed at an approximate feed rate of 300 pounds of additional chlorine per 24 hours.

The data also suggest that operations uses the chlorination system for control of filamentous organisms at an interval between 20 and 35 days. For analysis purposes, the interval between doses will be 30 days, once per month, at a dose rate of five lb Cl_2/1,000 lb VSS.

3.3 Chlorine Contact Basin Analysis

The capacity of the existing two-basin chlorine contact system was examined for current and future flows. A wide variety of general guidance is available to estimate the required hydraulic retention time (HRT) for satisfactory disinfection. The Handbook of Chlorination[1] suggests 30 minutes HRT at average daily flow and the 10 State Standards[2] suggests 15 minutes HRT at peak hourly flow. This is also consistent with DEQ guidelines.

As an example, utilizing a single CCB volume of 114,400 gallons and a 30-minute HRT, average flows of up to 5.49 mgd can be accommodated with one basin out of service.

With both CCBs in service, peak hourly flow rates of up to 21.9 mgd could be accommodated. However, in our opinion, the permitted discharge fecal coliform limits are high enough (200 MPN/100ml, monthly avg.; 400 MPN/100ml, weekly avg.) to suggest that the above criteria are adequate, and no additional analysis of basin performance is warranted as they are relatively, conservative valves. Therefore, we recommend criteria for the CCB as follows:

- 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.

Liquid Process Assessment TM 4 included secondary bypass as one alternative for handling peak storm events. Only two mgd of primary effluent will bypass secondary treatment and go to disinfection during a 29 mgd peak hour flow event. Based upon the small percentage of flow, along with bench and full scale experience with blended flow disinfection at Salem and Clean Water Services District, the preceding design criteria are considered adequate for this blending scenario.

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. Additional bench and full-scale testing may be performed

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[1] White, G.C. (1999) *Handbook of Chlorination and Alternative Disinfectants*, *Fourth Edition*. Wiley-Interscience, Hoboken, New Jersey.

[2] Great Lakes -Upper Mississippi River Board of State Sanitary Engineers (2003) *Recommended Standards for Water Works*.

during Predesign to refine the design HRTs, which could result in smaller basin requirements.

3.4 Chlorine Delivery and Container Analysis

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. This is very close to the current average annual flow of 5.9 mgd. Plant records show that for a seven-day period in September 2003, an average of 794 lb/day of chorine was used. Additional peak days occurred in February 2005 (750 lb/day), and May 2006 (700 lb/day). Given the current chlorinator capacity of 720 lb/day, the plant also appears to be at capacity based upon historical peak day usage. Therefore, the existing gas portion of the chlorination system is currently near capacity.

Table 3 indicates the projected amount of chlorine demand for different years for the current biological process (MLE), and Table 4 indicates the number of chlorine cylinder pairs required for each year. Peak day flow chlorine demand controls the peak usage. The peak values will remain the same even if an alternative to chlorination for filament control is established. A discussion on the use of PAX for filament control is provided in the Liquid Process Assessment TM.

Table 3 Chlorine Demand
Disinfection Evaluation
City of Bend

Year	AAF (MGD)	Peak Day Wet Weather (MGD)	MLE MLSS (Pounds)	4-Stage Bardenpho MLSS (Pounds)	Average Flow Based Chlorine Demand (Pounds/ day)	Peak Day Wet Weather Chlorine Demand (Pounds/ day)	MLE Chlorine Demand Filamentous Control (Pounds/day)	4-Stage Bardenpho Chlorine Demand Filamentous Control (Pounds/day)	Worst Case Total[4] (Pounds/day)
2010	6.7	13.2	86,700[1]	144,490[5]	584	1,149	434	722	1,306
2020	9.0	17.6	110,000[2]	192,500[6]	784	1,532	550	963	1,747
2030	10.9	21.4	136,600[3]	245,900[7]	949	1,863	683	1230	2,179

Notes:

1. 3 basins, MLSS=3,300 mg/L.
2. 4 basins, MLSS=3,140 mg/L.
3. 5 basins, MLSS=3,120 mg/L.
4. Total of either AAF demand plus filamentous control or chlorination required for peak day wet weather flow. Filamentous control was assumed to be able to be accomplished at a time not corresponding to the max month flow condition.
5. 5 basins, MLSS=3,300 mg/L.
6. 7 basins, MLSS=3,140 mg/L.
7. 9 basins, MLSS=3,120 mg/L.

Table 4	Chlorine Cylinder Pairs[1] Disinfection Evaluation City of Bend			
Year	**Average Demand (Pounds/day)**	**Required Cylinder Pairs**	**Peak Demand[2] (Pounds/day)**	**Required Cylinder Pairs**
2010	584	2	1,306	4
2020	784	3	1,747	5
2030	949	3	2,179	6

Notes:

1. Based upon withdrawal rates of 360 pounds/day/cylinder.
2. From Table 3.

4.0 CHLORINE DISINFECTION ALTERNATIVES

Three general types of systems are available for disinfection at the WRF. They are gaseous chlorine, hypochlorite, and ultraviolet light. Control of filamentous organisms is anticipated to require the continued use of chlorine at approximately 5 pounds of chlorine per 1,000 pounds of MLSS in the system dosed approximately once per month.

4.1 Gaseous Chlorination

As previously discussed, the existing gaseous chlorination system is essentially at capacity for disinfection and filamentous control and needs to be expanded in the near term. Analysis of the data presented in Tables 3 and 4 suggests that for the average flow condition over the planning period, one additional set of one-ton cylinders would be required. However, sufficient chlorine must be available to meet peak flow conditions. Therefore, if the 4-stage Bardenpho process is implemented and filamentous organism control requires chlorination at current levels, up to six pairs of one-ton cylinders will need to be online. If the MLE secondary treatment system is implemented the number of one-ton cylinder pairs required may be reduced by one due to the lower biological mass under aeration.

The total chlorine requirement is, therefore, indirectly related to the regulatory requirements that will apply to the allowable Total Nitrogen limits placed on the WRF. Stricter TN discharges require more chlorination for control of filamentous organisms. Therefore, since only one additional pair of one-ton cylinders separates the MLE (TN=10 mg/L) and the 4-stage Bardenpho (TN=3 mg/L) requirement, it is our recommendation to plan for six pairs of one-ton cylinders.

The WRF currently has two pairs of one-ton cylinders operational with storage for an additional seven cylinders. It appears that adequate space exists both in the active chlorine cylinder room and in the adjoining chlorinator room to increase system capacity up to six active chlorine cylinder pairs by modifying the existing south end of the building and constructing a new cylinder receiving and storage building to the east.

New storage for reserve cylinders would need to be constructed, and we would recommend installation of a chlorine gas scrubber. Chlorine is readily available; however, approximately 30 days of supply at average flow rates and average dosages should be kept in reserve as should storage for empty cylinders. Average demand was estimated at 949 pounds per day; therefore, up to approximately 14 cylinders should be on hand. Storage for 14 empty cylinders should likewise be provided.

Adequate open space exists on the plant site, to the east of the existing chlorination building, to provide for additional cylinder storage and for an emergency chlorine gas scrubber system. Costs for an upgraded gaseous chlorination system include the following major elements:

- Additional third parallel CCB.
- Emergency chlorine gas scrubber.
- Existing building modifications including new trolley and hoist.
- New scales and chlorinators.
- New chlorine cylinder storage building.

The estimated capital cost for the upgraded gaseous chlorination system is summarized in Table 5.

Table 5 Gaseous Chlorination Capital Cost Summary
Disinfection Evaluation
City of Bend

Chlorine Contact Basin Number 3	$663,000
New Building, Scrubber, and Modifications to Existing Building	$1,954,000
Electrical, Instrumentation, and Control	$916,000
Total Construction Costs	$3,533,000
Engineering, Legal, and Administrative	$883,000
Total Capital Cost	$4,416,000

4.2 Sodium Hypochlorite Disinfection

The use of liquid hypochlorite disinfection can be implemented to eliminate the gaseous chlorination systems. The same chlorine demands as outlined in Table 3 and chlorine contact times would apply. The third CCB would also be required. There are two alternatives for supply of hypochlorite solution. It can either be generated on-site electrolytically using salt, water, and power, or it can be purchased in a bulk-solution form.

4.2.1 On-Site Generation of Hypochlorite

Onsite generation of hypochlorite solution is straightforward and uses only rock salt, conditioned water, and electricity. Rock salt is purchased in bulk and dissolved to make a concentrated brine (30% total dissolved solids). This brine is diluted with softened water and passed across electrodes. The result is a 0.8% hypochlorite solution and hydrogen as an off gas. This solution is fairly 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.

The basic equation is 3.5 pounds of salt mixed with 15 gallons of water and 2.5 kWh of electricity will make 15 gallons of 0.8% solution. These 15 gallons are equivalent to one pound of gaseous chlorine.

Using the data from Table 3, Table 6 projects the average daily salt consumption and hypochlorite storage requirements.

Table 6 Average Salt Consumption and Hypochlorite Storage
Disinfection Evaluation
City of Bend

Year	AAF (mgd)	Chlorine Demand (Pounds/day)	Salt Consumption (Pounds/day)	Hypochlorite Storage (Gallons)
2010	6.7	584	2,044	8,760
2020	9.0	784	2,744	11,760
2030	10.9	949	3,322	14,235

However, the system needs to be capable of meeting the maximum demand, including storage. Table 7 indicates the maximum projected salt consumption and onsite hypochlorite storage requirements.

Table 7 Maximum Salt Consumption and Hypochlorite Storage
Disinfection Evaluation
City of Bend

Year	Chlorine Demand (Pounds/day)	Salt Consumption (Pounds/day)	Hypochlorite Storage (Gallons)
2010	1,306	4,571	19,590
2020	1,747	6,115	26,205
2030	2,179	7,626	32,685

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. Salt would be delivered by truck and blown, using high volume low pressure compressed air, into a storage silo that would feed the rock salt into the brine tank. The brine tank, rectifiers, feed pumps, and solution storage need to be climate controlled. The salt storage silo can be outdoors.

Implementation of this alternative would include the following major elements:

- Abandon existing gaseous chlorine system.
- Additional third parallel CCB.
- Salt storage silo.

- Electrolytic equipment (rectifiers).
- 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 estimated cost for this alternative is summarized in Table 8.

Table 8 Onsite Hypochlorite Generation Capital Cost Summary
Disinfection Evaluation
City of Bend

Chlorine Contact Basin Number 3	$663,000
Salt Storage Silo	$126,000
Modify Existing Building and Install Tankage	$534,000
Abandon Existing Gas Chlorine System	$39,000
Electrolytic Equipment and Feed Pumps	$1,673,000
Electrical Instrumentation and Controls	$1,062,000
Total Construction Costs	$4,097,000
Engineering, Legal, and Administrative	$1,024,000
Total Capital Costs	$5,121,000

As a side note, it may be desirable to consider this system for control of filamentous organisms if UV disinfection is selected for the overall disinfection process. However, the starting and stopping of the sodium hypochlorite generation system every 30 days may prove problematic and it may be simpler and less expensive to consider purchasing bulk hypochlorite for control of filamentous organisms.

4.2.2 Bulk Commercial Sodium Hypochlorite

For this alternative, commercially produced sodium hypochlorite solution (12% by weight) is delivered to the site by a contracted chemical supply and delivery company. It is stored in tanks and metered into the process flow just like the onsite generation alternative. The major differences are the smaller tanks, lack of salt storage and handling, and dramatically reduced electrical requirements. However, hypochlorite 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 should not exceed 30 days, and 15 days storage at ADMM flows is recommended. This product also off-gasses chlorine, and although not serious, it can be corrosive to surrounding equipment. Since this chemical readily degrades, it will be important to contract with reliable suppliers. Additionally, chlorine residuals must be closely monitored and feed rates increased as the chemical concentration decreases to maintain chlorine residual.

For control of filamentous organisms, it is recommended that a special delivery be scheduled and the product used quickly while at maximum chlorine concentration. Using the preceding recommendations, Table 9 summarizes the tankage requirements.

Table 9 Bulk Hypochlorite Storage Requirements[1]
Disinfection Evaluation
City of Bend

Year	ADMMF (mgd)	15 Day Storage Requirement (Gallons)	Filamentous Organism Control[2] (Gallons)	Total Storage (Gallons)
2010	7.3	363	722	1,358
2020	9.8	853	963	1,816
2030	11.9	1,036	1,230	2,266

Notes:

1. Based upon 1 gallon 12% hypochlorite = 1 pound gaseous chlorine.
2. See Table 3.

The total storage capacity from Table 9 indicates, when compared to the “worst case” chlorine demand from Table 3, that the required amounts are very similar. Therefore, to increase operations flexibility, it is our recommendation to install two 2,500 gallon tanks and not fill the second tank unless filamentous organism control dosing is planned.

Implementation of this alternative would include the following major elements:

- Abandon existing gaseous chlorine system.
- Additional third parallel CCB.
- Install tanks and metering pumps.

With modification, the existing chlorination building can be used to house all the necessary equipment. The estimated cost for this alternative is summarized in Table 10.

Table 10 Bulk Hypochlorite Capital Cost Summary
Disinfection Evaluation
City of Bend

Chlorine Contact Basin Number 3	$663,000
Abandon Existing Gas Chlorine System	$39,000
Modify Existing Building and Install Tankage and Feed Pumps	$505,000
Electrical, Instrumentation, and Controls	$423,000
Total Construction Costs	$1,630,000
Engineering, Legal, and Administrative	$409,000
Total Capital Cost	$2,039,000

4.3 Split Flow Chlorination

The WRF can produce two different effluent streams. Outfall 001 effluent that is sent to the seepage ponds could be produced using the existing two chlorine contact basins up to peak flows of 21.9 mgd using a 15 minute HRT and both basins in service and up to average flows of 10.9 mgd using both basins.

For the purposes of this “split flow chlorination” analysis it is assumed that filtration is to precede disinfection for Level IV reuse. This is the methodology used by other states that have a large number of wastewater reuse facilities. Filtration before disinfection also lessens the likelihood of particular hindered disinfection.

Level IV reclaimed water (Outfall 004) could be produced using a single new chlorine contact basin and a new Level IV scalping pump station positioned between the secondary clarifiers and chlorine contact basin. See Figure 2. The new chlorine contact chamber would need to be constructed “hydraulically higher” than the existing chlorine disinfection system or double isolation backflow prevention would need to be installed to ensure that no possibility existed for the effluent disinfected to only 200 MPN/100 ml entered the Level IV reclaimed water system.

The WRF currently produces approximately 1.5 mgd of Level IV reclaimed water. It is feasible that it could rise to 5.0 mgd and beyond. Therefore, as proof of concept, and to identify potential costs, and for comparison purposes against other forms of disinfection, the flow will be split with up to 5 mgd for Level IV reclamation and 16.4 mgd flowing to the seepage ponds on the peak day.

The Level IV reclaimed water system would be sized at approximately 5 MGD, and the scalping pump station piping could be configured to bypass the filters and discharge directly to the third chlorine contact basin during those times when one of the existing two chlorine contact basins was off line for maintenance. Depending upon incoming plant flows, no Level IV reclaimed water would be produced during this maintenance activity.

The amount of chlorine usage could be reduced, approaching the values as shown in Table 2, based upon the amount of effluent that is not disinfected to Level IV requirements.

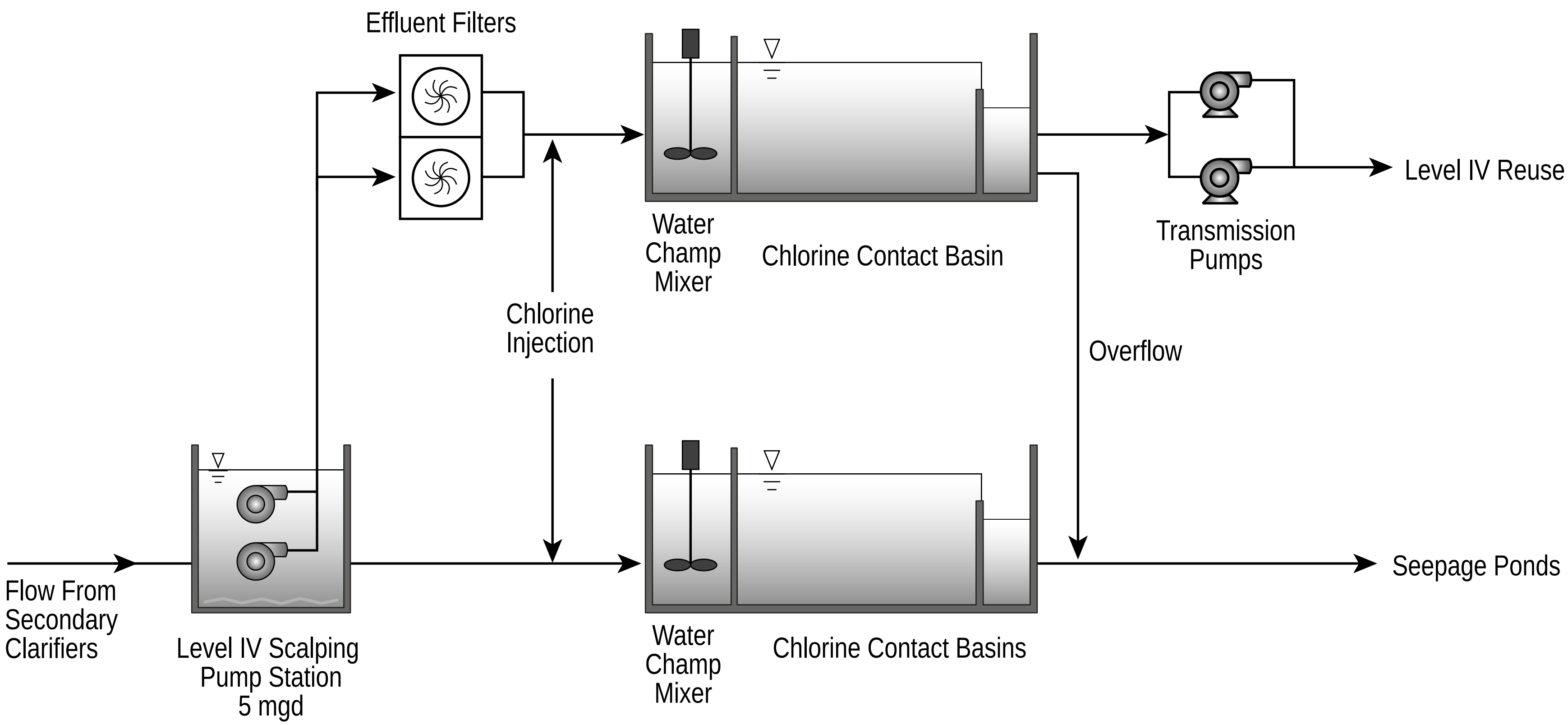


Figure 2
Split Flow Chlorination Disinfection Schematic
DISINFECTION EVALUATION
CITY OF BEND

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

- Level IV reclaimed water scalping pump station and piping.
- Elevated (higher than existing) third chlorine contain basin.
- Bulk liquid hypochlorite improvements, as previously defined.

The estimated cost for this alternative is summarized in Table 11.

Table 11 Split Flow Chlorination Capital Cost Summary
Disinfection Evaluation
City of Bend

Chlorine Contact Basin Number 3	$663,000
Level IV Reclaimed Water Scalping Pump Station and Piping	$925,000
Bulk Hypochlorite System	$545,000
Electrical, Instrumentation, and Control	$745,000
Total Construction Costs	$2,900,000
Engineering, Legal, and Administrative	$720,000
Total Capital Cost	$3,620,000

4.4 Modified Split Flow Chlorination

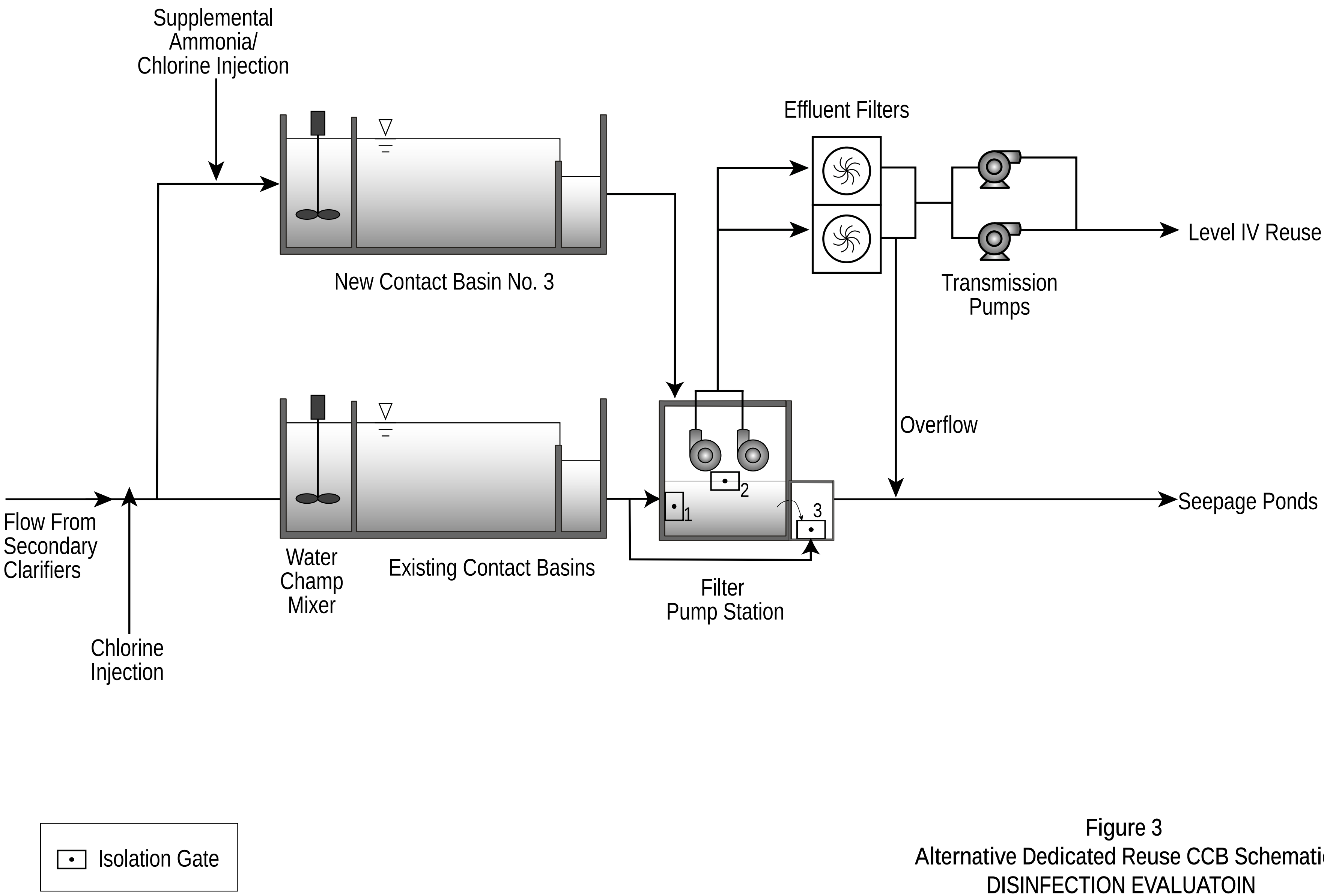
An alternative split chlorination approach that leaves filtration downstream of disinfection process could significantly reduce operating costs (see Figure 3). This option has a much lower capital cost compared the split flow option that moves filtration ahead of disinfection, since it only requires 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. It should be noted that ammonia addition is anticipated to continue during the reuse season with split chlorination.

5.0 UV DISINFECTION ALTERNATIVE

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 three types of UV systems currently being employed to disinfect wastewater are:

- Medium Pressure (MP)
- Low Pressure High Output (LPHO)
- Low Pressure (LP)



Note: Gates 1 and 2 are closed when CCB3 is dedicated to reuse

Figure 3
Alternative Dedicated Reuse CCB Schematic
DISINFECTION EVALUATOIN
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MP lamps operate at a much higher intensity than LP or LPHO systems, which results in fewer lamps and an overall smaller system. However, the higher intensity lamps require more power, and operate at higher temperatures (600 to 800 degrees Centigrade). MP lamps are polychromatic and cover a wide range of light wavelengths. The germicidal action of UV light is most effective at wavelengths from 240 to 300 nm. Due to the broadband nature of the light generated by MP systems, much of the total energy output from MP lamps is not available for disinfection. As a result, the electrical efficiency of MP systems is much lower than for the monochromatic LP and LPHO technologies, translating to higher power costs.

LPHO lamps combine some of the benefits of the LP and MP systems. As these systems emit monochromatic germicidal light at higher intensity levels than LP systems, the number of lamps needed for a given dose is less than the number used in a LP system, yet higher than the number required for a MP system.

Because of the low intensity level of the LP systems, a significant number of lamps are required to disinfect large flows. This large number of lamps has a significant impact on O&M and reliability. Therefore, LP systems were eliminated from consideration.

Of the remaining systems (LPHO and MP), the LPHO system offers a lower operating temperature and greater efficiency than the MP lamps; however, the LPHO system would require about three times the number of lamps than the MP system.

To logically implement a UV system, the effluent will need to be split between the seepage ponds and Level IV reclamation. Figure 4 depicts the flow schematic. The split will need to be adjustable and expandable based upon the future demand for Level IV reclaimed water. Future demand for Level IV reclaimed water is unknown but is expected to grow.

The WRF currently produces approximately 1.5 mgd of Level IV reclaimed water. It is feasible that it could rise to 5.0 mgd and beyond. Therefore, as proof of concept, and to identify potential costs, and for comparison purposes against other forms of disinfection, the flow will be split with up to 5 mgd for Level IV reclamation and 16.4 mgd flowing to the seepage ponds on the peak day.

Part of this analysis is to consider ways to allow for either the Level IV reclaimed water to be filtered prior to disinfection or for the filters to be 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 UV system with different numbers of lamp banks in each channel. Therefore, only LPHO UV systems will be examined for the open channel UV alternative. The existing hydraulic profile at approximately 22 mgd indicates approximately 4.5 feet of headloss is available for installation of a channelized UV system.

The option also exists for the same flow split described above but employs the use of a closed vessel UV system on the Level IV reclaimed water only. The effluent directed to the seepage ponds would continue to be chlorinated. Because the demand for Level IV reclaimed water may be sporadic throughout the year, the chlorination system will need to be sized to treat peak flows. Figure 5 depicts the flow schematic.

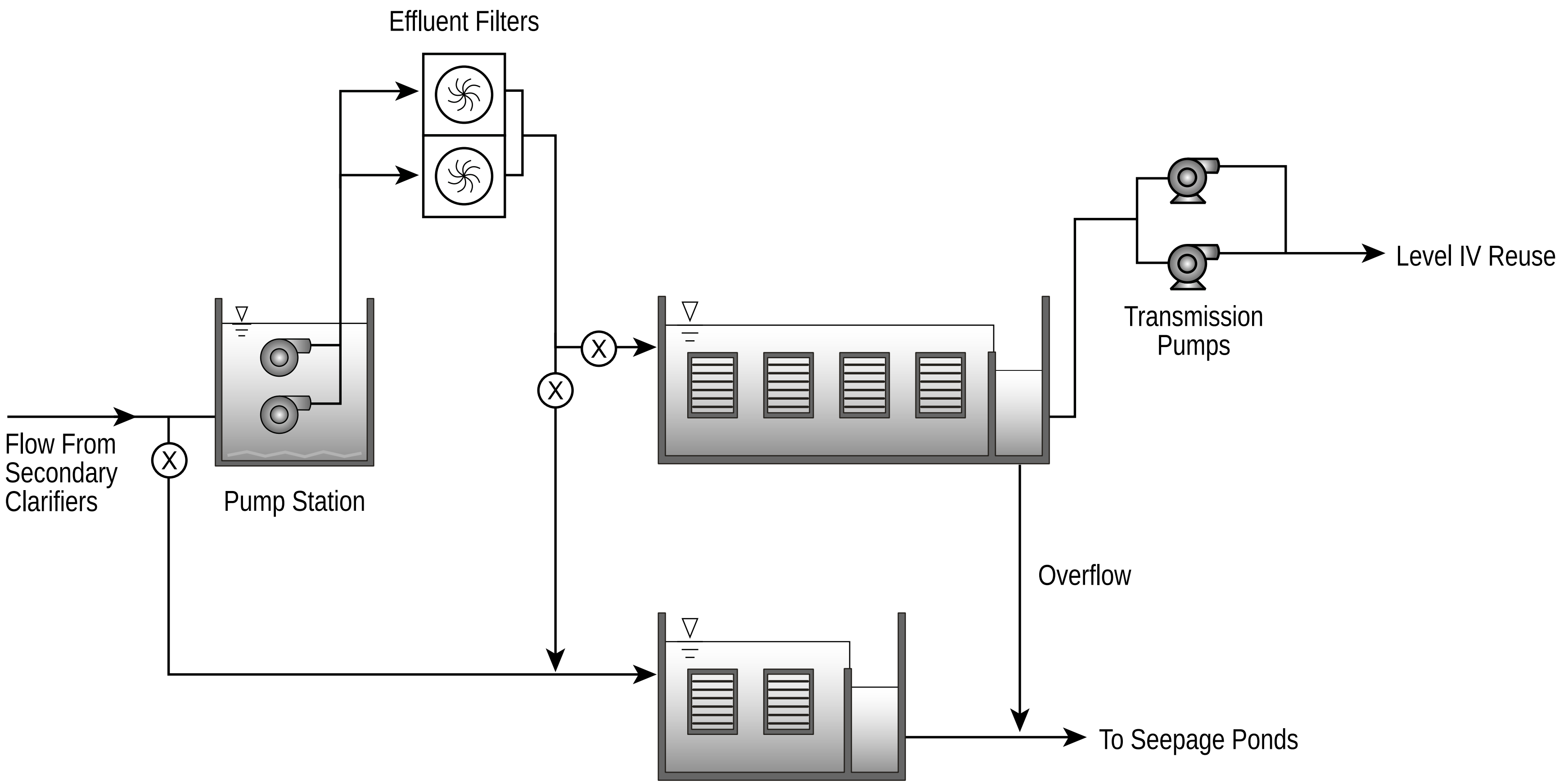

Figure 4
Open Channel UV Disinfection Schematic
CITY OF BEND
DISINFECTION EVALUATION

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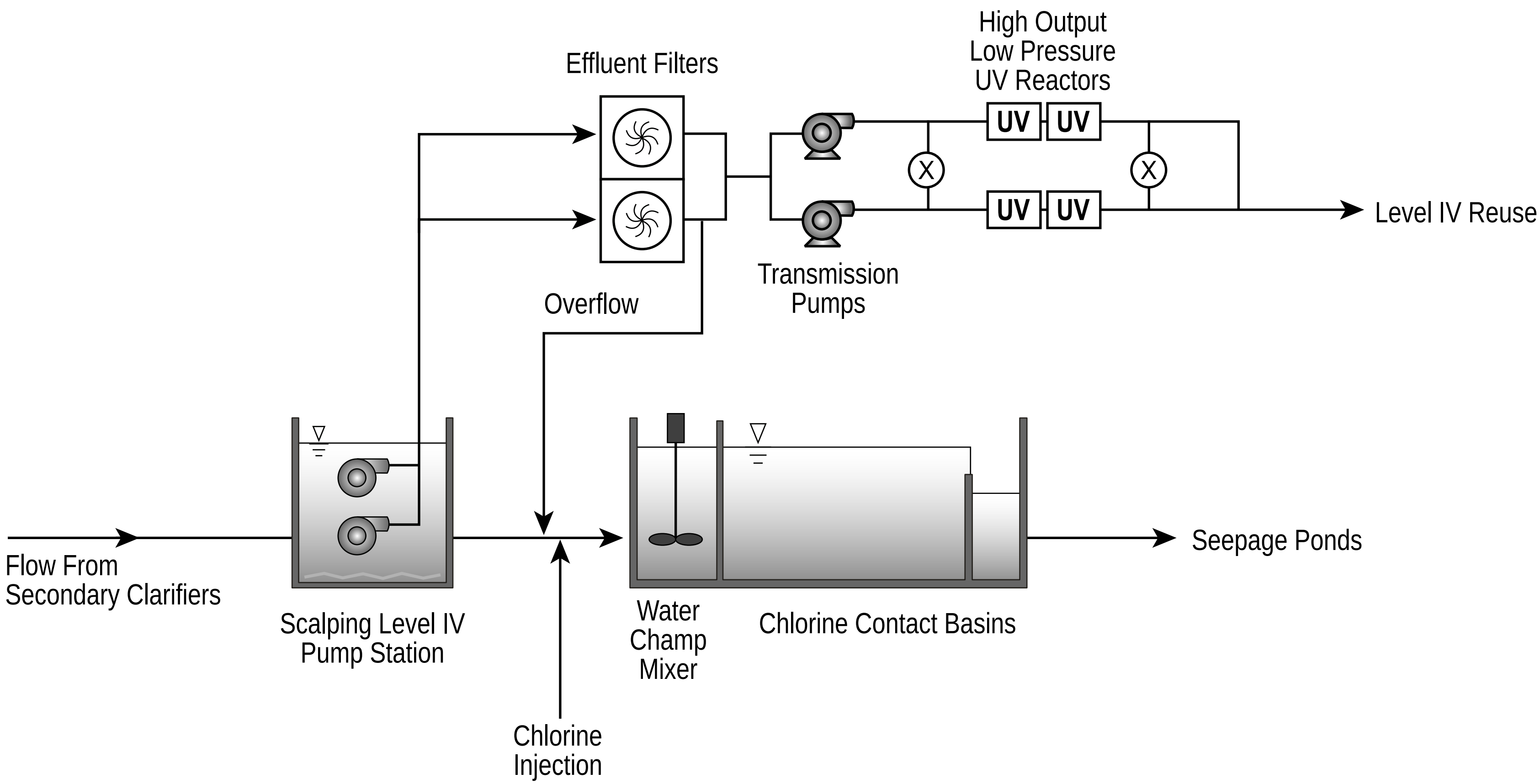

Figure 5
Closed Vessel UV Disinfection/Chlorination Schematic
DISINFECTION EVALUATION
CITY OF BEND

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5.1 Design Flow and Disinfection Level Requirements

The WRF is permitted to 200 FC/100 ml for effluent delivered to the seepage ponds and is also permitted at total coliform 2.2 MPN for Level IV reclaimed water. The combination of these very different effluent disinfection requirements does not lend itself to a "one size fits all" approach.

Attempting to treat the peak flow to 2.2 TC MPN without filtering produced a UV system requiring five channels, each at least 60 feet in length with 320 lamps per channel. Estimated UV equipment cost alone was in excess of $3.8 million with annual electrical and lamp replacement costs in excess of $230,000. Capital costs were estimated at over $15 million. Therefore, applying a UV system prior to filtration and attempting to inactivate to 2.2 MPN is not deemed economical and is also not recommended from a technical standpoint. Furthermore, it is not recommended that the UV disinfection be accomplished prior to filtration due to the occurrence of "particle shielding" than may protect coliforms from the UV radiation. Therefore UV disinfection prior to filtration is dropped from further consideration.

A key water quality parameter that impacts the analysis and sizing of a UV system is UV transmittance (UVT).

The effectiveness of UV light for inactivation of microorganisms is contingent upon the ability to transfer germicidal energy from the UV source (the lamp) through the wastewater and into the cellular structure of the microorganism where it is absorbed by the cell's genetic material, causing damage that prevents cellular replication. Its effectiveness is in direct proportion to the intensity of germicidal light and the exposure time. The dose of UV radiation is defined by the product of average intensity and exposure time and is generally expressed in units of millijoules per centimeter squared (mJ/cm^2).

The time a microbe is exposed to UV light is related to reactor design and wastewater flow rate, while the amount of light the organism is exposed to is determined by the UVT of the water. Referred to in units of percent per cm (%/cm), UVT is defined by the percent ratio of 254 nm light passing through one cm of wastewater compared to that passing through one cm of distilled water. The presence of dissolved materials in wastewater affects the UVT and limits the effectiveness of UV disinfection. Waters with lower UVT values require higher UV intensities (or longer exposure times) to achieve a given level of disinfection compared to waters with higher UVT levels. Therefore, UVT is a critical design parameter for evaluating UV disinfection alternatives.

By April 2007, two samples of the secondary clarifier effluent had been collected (3/28/07) and tested. UVT was reported as 64 percent and 67 percent. No samples were available for the cloth disk filter filtrate. For accurate sizing of a UV system, significantly more samples should be taken and tested. It is our understanding that before pursuing UV disinfection, the WRF would take samples on a weekly basis and the overall system layout adjusted accordingly after sufficient samples are gathered. To accurately begin to evaluate UVT, at least three samples per day per flow stream should be collected and analyzed for a period not less than six months. The sampling period should include the wet weather season. With these additional data, the 10 percent exceedance UVT can be derived and used. Lacking significant data, and for comparison purposes, UVT was assumed to be 60 percent for secondary clarifier effluent and for the cloth disk filter filtrate.

A UV system must be designed to meet the differing requirements of the effluent stream. For typical treatment plant discharges, UV doses of 15-30 mJ/cm^2 are used. For Level IV reclamation (2.2 MPN TC/100 ml), dosages of 100 mJ/cm^2 are generally recommended, if not required. Figure 5 shows an example of the log reduction of fecal coliform as a function of UV dose at a typical wastewater treatment plant. With a requirement of 200 FC/100 mL and assuming a maximum fecal coliform concentration of 100,000 per 100 mL, 99.9 percent reduction of fecal coliform, or 3-log removal, is required. For 3-log reduction of fecal coliform, a design UV dose of 15 mJ/cm^2 would be sufficient based upon Figure 6.

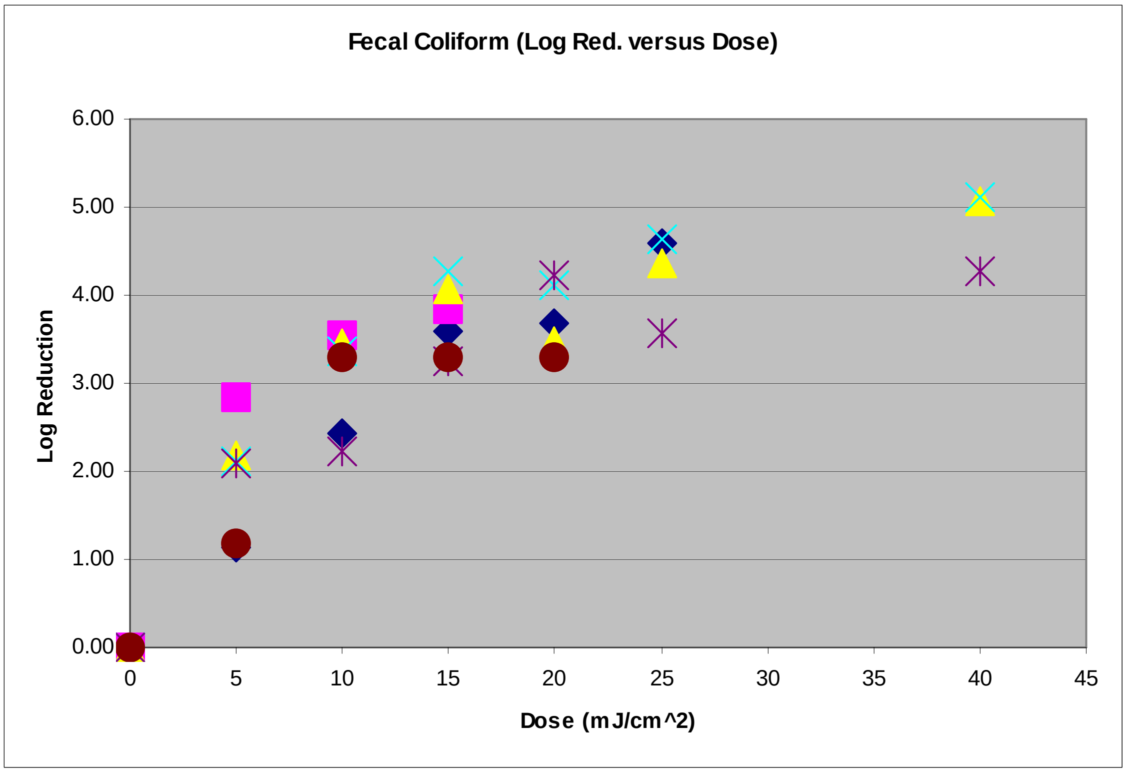

Figure 6. Fecal Coliform Log Reduction Data

Table 12 presents the criteria for a potential flow split use the two-channel UV system.

Table 12 UV Criteria
Disinfection Evaluation
City of Bend

	Seepage Ponds	**Reclamation Level IV**
Peak Flow Rate, mgd	16.4	5
UVT, minimum	60%	60%
Effluent Fecal Coliform	200 FC/100 ml	2.2 TC/100 ml
Number of Banks	2	4 (3 duty; 1 redundant)
Number of Lamps	320	320
Dose mJ/cm^2	15	100

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. At least 30 feet long, 3'-6" wide, 5'-2" deep.
- UV channel for Level IV reclaimed water. At least 60 feet 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.

The switch from gaseous chlorine to UV disinfection will require upgrading of the plant's standby power generation capacity. Improvements to that system are covered in a separate technical memorandum.

The estimated cost for this alternative is summarized in Table 13.

Table 13 UV Disinfection Capital Cost Summary Disinfection Evaluation City of Bend	
UV Channels with Weirs	$168,000
UV Equipment	$2,814,000
Building	$1,030,000
Site Piping	$292,000
Bulk Hypochlorite (Filamentous Control)	$330,000
Electrical, Instrumentation, and Controls	$1,622,000
Total Construction Costs	$6,256,000
Engineering, Legal, and Administrative	$1,564,000
Total Capital Cost	$7,820,000

6.0 COMBINATION UV AND CHLORINE DISINFECTION ALTERNATIVE

A combination could be implemented in which effluent that is sent to the seepage ponds could be produced using an upgraded chlorine system and Level IV reclaimed water could be produced using a closed UV vessel configuration installed down stream of the existing reclaimed water distribution pumps (downstream of the filters). See Figure 4 for a flow schematic.

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

Table 14 shows the criteria for developing this combination alternative. The same flow split was used as for analysis of the open channel UV alternative and split flow chlorination alternative.

Table 14	Combination Alternative Criteria Disinfection Alternative City of Bend	
	Seepage Ponds Level I	**Reclaimed Level IV**
Disinfectant	Chlorine	UV
Peak Flow, mgd	16.4	5.0
Chlorine Demand, mg/L	7.5	-
Ammonia Demand, mg/L	0	0
UVT, Minimum	-	60%
Reactor Configuration	-	Closed Vessel[1]
Effluent Coliform Limit	FC 200 MPN/100 ml	TC 2.2 MPN/100 ml
Dose, mJ/cm^2	-	100

Note:

1. LPHO System.

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. Therefore, even though some reduction in chlorine operation expenses may be seen, reducing the size of the chlorine system does not appear to be prudent. 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.
- Bulk hypochlorite chlorine system as per Section 4.2.2.

The estimated cost for this alternative is summarized in Table 15.

Table 15 Combination Closed Vessel UV and Bulk Hypochlorite Disinfection
Disinfection Evaluation
City of Bend

Transfer Structures and Yard Piping Modifications	$874,000
UV Equipment (4 Reactors)	$2,096,000
UV Piping Modifications	$146,000
Chlorine Contact Basin Number 3	$663,000
Abandon Existing Gas Chlorine gas system and modify Existing building and install Tankage and Field Pumps	$544,000
UV Associated Electrical, Instrumentation, and Control	$1,515,000
Total Construction Cost	$5,835,000
Engineering, Legal, and Administrative	$1,460,000
Total Capital Cost	$7,295,000

This combination alternative will not be the least costly option as it has all the capital expenses of the least costly chlorine alternative plus significant additional costs associated with a new UV system.

7.0 ALTERNATIVES COMPARISON AND RECOMMENDATION

7.1 Economic Comparison

Cost estimates were developed by first estimating total direct costs (based on recent project experience, project bids, and vendor quotes), then applying factors for contingencies, engineering, and electrical, instrumentation and control (EI&C). A contingency factor is often used to compensate for lack of detailed information, oversights, anticipated changes, and imperfection in the estimating methods used. As the project design progresses and elements become better defined, smaller contingencies may be applied. Percentages (as opposed to discrete dollar amount allowances) are typically used for contingencies as well as other elements in an estimate. Percentages (typically part of total direct costs) used in the development of this cost estimate include the following:

- Electrical, Instrumentation & Control: 35%
- Construction Contingency: 35%
- Engineering, Legal and Administration: 25%

The accuracy of a cost estimate depends on the quantity and quality of the information available to prepare that estimate. Typically, as a project progresses from master planning studies, to conceptual design, to final design, the project elements become better defined, thereby providing more and better information for development of progressively more accurate estimates. The Association for Advancement of Cost Engineers (AACE) has suggested a level of accuracy for planning of +30 to -15 percent.

In order to develop net present worth (in 2007 $) for the alternatives, interest (6%), inflation (3%), and construction cost escalation (ranging from 8% in 2010 to 4% in 2030) were considered. Individual expansion components were sequenced based on flow projections in the years 2010, 2020, and 2030.

Average annual flows and chlorine demand were used to project O&M costs. Additionally, control of filamentous organisms was assumed to occur once per month and added to the total chemical chlorine requirement. Major assumptions used in the O&M NPW analysis are summarized below:

- Chlorine gas in ton cylinders cost $0.38/lb.
- Bulk hypochlorite cost $1.05/gallon.
- Bulk salt cost $0.08/pound.
- Electricity cost $0.07/KwHr.
- UV operation costs assumed 77 lamps per channel were replaced each year (154 lamps/yr total).

Annual estimated operation costs for disinfection alternatives are summarized in Table 16 for each of the disinfection alternatives at the midpoint (year 2020) of the planning period.

Table 16 Disinfection Alternatives Annual Operating Cost
Disinfection Evaluation
City of Bend

	Disinfection	Filament Control	Total
Gaseous Chlorination	$160,000	$4,000	$164,000
Bulk Hypochlorite	$441,000	$11,000	$451,000
On-Site Hypochlorite	$191,000	$5,000	$201,000
UV Disinfection [(1)]	$165,000	$7,700	$173,000
Split - Flow Chlorination	$318,000	$11,000	$329,000

[(1)] Includes $99,500/yr for lamp replacement and $65,400/yr for power.

A comparison of the overall present worth of the disinfection alternatives is shown in Table 17. The estimated expenses associated with chlorine disinfection are lower compared to those expected for UV disinfection. While the capital cost is higher for gaseous chlorine compared to hypochlorite, its overall present worth cost is somewhat lower due to chemical cost savings. However, liquid chlorination has significant non-economic advantages, as discussed in the following section.

Table 17 Net Present Worth of Disinfection Alternatives
Disinfection Evaluation
City of Bend

	Capital	O&M	Total
Gaseous Chlorine	$4.7 million	$2.0 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	$3.6 million	$4.8 million	$8.4 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.

7.2 Non-Economic Evaluation

Non-economic advantages and disadvantages of the alternatives are listed in Table 18. The primary advantage of the hypochlorite and UV systems is safety, which is a very significant consideration.

Table 18 Advantages/Disadvantages of Disinfection Alternatives
Disinfection Evaluation
City of Bend

Disinfection Alternative	Advantages	Disadvantages
Gaseous Chlorine	• Operator familiarity. • Less standby generator power required. • Proven effectiveness.	• Safety. • Continued chlorine impact to filters. • High residuals in reclaimed water.
Bulk Hypochlorite	• Less standby generator power required. • Simple to operate. • Safety.	• Off gassing of chlorine. • Continued chlorine impact to filters. • High residuals in reclaimed water.
Onsite Hypochlorite Generation	• Less standby generator power required than UV. • Simple to operate. • Safety.	• Material handling. • Off gassing of chlorine. • Continued chlorine impact to filters. • High residuals in reclaimed water.
UV	• Eliminates chlorine impact to filters. • Improved plant safety.	• More standby generator power required.

7.3 Recommended Approach

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 net present worth 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.

As previously discussed, 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. It should be noted that ammonia addition is anticipated to continue during the reuse season with split chlorination.

The following was developed for comparison purposes and assistance in budgeting for chemical costs: In 2005, approximately 161,000 pounds of chlorine was used. At a price of gaseous chlorine at $0.38/pound and $1.05/gallon for bulk hypochlrite annual chemical expenditures would be approximately $61,200 and $169,000 respectively. For the first year of operation using bulk hypochlorite we would recommend the chlorine gas budget be increased by a factor of 2.75 (ratio of the cost of bulk hypochlorite to chlorine gas). It is anticipated that the recommended approach will still require the addition of ammonia to address the operational issue the plant previously experienced with free chlorine disinfection. Estimated ammonia costs are approximately $5,000/yr in 2010 and $13,750/yr in 2030.

City of Bend

Water Reclamation Facilities Plan

TECHNICAL MEMORANDUM NO. 7
SOLIDS PROCESSING SYSTEMS

April 2008

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CITY OF BEND

WATER RECLAMATION FACILITIES PLAN

TECHNICAL MEMORANDUM
NO. 7

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SOLIDS PROCESSING SYSTEMS

1.0 INTRODUCTION

This technical memorandum (TM) evaluates the existing solids processing system at the Bend Water Reclamation Facility (WRF), and develops a plan for improving and expanding the system to handle projected loadings through the 2030 planning period. Projected system loadings are based on the process model (Biotran) developed for the liquids treatment analysis (see TM No. 4). The values for the MLE configuration developed for an effluent total nitrogen limit of 10 mg/L were used in this TM. Other configurations would have slightly differing solids production values, but the variation would not be significant enough to impact the findings of this evaluation.

2.0 BACKGROUND

The existing solids treatment system consists of the following processes:

- Primary sludge thickening;
- Waste activated sludge (WAS) thickening;
- Digestion, and;
- Biosolids dewatering.

The existing solids treatment system produces Class B biosolids, which are then land applied. Currently, there are no drivers to implement a Class A biosolids program. However, alternatives for upgrading the current system to meet Class A standards are evaluated in this report to ensure that adequate flexibility is provided in the recommended solids treatment approach to implement a future Class A program.

Cost estimates in this TM were developed by first estimating total direct costs (based on recent project experience, project bids, and vendor quotes), then applying factors for contingencies, engineering, and electrical, instrumentation and control (EI&C). A contingency factor is often used to compensate for lack of detailed information, oversights, anticipated changes, and imperfection in the estimating methods used. As the project design progresses and elements become better defined, smaller contingencies may be applied. Percentages (as opposed to discrete dollar amount allowances) are typically used for contingencies as well as other elements in an estimate. Percentages (typically part of total direct costs) used in the development of this cost estimate include the following:

- Electrical, Instrumentation & Control: 35%
- Construction Contingency: 35%
- Engineering, Legal and Administration: 25%

The accuracy of a cost estimate depends on the quantity and quality of the information available to prepare that estimate. Typically, as a project progresses from master planning studies, to conceptual design, to final design, the project elements become better defined, thereby providing more and better information for development of progressively more accurate estimates. The Association for Advancement of Cost Engineers (AACE) has suggested a level of accuracy for planning of +30 to -15 percent.

In order to develop net present worth (in 2007$) for the various alternatives, interest (6%), inflation (3%), and construction cost escalation (4%) were considered. Individual expansion components were sequenced based on flow projections in the years 2010, 2020, and 2030.

2.1 Current and Projected Solids Loadings

Table 1 shows the projected solids loadings for the design maximum month condition. The current sludge production values were compared to the primary and secondary sludge production values from the *Solids Master Plan* completed by Vision Engineering. The Solids Master Plan indicated current peak month solids production numbers of 17,720 lb/day for primary sludge and 7,122 lb/day for secondary sludge. These values are somewhat higher than those predicted in Table 1, but compare reasonably well given that a higher influent TSS concentration was cited in the solids master plan. Plant data correlated very well with the measured WAS, but modeled primary sludge flow is higher than the amount calculated based upon pump run time. The primary sludge values in the table are based upon mass balance approach using primary clarifier flow, influent TSS, and effluent TSS. Based upon the inherent difficulty in accurately measuring primary sludge concentration and flow, it was agreed that the mass balance approach would be used.

Table 1 Maximum Month Projected Solids Loadings
Water Reclamation Facility 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

2.2 Current Solids System

The current solids processing system consists of clarifier thickening of primary sludge, gravity belt thickening of WAS, anaerobic digestion, and belt filter press dewatering. Table 2 provides a summary of the sizes of the existing systems.

Table 2	Existing Solids System Summary Water Reclamation Facility Plan City of Bend
Gravity belt thickener	1 @ 2.0 M
DAF thickener (backup)	1 @ 20 ft. diameter
Belt filter press	1 @ 2.0 M
Digesters	
Original (Nos. 1 and 2)	2 @ 411,000 gallons
New digester (No. 3)	1 @ 820,000 gallons
Total, all digesters	1,642,000 gallons
Drying beds	12 acres

3.0 THICKENING

3.1 Primary Sludge Thickening

As noted above, primary sludge is currently thickened in the primary clarifiers. This is a low-cost and effective process, that provides a reliable solids concentration of 4.4%. Alternatives for thickening this material are:

1. Gravity belt thickening, either directly or blended with WAS.
2. Gravity thickeners.

Gravity belt thickening of primary sludge can provide slightly higher solids concentrations, but at considerable effort and expense. Primary solids exert a lot of wear on belts, resulting in high maintenance costs and relatively high downtime. Because primary sludge is usually septic, odor generation is excessive, and corrosion is accelerated. Because of these issues, gravity belt thickening is not recommended for primary sludge.

Gravity thickeners are relatively easy to operate. They are configured much like primary clarifiers, but are typically a little deeper with greater floor slopes and are operated at lower loadings to allow the sludge to thicken further than is achievable in clarifiers. Reported thickened sludge concentrations for primary sludge are in the range of 5-10% solids. For planning purposes, a thickened sludge concentration of 6% is assumed for the gravity thickener option.

Increasing the primary sludge solids concentration from 4.4% to 6.0% would reduce the total combined flow to the digesters approximately 23%. This has the effect of gaining additional capacity from the available digester space, since they are constrained by the hydraulic retention time. Figure 1 shows the projections for gravity thickening and clarifier thickening. With clarifier thickening, a digester is needed to be in service by 2017. This is delayed until 2028 if gravity thickeners are constructed.

A present worth analysis was prepared to evaluate the cost-effectiveness of installing gravity thickeners relative to the savings in digester capacity. These were based on installing two 35 foot diameter thickeners, which will provide sufficient capacity for the design year with one basin out of service at average loading conditions.

The detailed calculations are provided in Table A1 in the Appendix. The calculations take into account the fact that there is a significant difference in the residual capacity of the digester at the end of the planning period. According to the process parameters described above, the year at which the digester is required under the gravity thickening option (2027) is almost beyond the planning period. If installed as shown, it would still have about 94% unused capacity at year 2030, compared to about 37% for the other alternative. If an assumption of 6.3% solids from the thickener were used rather than the 6.0% assumed above, no additional digester would be needed within the planning period.

The present worth cost analysis is summarized in Table 3, and indicates that the present worth of the gravity thickener option is approximately $800,000 lower than continued thickening in the primary clarifiers. In addition to the cost savings, the gravity thickener option also has the following process advantages:

1. Eliminating the primary sludge blanket is expected to improve performance in the clarifiers, especially during high flow events.

2. The gravity thickeners may be used to provide backup capacity for WAS thickening, as discussed in the following section. Primary sludge and WAS can be successfully co-thickened, especially for short periods.

Based upon these considerations, gravity thickeners are recommended and should be constructed by approximately 2016, when the digesters are nearing their capacity.

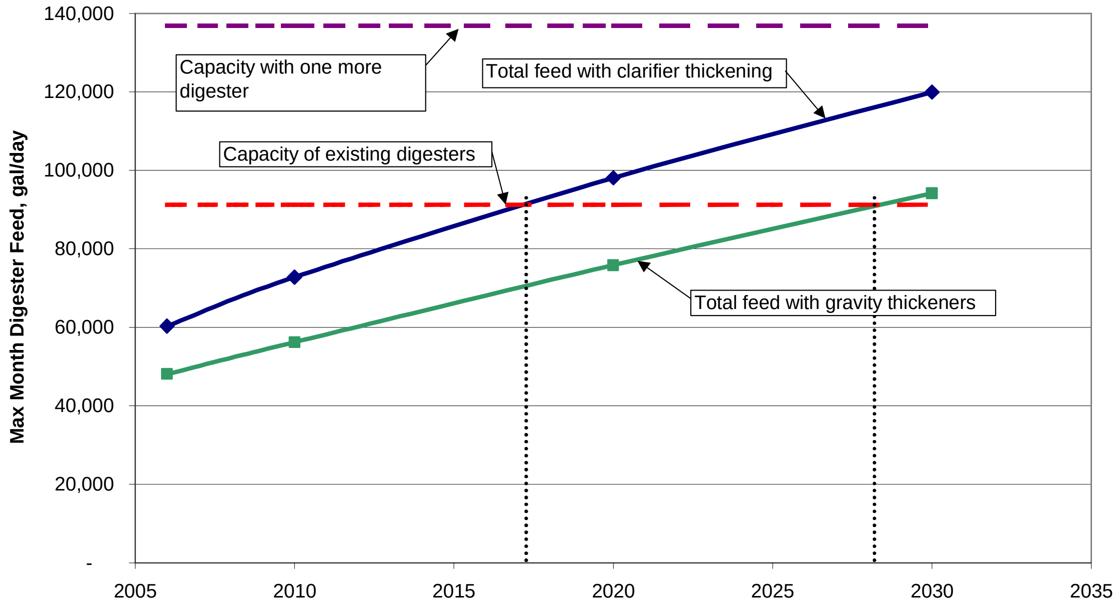

Figure 1 Digester Capacity Chart

Table 3 Present Worth Analysis for Primary Sludge Thickening Alternatives Water Reclamation Facility Plan City of Bend

Parameter	Primary Clarifier Thickening	Gravity Thickener
Thickener description	N/A	2 @ 35' diameter
Loading rate, lb/sf/day (max. month)	N/A	19
Year for Installation:		
Gravity thickener	N/A	2016
Digester	2016	2027
Total Present Worth	$2,865,000	$2,100,000

3.2 Waste Activated Sludge Thickening

The current gravity belt thickener has sufficient capacity to thicken WAS through the planning period, as shown in Table 4. Even at year 2030 maximum month loadings, the existing unit need only be operated approximately nine hours per day, based on operating seven days per week.

With a single unit, backup capability must be addressed. The dissolved air flotation system is currently available as a backup, but it has insufficient capacity to handle projected WAS loads. The system design parameters are presented in Table 5. Even at the aggressive rated capacity of 1.0 lb/hr/sf, the capacity of 7,500 lb/day is slightly below the projected WAS loading for year 2010, and less than half of the year 2030 projection.

Table 4	**Summary of Unit Process Sizing and Design Criteria - Gravity Belt Thickener Water Reclamation Facility Plan City of Bend**				
Parameter	**Unit**	**2006**	**2010**	**2020**	**2030**
Number	-	1			
Size	meters	2			
Capacity, hydraulic	gpm	500			
Capacity, solids loading	lbs/hr	2,000			
WAS concentration	mg/L	6,000-8,000			
WAS load @ ADMMF	ppd	6,730	7,900	10,900	17,200
WAS flow @ ADMMF	mgd	0.10	0.12	0.16	0.26
Operation req'd (7d/wk)	hours/day	3.4	4.0	5.5	8.6

Table 5	**Summary of Unit Process Sizing and Design Criteria - Dissolved Air Flotation Thickener System Water Reclamation Facility Plan City of Bend**	
Parameter	**Unit**	**Value**
Number	-	1
Diameter	feet	20
Typical design loading rates (WEF MOP8)	lb/hr/sf	0.4 - 1.0
Original design solids loading rate	lb/hr/sf	1.0
Rated capacity	lbs/day	7,500
Estimated TWAS concentration	%	4

Coupled with the facts that the DAF system is mechanically complex, operator-intensive, and in generally poor condition, it does not present a viable option for backup WAS thickening service. An alternative for backup WAS thickening is to rely on co-thickening of WAS in the primary clarifiers (or gravity thickeners when installed) during the infrequent and short-term periods when the GBT system is unavailable. Depending on conditions, this strategy could also be coupled with a temporary reduction in wasting rates, thereby providing storage within the biological process.

The co-thickening strategy does have drawbacks; primarily that the thickened solids concentration would be appreciably lower than is achieved in the GBT. The expected equivalent concentration will be in the range of 2-3% solids (based on WAS only; the primary sludge would remain at the expected 4.4%, or 6% with gravity thickening). Therefore, it is only applicable for "emergency", short-duration outages.

An alternative approach is to install a "dual-purpose" belt filter press (BFP). As described in Section 5, 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.

4.0 ANAEROBIC DIGESTION

A description of the existing digestion system is provided in Table 2. Solids first go to Digester 3 (the large one), then to the smaller tanks in series operation. Although all digesters are heated, the last digester currently serves primarily as a holding tank. However, with the upcoming digester mixing improvements, all tanks will be operable as fully heated and mixed tanks, and are included in the detention times presented below.

The planned improvements will provide high-intensity mechanical mixing to existing Digesters 1 and 2, which currently have inefficient and ineffective gas mixing. This will provide the capability to achieve good mixing at higher solids levels than can now be achieved.

Table 6 is a summary of projected digester loadings, based on incorporation of gravity thickening for primary sludge, as discussed above.

Table 6 Projected Maximum Month Digester Loadings
Water Reclamation Facility Plan
City of Bend

Stream	2006	2010	2020	2030
Primary sludge				
Lbs/day	16,800	22,800	30,600	35,500
% solids[1]	4.4%	4.4%	6.0%	6.0%
Gal/day	45,800	62,100	61,200	70,900
Thickened WAS				
Lbs/day	6,060	7,110	9,810	15,500
% solids[2]	5.0%	8.0%	8.0%	8.0%
Gal/day	14,500	10,700	14,700	23,200
Total digester feed				
Lbs/day	22,900	29,900	40,400	51,000
% solids	4.5%	4.9%	6.4%	6.5%
Gal/day	60,300	72,800	75,900	94,100

Note:
1. Reflects future increase in TS concentration from gravity thickeners in 2016.
2. Reflects increase in TS concentration based on 90% recovery.

Table 7 shows the recommended loading criteria, along with calculated loading rates based on the projections in Table 6. 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 period to meet the design criteria with all digesters in service.

Table 7 Summary of Unit Process Sizing and Design Criteria - Anaerobic Digestion
Water Reclamation Facility Plan
City of Bend

Parameter	Unit	2006	2010	2020	2030
Digestion Design Criteria (Max. Month Loads)					
Minimum retention time	days	18			
Maximum volatile solids loading	lb VS/cf/day	0.20			
Existing tanks - diameter (all)	ft	50			
Existing tanks - depth					
Digesters 1 and 2	ft	28			
Digester 3	ft	57			
Existing tanks - volume					
Digesters 1 and 2, each	gallons	411,000			
Digester 3	gallons	820,000			
Total (all digesters)	gallons	1,642,000			
Existing Tanks Loadings @ ADMMF					
HRT @ ADMMF	days	27.2	22.6	21.6	17.4
Volatile solids loading @ ADMMF	lb VS/cf/day	0.078	0.101	0.092	0.116
Estimated volatile solids destruction	%	56	55	55	52

5.0 SOLIDS DEWATERING

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

5.1 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. As indicated, the table values are based on 5 days/week, and 24 hours/day. 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.

Table 8 summarizes the rated capacity and calculated loadings on the BFP. Figure 2 shows the results in graphical format. 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 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, and is based upon the assumption that the new unit is installed in the existing centrifuge location.

Table 8	**Summary of Unit Process Sizing and Design Criteria - Belt Filter Press Water Reclamation Facility Plan City of Bend**				
Parameter	**Unit**	**2006**	**2010**	**2020**	**2030**
Size	Meters	2.0			
Capacity	Lbs/hr	1,600			
Design operating period		5 days/week; 24 hours/day			
Digested solids loading (ADMM)	Lbs/day	13,600	18,600	28,000	31,000
No. of BFPs required[1]	-	0.6	0.7	1.0	1.1
Required pump rate to BFP	gpm	110			
Estimated cake dryness	%	16			

Note:
1. If operated for period shown.

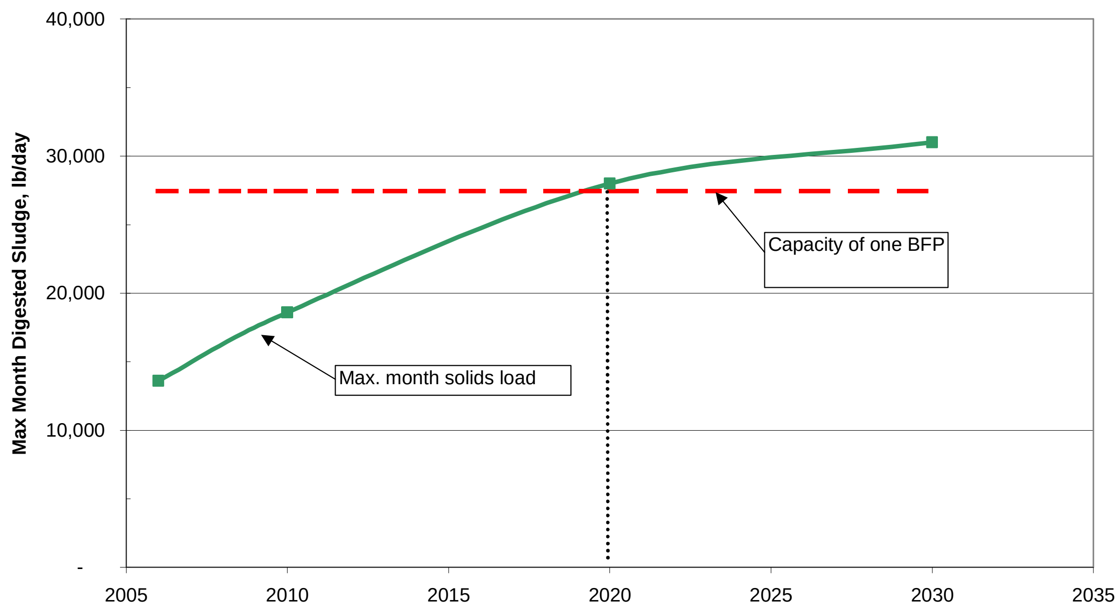

Figure 2 Belt Filter Press Capacity Chart

5.2 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.

6.0 CLASS A BIOSOLIDS EVALUATION

6.1 Background

The current biosolids program at the WRF produces a Class B biosolids product as defined under EPA and DEQ regulations. This means that the product is well stabilized, but still contains minor levels of pathogens that are a potential threat to people or animals that may be exposed to the material soon after it is applied. This results in certain requirements for monitoring and reporting, setbacks for application areas, restrictions on site access for a period after application, and restrictions on the timing and/or ability to apply the material to certain food chain crops. Within the WRF's current program, these limitations are insignificant.

The other category is Class A, in which pathogens are virtually eliminated by treating the biosolids by one of several methods. Besides elimination of pathogens, certain standards for levels of metals must also be met, termed "exceptional quality" biosolids. If this is accomplished, all restrictions for distribution and application are removed.

6.2 Summary of Class A Criteria

Class A biosolids are essentially pathogen free. They can be sold or given away for application on land or in a surface disposal site without any pathogen-related restrictions. There are six alternative methods within the Part 503 regulation for demonstrating Class A pathogen reduction. The objective of these methods is to achieve the following conditions in the product:

- Either <1000 MPN fecal coliform/g of total biosolids, dry weight basis or <3 MPN of *Salmonella* sp./4 g total biosolids, dry weight basis;
- Enteric viruses: <1 PFU/4 g of total solids, dry weight basis;
- Viable helminth ova: <1 viable helminth ovum/4 g of total solids, dry weight basis.

One of the "vector attraction reduction" (VAR) requirements must also be met when biosolids are applied to land or placed on a surface disposal site. At the WRF, this requirement is satisfied through anaerobic digestion.

6.3 Class A Alternatives

Class A biosolids must meet the pathogen limits listed above *and* one of the following six alternatives:

1. *Time and Temperature Requirements.* Contact time and temperatures during that time are specified. They depend primarily upon the material's solids content. Viruses and viable helminth ova are assumed to satisfy Class A criteria in biosolids treated in this manner, and their monitoring is not required.

2. *Alkaline Treatment Requirements.* Biosolids pH must be >12 for at least 72 hours and the biosolids temperature must exceed 53^{o}C (127^{o}F) during that period. Then, the biosolids must be dried to a concentration exceeding 50% solids. Viruses and viable helminth ova are assumed to satisfy Class A criteria in sludge treated in this manner, and their monitoring is not required.

3. *Treatment by Other Processes.* This alternative applies to processes that do not meet the conditions required by Alternatives 1 and 2. Sometimes viruses and helminth ova are not detected in the *untreated* material (feed). In this case, the absence of these pathogens in the treated biosolids does not demonstrate the process can reduce them to the Class A criteria.

   Therefore, this alternative requires untreated sludge to be monitored for viruses and pathogens. If these pathogens are not detected in the feed sludge, the treated biosolids are assumed to be Class A biosolids until the next monitoring period. Monitoring continues until viruses and/or helminth ova in the untreated material exceed Class A criteria. Then, the treated biosolids are analyzed to see if these pathogens meet Class A criteria. If they do, the treated biosolids meet Class A criteria as long as the treatment process is operated under the treatment conditions that successfully reduced the pathogens. Then, virus and helminth monitoring is not required.

4. *Unknown Processes.* This alternative applies to processes (such as lagoon storage, air drying, or cake storage) where kill mechanisms are not well understood or there is a lack of control over kill mechanisms. Virus and helminth monitoring are required for each batch of product.

5. *Processes to Further Reduce Pathogens (PFRP).* This alternative provides continuity with 40 CFR Part 257 regulations, which listed the following processes as PFRPs:
   - *Composting.* Time and temperature requirements depend on the type of compost system being operated (within-vessel, static aerated pile, or windrow).
   - *Heat Drying.* Residual moisture and biosolids temperature or wet bulb temperature of the exit gas are specified.
   - *Heat Treatment.* Liquid biosolids temperature and contact time are specified.

– *Beta-ray Irradiation.* Radiation doses are specified.

– *Gamma-ray Irradiation.* Radiation doses are specified.

– *Pasteurization.* Contact time and temperature are specified.

Viruses and viable helminth ova are assumed to satisfy Class A criteria in the biosolids treated as specified and their monitoring is not required.

6. *Process Equivalent to a PFRP.* Alternative 6 allows new processes to be determined equivalent to a PFRP. U.S. EPA's PEC (Pathogen Equivalency Committee) provides guidance and recommendation on equivalency to the permitting authority. To be equivalent, a process must consistently reduce pathogens to levels achieved by the listed PFRPs.

While there is no current pressure or cost advantage for the WRF to upgrade to a Class A product, it is possible that conditions could change to make it more desirable. The probable driver would be local or statewide initiatives that would severely restrict or ban application of Class B biosolids. This sort of regulation has been implemented in a few areas around the country. As noted above, however, there are no indications at this point of any impetus in Oregon for such a condition. Even if one were to begin forming in the near future, it would take a number of years for development and implementation.

Meanwhile, the technologies of most of the leading Class A processes are generally poorly developed. That is especially true of the processes that appear to be relatively low in cost. The development of Class A technologies is relatively rapid at this point. By waiting as long as possible to commit to a technology, the City is likely to gain the benefit from continued research and development activities that will result in a better system at a lower cost.

6.4 Process Alternatives

The potential process options for achieving a Class A product at the WRF can be broken down into four major categories:

1. Low-tech air drying (existing system).
2. Post-processing that produces a dry soil-like material that is typically distributed to the public.
3. Advanced digestion processes that provide Class A pathogen levels, and from which the product is aesthetically similar to the existing Class B product.
4. Pre-digestion pasteurization, which also produce material similar in character to the current product.

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. Therefore, it would be very difficult to develop an adequately sized market for either of these options.

In addition to the production of a less desirable product, both the advanced digestion and pre-digestion pasteurization process have issues that make them less attractive for the WRF. Recent studies have indicated potential pathogen regrowth issues with advanced digestion processing, which has raised concern over its long-term viability as a Class A option. Among the two available pre-pasteurization processes, the Cambi alternative is generally only cost effective for very large municipalities. Both the Cambi and Eco-Therm systems have been plagued by mechanical and maintenance issues, due the complex nature of treating sludge at high temperatures and pressures.

Given these considerations, the following Class A evaluation was limited to air drying and post-digestion processing.

6.4.1 <u>Low-Tech Air Drying</u>

This approach involves using the provisions of Alternative 3 (*Treatment by Other Processes*) described above to meet the pathogen standards. The literature documents facilities that employ extended air drying processes, such as now used at the WRF, and have been shown through testing to generate a final product that meets the requirements. The Water Environment Research Foundation (WERF) recently published a report on these and other low-tech, low-cost systems.[1]

The study found that while it is possible to accomplish this, the required conditions are not well established and performance in operating systems is inconsistent. The following is paraphrased from the WERF report:

“This project’s literature review suggests that Class A biosolids might be produced by air drying or cake storage when the following requirements are satisfied:

- Providing adequate sludge pretreatment is satisfied by preceding either process with aerobic or anaerobic digestion. When mesophilic anaerobic digestion is used, SRTs of at least 15 days are preferred.
- Providing requisite helminth kill may be satisfied by desiccation, time, and temperature.

Desiccation-oriented air drying systems. It is necessary to reduce biosolids moisture contents to below 5% to achieve complete inactivation of helminth ova by desiccation. Operators of most U.S. air drying plants will be unable to dry their biosolids to moisture levels under 5% because of rainfall or humidity constraints. Operators in hot, arid regions (e.g., the southwestern U.S.) may be the exception. Even those who can achieve such low moisture levels may be unwilling to do so because of dusting problems. Drying time and drying

[1] “Producing Class A Biosolids with Low-Cost, Low-Technology Treatment Processes” Water Environment Research Foundation Publication 95-REM-2, 2004.

temperature still play roles in desiccation-oriented drying systems. However, time and temperature guidance cannot be given for these systems at this time.

Time- and temperature-dependent systems. Air drying systems that do not rely on desiccation (the great majority) and cake storage systems must provide processing times long enough and operating temperatures high enough to ensure the requisite destruction of helminth ova. These air drying or cake storage systems should be operated for at least 250 days in locations with warm summers and mild winters and at least 350 days in locations with warm summers and cold winters. A summer should be included in the operating period. Pile or windrow moisture content should remain above approximately 40% for most of the storage or drying periods to promote continued biological activity. Windrows should be turned to control the windrow moisture content and temperature.

- Meeting VAR (vector attraction reduction) objectives can be satisfied through VAR Option 7 for desiccation-based air drying systems (stabilized biosolids with moisture content <25% satisfy Option 7 as long as they are not rewetted). For systems that do not dry to low moisture contents, VAR objectives could be satisfied within the time frames necessary to satisfy helminth kill requirements (250 to 350 days) through compliance with Options 1, 2, 3, or 4 of the VAR regulations. The pile or windrow should remain moist enough (>40% moisture) for most of this period to promote continued biological activity.

- Preventing bacterial regrowth may be problematic for desiccation-based air drying systems. If drying has been rapid and insufficient organic matter has been destroyed, regrowth may occur if the biosolids are rewetted. Systems that rely primarily on time and temperature to achieve the requisite pathogen kill may experience fewer regrowth problems. They will be operated long enough (250 to 350 days) that residual organic matter should be insufficient to support bacterial regrowth.

- Ensuring uniform treatment can be achieved in windrow systems by periodically turning the sludge. Turning also promotes autoheating, which encourages drying."

These findings suggest that performance is highly site-specific, so the current WRF drying system may or may not meet the pathogen standards. The only way to know is through testing. If it is found that standards are met, the material can be classified as Class A, with the resulting benefits. It will be necessary to continue to test the product to ensure that each batch meets the standards, however, before distribution. Because these tests are relatively expensive and take time to get results, this may or may not be worth the effort at this point.

It is possible to petition the EPA Pathogen Equivalency Committee for certification of an established process under prescribed conditions, which would then remove the testing requirement. This process, however, is very rigorous and should be considered only after demonstrating through a long period of testing that the process is effective and reliable, and that the costs of the petition process justify the benefits.

6.4.2 Post-Processing Alternatives

These alternatives are add-on processes intended for use with the existing anaerobic digestion system. There are several types of processes that can be considered for a facility of this size, including composting, advanced alkaline stabilization, and drying. All three processes are applied on dewatered biosolids.

6.4.2.1 Composting

Composting with biosolids is typically achieved by mixing the dewatered biosolids with a bulking agent such as bark, sawdust, or processed yard debris. The process can be done using either open or confined systems. The open style is typically accomplished using aerated static pile composting. Several proprietary confined systems are in use around the country. They are generally more mechanically intensive and occupy somewhat less space than aerated static pile systems.

While composting processes have received a lot of attention over the last twenty years, few have been implemented and even fewer have been successful. This is particularly true in the Northwest. The City of Portland shut down their mechanical composting facility a few years ago because of very high operation and maintenance costs relative to product revenues. The City of Newberg continues to operate their mechanical composter with some success, but it is of a smaller scale than what would be required at the WRF and has had a history of mechanical problems. It is also the only stabilization process available in the facility. The Eugene Biosolids Management Facility processes about 10 percent of its production through a low-tech aerated static pile composting system, using ground yard debris for the bulking agent. The City of Grants Pass developed a composting program within the past couple years, and reports that they are generally satisfied with the approach.

The economics of composting have been impacted over the past few years by the tightening market for bulking agent materials. It has been found that revenues from product sales cover only a small fraction of the costs of production. In addition, many installations are plagued by odor generation issues. This is more of an issue with facilities that are near populated areas.

For an operation at the WRF, the following assumptions are made:

1. Extended aerated static piles on existing paved drying bed area, using positive aeration.
2. Detention time of 28 days, with pile depth of 8 feet.
3. Aerated curing time of 28 days, with pile depth of 10 feet.
4. Sawdust or wood shavings as bulking agent at 55% solids; no product screening was assumed in the analysis, but may be required for some markets.
5. Partially dried biosolids feed, at 30-40% solids (higher solids are possible, but not beneficial to composting process; lower solids would require greater amounts of bulking material).

6. Bulking agent added at 2:1 ratio by volume to obtain required porosity.
7. Operation by City employees; seven days/week.
8. Provide uncovered bulking material storage, with 60 operating days capacity.
9. Use of sawdust or wood chips at $10/CY.
10. Revenue from product sale of $12/CY.
11. Construct aerated floor system for composting and curing areas.
12. Uncovered product storage for 120 days (existing covered area can also be used).

Table 9 lists a summary of the design criteria, facilities requirements, and capital costs based on composting of 100% of biosolids production. The estimated site area is based on year 2030 projected solids production rates. The estimate assumes use of existing paved areas in the drying beds. This is reasonable since the composting process provides storage and drying, and fully dried biosolids are not needed for initiating the process. The area for the year 2030 production rate would occupy almost two of the existing eight drying beds.

Capital costs include a front-end loader, material mixer, and aeration equipment. These are amortized at 10 years, the estimated useful life.

This analysis shows that the composting process would have a net cost of about $160,000 per year. The economics are highly dependent on costs for bulking material and for the revenue for the finished product. The values shown are typical planning numbers, and represent a $2/CY difference in the cost of bulking material and the price received for the product. These values need to be verified with a local study before embarking on a formal program. This would include the reliable availability of suitable bulking material.

Table 9	Design Criteria and Cost Summary for Composting System Water Reclamation Facility Plan City of Bend	
Parameter	**Units**	**Quantity**
Biosolids processed [1]	DT/year	3,400
Site area	Acres	~ 1.1
Bulking material quantity	CY/year	27,500
Capital Costs		
Site improvements	$	50,000
Equipment	$	500,000
Contingency & engineering	$	200,000
Total	$	750,000
O&M Costs		
Labor	$/yr	150,000
Materials, fuel, power	$/yr	32,000
Bulking material [2]	$/yr	212,000
Total	$/yr	394,000
Amortized capital costs (6%, 10 yrs)	$/yr	100,000
Total annual cost	$/yr	494,000
Product volume	CY/year	27,600
Product sales revenue[3]	$/yr	331,000

Notes:

1. Based on year 2020 average production rates.
2. Estimated at $10/CY.
3. Estimated at $12/CY.

6.4.2.2 Advanced Alkaline Stabilization

Advanced alkaline stabilization processes involve the addition of alkaline materials (usually lime, sometimes amended with cement kiln dust or other materials) to achieve a high pH. This is done along with further processing to reach elevated temperatures, certain levels of product dryness, or a combination of the two. Representative proprietary processes include the N-Viro Soil system and RDP's EnVessel Pasteurization. These processes can be applied either to digested or undigested sludge. Both of these processes have been applied in a number of large-scale facilities throughout the country, and are considered well-established technologies.

The EnVessel Pasteurization system was selected as being representative of this technology. The system consists of a lime feed system, paddle mixer, and heated flow-through reactor that holds the treated material at the requisite temperature and time to meet Class A standards. The WRF would require a system with a capacity of about two dry tons/hour. Based on analyses for other facilities in this size range, the capital cost for this system would be approximately $3 to $5 million. Operating costs are on the order of $150-200 per dry ton of feed, or $500-700,000 per year in 2020.

The product is soil-like and readily marketable, especially after a period of air drying. However, because of the generally high pH soils in the region, there would not be expected to be a large market for lime-amended biosolids. It is not likely that a revenue stream could be generated.

6.4.3 Drying

Drying processes use heat to evaporate moisture from the solids using either direct or indirect contact with hot gases. The gases are usually produced by burning natural gas or digester gas. The high temperatures and low moisture content kills pathogens and significantly reduces the volume of material. The product is generally in a pellet form, and can be distributed to the public or through wholesale distributors as soil amendment.

Drying systems are mechanically complex. Handling of exhaust gases is a concern, especially with direct contact systems due to particulates and volatile organic compounds. These can be handled using appropriate scrubbing systems. Another risk issue is fires and explosions; these are largely mitigated through design safeguards.

There are a number of facilities around the country, and a growing number in the Pacific Northwest, concentrated in western Washington. This is considered a well-established technology.

For the WRF, a representative dryer facility would include a direct drying system such as the Andritz drum dryer. The dryer could be fed either directly from the belt filter presses, which would eliminate a handling step; or from drying beds, which would provide a much lower water content, reduced operating costs, and inherent storage. For this analysis, it is assumed that partially dried material from the drying beds is fed at 30% solids.

There are also many options regarding the dryer throughput capacity and hours of operation. Greater capacity means higher installation costs, but lower operating hours and reduced labor costs. For the purposes of providing an example configuration and cost, an Andritz DDS20 was chosen. The resulting estimated costs and operating conditions are shown in Table 10. These values assume all fuel requirements are met by purchased natural gas at $1.00/therm. Some of this could be offset by use of digester gas, with some capital investment. A gas utilization analysis would be needed to identify the reliable availability of excess gas.

Table 10	Design Criteria and Cost Summary for Drying System Water Reclamation Facility Plan City of Bend	
Parameter	**Units**	**Quantity**
2030 Maximum month solids	Dry tons/day	13.1
Assumed cake solids	%	30
Drying operating period (2030 MM)	Hours/week	90
Water evaporation rate	Lb H_2O/hour	4,500
Installed cost for dryer system	$	4,000,000
O&M Costs [1]		
Labor and maintenance	$/yr	140,000
Power	$/yr	60,000
Fuel [2]	$/yr	210,000
Total	$/yr	410,000
Amortized capital costs (6%, 20 yrs)	$/yr	336,000
Total annual cost	$/yr	746,000
Product volume [1]	Tons/year	3,600

Notes:
1. Based on mid-period loadings.
2. Assuming using purchased natural gas; could be partially offset with digester gas.

6.5 Class A Alternatives Comparison

Table 11 presents a summary of the non-economic evaluation of the technologies listed above. At this point, several of the promising technologies have yet to be firmly established in terms of long-term performance on a large scale.

Table 11	Summary of Class A Biosolids Technologies Water Reclamation Facility Plan City of Bend		
	Product Type	**Current Status**	**Viability for the WRF**
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 U.S. Heat exchanger problems.	Poor
ECO-Therm	Wet cake	New technology; not well established.	Poor

For reference purposes, preliminary capital costs were prepared for the potentially applicable (post-digestion) processes for the WRF. These are presented in Table 12. These costs are intended to provide an order of magnitude value. Actual installed costs will depend on a number of site-specific details such as hours/day of operation, amount of product storage space required, and cost of land (if needed).

At this point, the best candidates appear to be the low-technology post-processing systems. Clearly, the current air-drying system is the most attractive if product quality can be proven. Beyond that, composting appears to be potentially viable if a reliable and economical source of bulking material can be identified.

Table 12	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

7.0 SUMMARY AND CONCLUSIONS

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 and waste activated sludges 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.

A detailed evaluation of the Cannibal^{TM} solids reduction system was not included in this TM. This system is not suitable for primary sludge and has only been proven effective for small installations with secondary treatment processes operating at longer solids retention times. While it could reduce operating cost by lowering the WAS production, it is generally cost-competitive when it also reduces digester expansion and other capital improvements. Therefore, this system should be considered in 2016, when gravity thickeners are needed to defer the next digester expansion and more operational experience has been gained at facilities similar to Bend.

Appendix A

GRAVITY THICKENER PRESENT WORTH ANALYSIS

Appendix A: Primary Thickening Alternatives Cost Summaries

	2007	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Alternative 1 - Primary clarifier thickening														
1. Add fourth digester when needed (2016)														
Capital	PRES WORTH													
4th digester	$ 3,065,667	$ 4,000,000												
Residual digester value	$ (748,890)													
O&M														
Digester O&M	$ 274,168	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000	$ 25,000
TOTAL PW:	**$ 2,590,945**													
Alternative 2 - Gravity Thickener														
1. Construct gravity thickener when current digester capacity reached (2016)														
2. Construct 4th digester when needed (2027)														
Capital														
4th digester	$ 2,214,703												$ 4,000,000	
Residual digester value	$ (1,896,547)													
Build grav. thickener & PS	$ 1,422,484	$ 1,700,000												
O&M														
Digester	$ 97,039													$ 50,000
Gravity thickeners	$ 252,235	$ 23,000	$ 23,000	$ 23,000	$ 23,000	$ 23,000	$ 23,000	$ 23,000	$ 23,000	$ 23,000	$ 23,000	$ 23,000	$ 23,000	$ 23,000
TOTAL PW:	**$ 2,089,913**													

City of Bend

Water Reclamation Facilities Plan

TECHNICAL MEMORANDUM NO. 8
HYDRAULIC CAPACITY

April 2008

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CITY OF BEND

WATER RECLAMATION FACILITIES PLAN

**TECHNICAL MEMORANDUM
NO. 8**

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1.0 INTRODUCTION

This memorandum reviews the hydraulic capacity of Bend's Water Reclamation Facility. The analysis was performed using Visual Hydraulics 2.1 (Innovative Hydraulics, Inc). The hydraulic evaluation was developed using projected 2030 flows developed in Technical Memorandum No. 1, as summarized below:

- Average day maximum monthly flow (ADMMF): 11.9 mgd
- Peak daily flow (PDF): 13.6 mgd
- Peak Hourly Flow (PHF): 21.4 mgd
- Peak Wet Weather Flow (PWWF): 29.1 mgd

The original plant was designed in 1978 to treat an average daily flow of 6.0 mgd and a peak flow of 12 mgd. Several previous projects were implemented to increase the capacity and treatment efficiency of various processes, including addition of a third aeration basin and secondary clarifier, and modification of the primary effluent flow splitting.

The most significant change to the existing plant configuration will be the addition of a new Headworks facility, which is now under construction. This facility will ultimately be capable of processing a 45 mgd peak wet weather flow with one screen out of service. The remainder of the facilities and their interlinked major process piping will be upgraded as capacity requirements increase.

2.0 HYDRAULICS DISCUSSION

The hydraulic profile for the 2030 design year is included in Appendix A, and is based upon the liquid stream recommendations previously outlined in *Liquid Process Assessment Technical Memorandum No. 4.* The liquid stream improvements are noted on the drawing. The hydraulic profile should be used throughout the planning period to develop final recommendations for hydraulic improvements related to each process expansion. The following discussion identifies critical hydraulic bottlenecks and options to alleviate them.

3.0 PRELIMINARY TREATMENT

The existing headworks currently limits the plant's capacity. Originally, the headworks was equipped with one ¾-inch spacing mechanical bar screen and a manually raked bar rack for redundancy. The mechanical screen was replaced in the 1980's with a ¼-inch spacing mechanical bar screen to improve solids capture. In the late 1990's a second mechanical screen was added with a 1/8-inch perforated plate screen to further increase solids capture and increase capacity. The existing headworks also includes aerated grit removal.

During the December 2005 storm event, the existing headworks was overwhelmed. It is estimated that plant flows reached approximately 20 mgd for a short period of time. As a result of this event and further capacity studies, a new headworks replacement project was undertaken by the City. The new headworks includes three perforated plate band screens and magnetic flow measurement of the screened effluent.

To accommodate the possibility of membrane treatment in the future, the new facility was designed to pass 30 mgd with screens fitted with 3 mm perforated plates and one screen out of service. Initially the screens will have 6 mm perforated plates and are capable of processing approximately 15 mgd each. Three of the four screens will be installed in the initial project, resulting in a firm capacity of 30 mgd with two screens on-line. With the fourth screen installed, firm capacity will increase to 45 mgd with the 6 mm plates. This will accommodate all peak flows for the foreseeable future.

Grit removal was not included in the new headworks project, largely due to the limited amount of grit accumulation that has historically occurred. Eliminating grit removal significantly increases the available head between the preliminary and primary treatment process. If grit becomes and issue in the future, primary sludge degritting is recommended to preserve the head gained by eliminating full-stream grit removal.

Flow will be routed to the new headworks via a new diversion box on the incoming 42-inch plant interceptor. This structure has provisions to add an additional 42-inch interceptor anticipating that the planned Southeast Interceptor will be constructed. Flow leaving the new headworks will be directed via a 30-inch line to the existing primary clarifiers. Provisions have been included to direct flow to the west of the building anticipating future primary clarifiers. After completion of the new headworks, no hydraulic bottlenecks will exist in the preliminary treatment process.

4.0 PRIMARY TREATMENT

Primary treatment at the plant consists of two 65-foot diameter primary clarifiers equipped with V-notch weirs. Flow splitting to the clarifiers is accomplished with a flow splitting structure adjacent to the primary sludge pump station. The flow splitting structure is built for easy addition of a third primary clarifier. Construction of a fourth clarifier will require significant modification of the flow splitting structure. The location of the fourth clarifier should be reviewed carefully and could potentially be located to the west of the proposed location and built in conjunction with a new process gallery and gravity thickeners as part of the Predesign effort. The only hydraulic issues related to the primary clarifiers are in the downstream control valves used to split flow among the aeration basins, as described below.

5.0 AERATION BASINS

The original plant consisted of two aeration basins with a flow splitting structure upstream of the basins to direct flow using overflow weirs. In 2000, a third basin was constructed and the flow splitting structure was replaced with a flow splitting gallery consisting of flow control valves and magnetic flow meters. RAS from the secondary clarifiers is similarly split to each basin. Currently, primary effluent feed is conveyed to the head of each each basin through 18-inch pipes. An additional 12-inch pipe is included to direct flow around the anoxic selectors in a step feed configuration to assist with peak flows.

Based on the proposed process configuration in the Liquids Technical Memorandum, the existing 12-inch pipes do not have adequate hydraulic capacity to match the peak wet weather process capacity. Increasing hydraulic capacity can be achieved by upsizing the existing 12-inch pipes or installing parallel pipes. Both will provide similar hydraulic capacity, but the parallel pipe approach was assumed in TM 4 because it is easier to construct and will provide a more accurate flow split over the wide range of flows.

The existing aeration basins have a series of baffle walls in both the anoxic zones and the aerobic zones. At peak flow, the head loss through the aeration basins is approximately 2.7 feet. This configuration was designed to promote scum removal by ensuring that scum does not accumulate in upstream areas. Scum is conveyed to the secondary clarifiers where it can be removed effectively. While overflows are necessary, provisions could be added in the form of downward activating gates located at the bottom of the baffle walls to reduce the head loss through the basins and preserve head for use in flow splitting the primary effluent.

Mixed liquor is collected in an effluent launder via a V-notch weir along the width of the basin. With the addition of the fourth aeration basin and the associated two additional secondary clarifiers, designers should evaluate the feasibility of adding separate mixed liquor conveyance to the new secondary clarifiers.

6.0 SECONDARY CLARIFIERS

The original plant included two 80-foot diameter secondary clarifiers. A third clarifier was added in 1999 to provide additional capacity. Flow splitting to the three clarifiers is accomplished with a flow splitting structure fitted with overflow weirs.

With the addition of two more secondary clarifiers to accommodate 2030 flows, consideration should be given to additional mixed liquor conveyance and flow splitting. The existing flow splitting structure is configured for three clarifiers and is not well suited for expansion. Options for additional flow splitting include a separate flow splitting structure similar to the existing unit, or more automated flow splitting similar to the primary effluent flow splitting method.

Secondary effluent is collected in a 24-inch line for each unit and combined into a 30-inch line feeding the chlorine contact basin. Hydraulic modeling indicates that the 30-inch line is a significant bottleneck for future expansion. As shown in Figure 1, the existing hydraulic capacity from the secondary clarifiers to the CCBs is approximately 15 mgd if the water level were allowed to rise to the top of the wall. Typically, a minimum of 1-foot of freeboard is assumed in establishing hydraulic capacity, which reduces the current capacity to approximately 14 mgd. Increasing the existing secondary effluent flow elements (FEs) will increase the hydraulic capacity by approximately 1 mgd. A more significant hydraulic bottleneck occurs in the existing contact basins, as described below. As shown in Figure 1, addressing the hydraulic bottleneck in the plant water pump station and upsizing the FEs increases the hydraulic capacity to approximately 17.5 mgd. These improvements are necessary to increase the hydraulic capacity so that it does not limit process capacity with the existing secondary clarifiers. Additional hydraulic capacity will be provided by constructing the new secondary clarifiers and a parallel secondary effluent pipe to convey flows from the additional clarifiers.

7.0 CHLORINE CONTACT BASINS

The original plant included two parallel chlorine contact basins. The plant water pump station is located at the head of the basins, and flow is directed up through a mixing chamber and through a series of channels and baffles. Some time ago, the plant abandoned the vertical shaft mixer and installed a high-energy chlorine injection mixer at the inlet of the 30-inch secondary effluent line. Chlorinated effluent still passes through the mixing chamber on its way to the plant water pump station. It is then passed through a 36-inch diameter orifice and into the basin feed launder. Isolation is accomplished using sluice gates.

The configuration of the feed to the chlorine contact basin introduces a significant amount of head loss under peak flow conditions. This analysis assumes that a second 36-inch diameter orifice is constructed in the plant water pump station to convey water to the chlorine contact basins. With that addition, head loss between the secondary effluent inlet and the head of the chlorine contact basin is slightly over one foot. As previously discussed, this will significantly increase the hydraulic capacity between the clarifiers and contact basins. Construction of this additional inlet will require some form of temporary bypass.

8.0 EFFLUENT

Effluent from the chlorine contact basin is conveyed to the filter pump station via a 42-inch line. During the summer irrigation season, a portion of the effluent is diverted to the effluent filters for reuse at Pronghorn Resort. The remaining portion of the effluent continues out to the infiltration ponds. The 42-inch line has adequate capacity for the study period.

9.0 RECOMMENDATIONS

Significant items that are recommended to 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

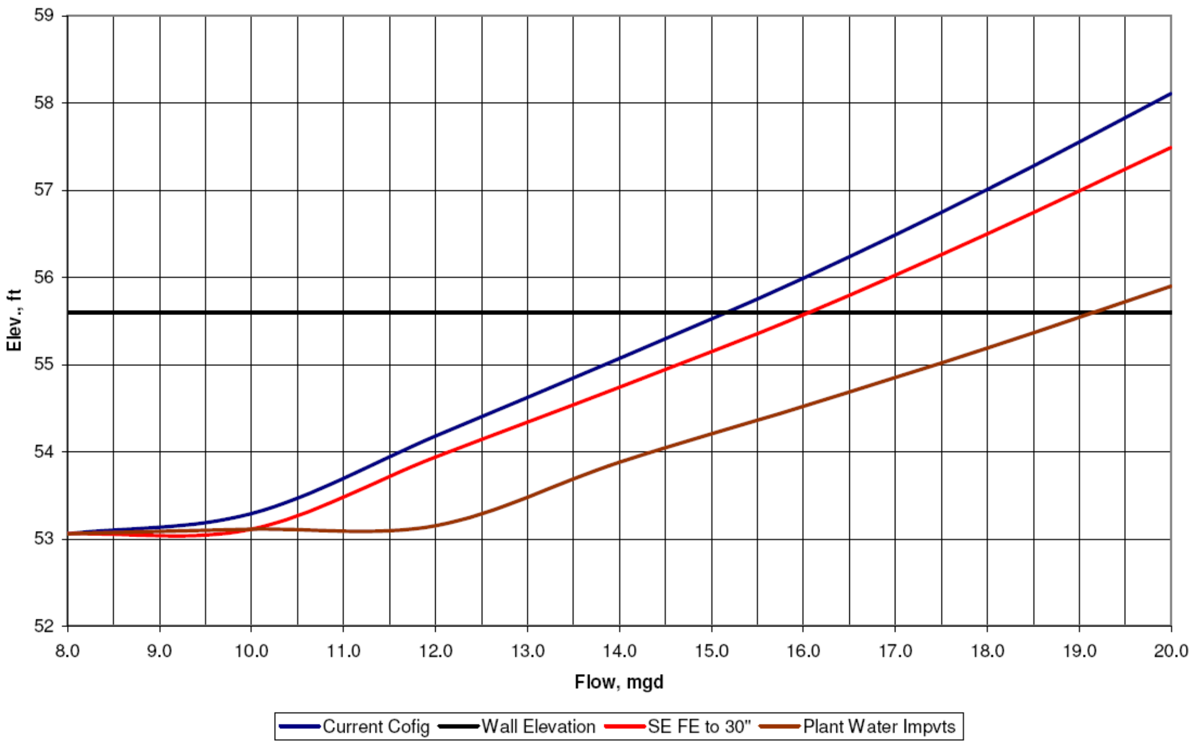


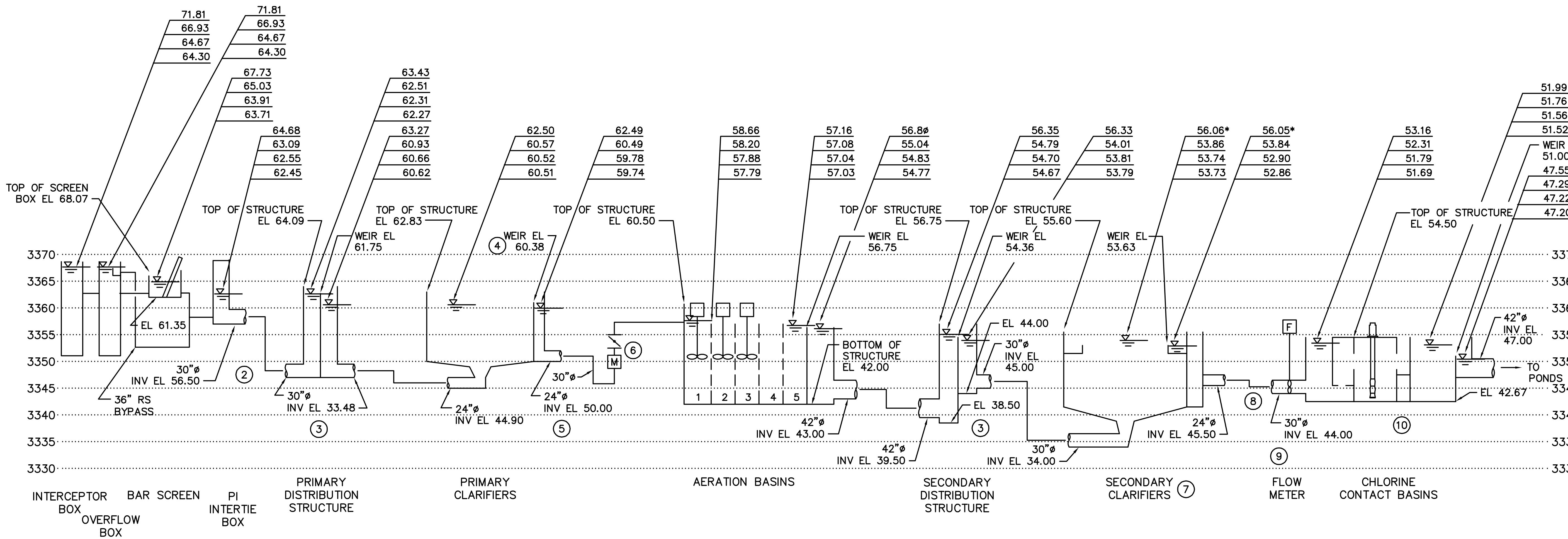
Figure 1 Secondary Effluent Capacity

- 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.

Appendix A

HYDRAULIC PROFILE



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.

APPENDIX A
HYDRAULIC PROFILE
WATER RECLAMATION FACILITIES PLAN
CITY OF BEND

VISION ENGINEERING

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City of Bend

Water Reclamation Facilities Plan

TECHNICAL MEMORANDUM NO. 9
NON-PROCESS FACILITIES EVALUATION

April 2008

Michael Willis Architects

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CITY OF BEND
WATER RECLAMATION FACILITY PLAN

TECHNICAL MEMORANDUM
NO. 9

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NON-PROCESS FACILITIES EVALUATION

1.0 INTRODUCTION

This Technical Memorandum (TM) presents alternatives and recommended plans for non-process facilities to support the Operations, Laboratory, and Maintenance activities through the planning period. Currently, these activities are performed in six buildings and supplemented by adjacent parking or outdoor storage areas. The site plan of these non-process support facilities is shown in Figure 1.

The evaluation of non-process improvements includes a condition and needs assessment to determine the best use of the existing facilities and the requirements for expansion. The TM also includes a description of the architectural and building code criteria for the recommended approach.

2.0 BUILDING CODES

As of April 2007, Oregon adopted the 2006 International Building Code (IBC). Per discussion with the local building official, this code has also been adopted by the county. This model with amendments specific to Oregon, makes up the 2007 Oregon Structural Specialty Code (OSSC). Previous buildings at the Bend WRF were constructed under the Universal Building Code (UBC). All new construction and renovation work will be done according to the 2007 OSSC. Other codes specific to the renovation and new construction of the Bend WRF include the 2004 NFPA 45 fire code, as well as specific codes related to lab design found in the Laboratory Criteria Memo. The following assesses existing buildings at the WRF assuming preferred Option is selected for construction.

The administrative portions of the buildings are classified under **B occupancy**; the business group. According to the 2007 OSSC, B occupancy “includes, among others, the use of a building or structure, or a portion thereof, for office, professional, or service-type transactions”. These areas will use **V-B construction type;** wood frame construction with non-rated walls. The maximum floor area, with sprinklers and smoke detection throughout, is 27,000 sf, and the maximum height is 40’. The administrative portion of the Operations Building has an occupancy load of 67. The training building has an occupancy load of 23. Both buildings require two exits. Ventilation recommended is 0.9 air changes per hour according to ASHREA 62.1- 2004 *Ventilation For Acceptable Indoor Air Quality*.

The existing maintenance building is classified as **S-2 occupancy,** for storage of low hazard equipment, in the bay areas, and **F-2 occupancy**, for factory industrial low hazard equipment, in the electrical work space. Both of these are **II-B construction.** The offices and their support areas are considered **B occupancy** with **V-B construction**. There is no separation requirement between these areas. The proposed new maintenance building will be classified as **F-1 occupancy**, for factory industrial equipment with moderate hazard, in the fabrication shop and flammable storage area, and **F-2 occupancy** in the rest of the building. Both are made up of **II-B construction**. Both allowable square footages are unlimited and the allowable heights are 55'. The existing maintenance building has an occupancy load of 14 and the proposed maintenance building has an occupancy load of 26. Two exits are required for both spaces.

The future laboratory areas of the Bend WRF are classified as **B occupancy** with **II-B construction,** building construction of non-combustible materials with non-rated walls. One hour separation from non-laboratory areas is recommended as a response to non-combustible construction between laboratory and non-laboratory areas per NFPA 45, Table 3-1 (a). The maximum floor area is 23,000 sf with a maximum height of 55'. The laboratory has an occupancy load of 34 and requires 2 exits. The ventilation requirement for the proposed lab addition is 6 air changes per hour, however 8-12 air changes per hour is recommended. A summary of the building code classifications for all non-process buildings is provided in Appendix C.

3.0 CONDITION ASSESSMENT

A condition assessment was performed for each existing non-process areas to determine if the existing facilities are capable of meeting their intended function through the existing planning period. This assessment includes an evaluation of both the physical condition and utility of the major non-process areas, and is primarily based upon on-site inspections and feedback from City staff.

3.1 Existing Operations Building

The existing Operations Building was constructed in 1977 with an addition in 2001. As shown in Figure 2, the Operations Building currently houses: a reception area; the WRF Plant Manager's office; restrooms/showers/locker rooms for both men and women; the control room/break room; maintenance spaces (i.e. janitor's closet and laundry); water quality laboratory (see Section 2.2), and an electrical room. Double-door air locks are located at all building entrances.

Figure 1 **Existing Site Plan**

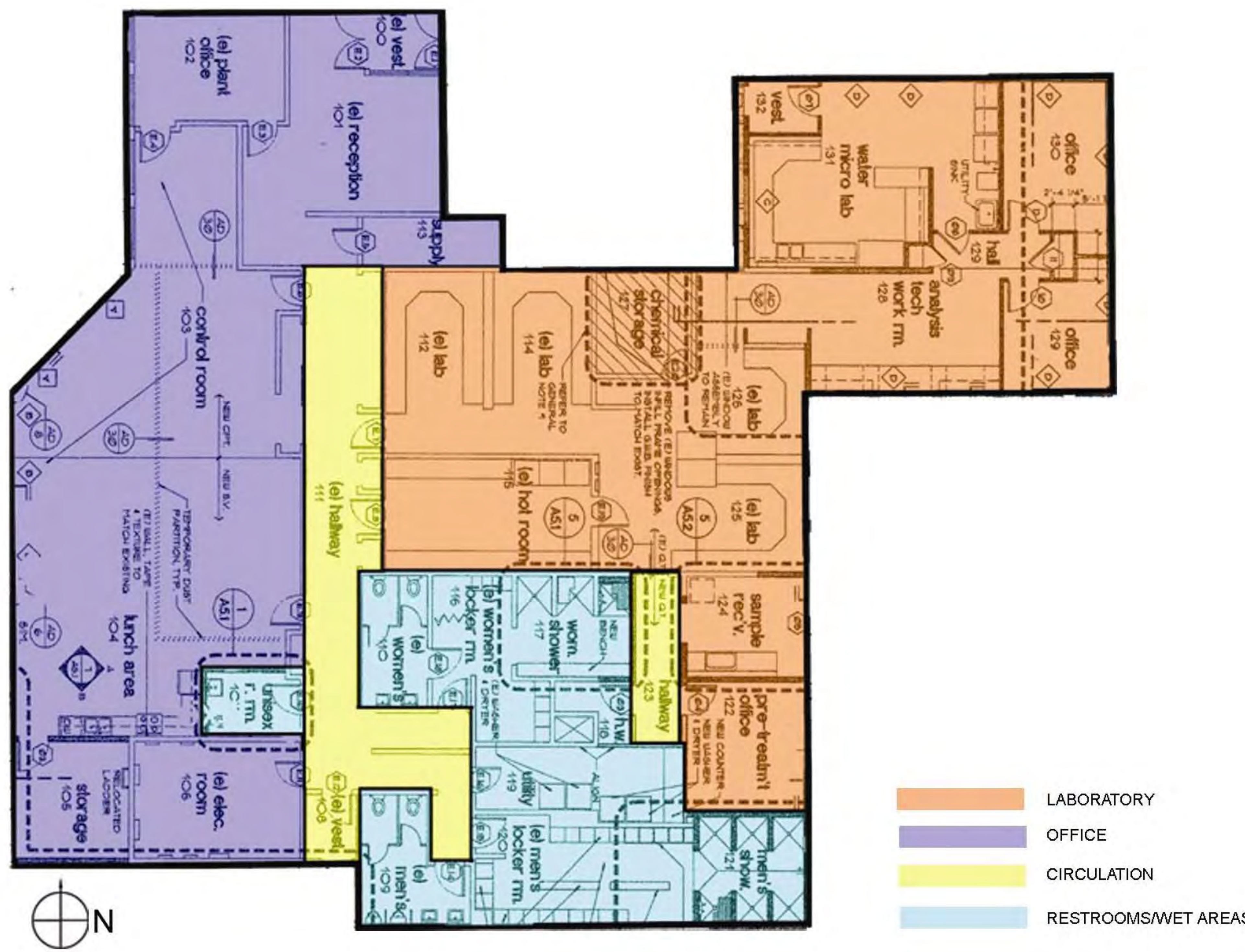

Figure 2 **Existing Operations Building**

The Operations Building in its present condition will not be sufficient for the same occupants through the planning period. The electrical and mechanical systems are a combination of old and new equipment, and are generally inadequate for long-term use. The laboratory mechanical and electrical systems currently serve the entire building. The building's overall layout and circulation pattern are poorly defined, and required life safety exiting is difficult to identify. Although the building has been well-maintained, there is deterioration among the environmental conditions with floor, ceiling, and interior finishes all showing wear and in some cases, failure. Generally, the building is temporarily adequate but not designed to address the future administrative or laboratory needs through our planning horizon. Project plant expansion related to population growth within the Bend area has necessitated a more efficient overall layout to the building and more area devoted specifically to administration.

With only one dedicated office for the plant manager, there is a need for more office space. Some offices have already been added to other buildings within the plant to accommodate growth. The circulation spaces in the building have become clogged due to the storage of equipment. Closets off the main corridor are used for storage, an IT closet, and a plotting/copy machine. The control room shares space with the break room, and often doubles as a conference room. It has enough square footage to be broken up to minimize the many disruptions that occur due to the space being used for more than one purpose. There are currently seven work-spaces in the control room with wall mounted monitors.

Although recently renovated, the locker rooms are insufficient. Both men and women need more space and more lockers, with women comprising about one-fourth of the buildings population. The crew would like to see a separate winter/rain gear space for storage, so as not to track mud into the offices. At this time the on-site maintenance man has his office in a storage room. Also, the existing electrical room is being used for electrical panels, a low-voltage phone system, the UPS, and a building transformer located in the middle of the room. Generally, we would recommend that several functions of this room be separated to address safety and system reliability concerns.

3.2 Existing Laboratory

The existing water quality Laboratory is currently certified for drinking water testing and microbiology. Any new and/or renovated lab space will allow the functions to be performed in accordance with the Oregon Environmental Laboratory Accreditation Program (OELAP) and the National Environmental Laboratory Accreditation Program (NELAP), as listed in the MWA/ Laboratory Design Criteria Memorandum. The following discussion describes the existing lab spaces and notable deficiencies.

Sample Receiving/ Wastewater: This area is specific to receiving samples from the plant. Drinking water samples come in to the lab from the field via another lab entrance. The Lab Manager, calls this area the "pig pen" as it is a catch-all for all sample bottles, totes, coolers, bottled gas storage, a small vacuum compressor and garbage and recycling receptacles.

All samples come in via totes or are hand carried. No samples arrive in rolling carts or will require loading dock facilities. Partial needs for this area are summarized below:

- A dedicated and secure sample receiving area for all samples that come into the lab. The on-site sample chain-of-custody will start within this room, while actual chain-of custody starts where samples are taken. All samples will be logged, refrigerated and stored here before analysis. All other functions currently served in this room will be relocated within dedicated areas of the lab, specific to use.
- Refrigerators: (1) 6'-0" slide across style refrigerator specific for lab use.
- Shelving: 40 linear feet of shelving for totes and coolers.
- Counter space: 10'-0" minimum with acid-resistant work surfaces.
- Large sink: 5'-0" linear minimum, 12" deep with spray attachment. Five-gallon jugs will be cleaned here.
- Located directly to secure exterior vestibule and with direct doorway to main lab space.
- Card key access: Secure entry with card swipe next to access door.

Wet Chemistry Area: Wet chemical testing, pH, BOD, Total Solids, and Volatile Solids testing occur within this space. City staff noted that this space is well configured, but dust, temperature and air quality have always been a problem. Partial needs for the wet chemistry area are described below:

- (1) 8'-0" fume hood;
- (1) glassware washer w/o deionized water, (can be a high-end dishwasher);
- Address bio-solid waste within this area;
- Lab services including vacuum and compressed air.
- Bottled gasses stored in each area and piped for future use.
- (1) slide across (6'-0") refrigerator;
- Flammable storage cabinet; and
- Ventilated chemical storage cabinet under fume hood.

Hood Room: As with many older water quality laboratories, this room is a repository of all things that generate heat and odors, including muffle furnaces, ovens, block-heaters, incubators and other electronic desk top equipment. Although it is unclear whether all of this equipment would stay together in one area in a new laboratory area, this equipment should be placed in an open laboratory and, in most cases, under canopy hoods or individually ducted via snorkel hoods rather than within fume hoods. All other equipment generating large amounts of heat should have separate snorkel hoods or pipes connected to the return HVAC unit, addressing heat demands before they enter the room and minimizing cooling requirement and cost.

Hood room requirements are as follows:

- (2) 6'-0" canopy hoods;
- (2) 6'-0" fume hoods;
- (1) work area for fat, soils and grease;
- 10'-" counter space;
- Sink area;
- Flammable storage cabinet; and
- Ventilated chemical storage cabinet under fume hood.

Operator Lab Area: This area will be included within the new lab layout. The Operator's laboratory will have a separate entry and access to the secure areas of the lab. Although this area could be located within the remodeled administrative building, it is considered more cost effective to include a dedicated Operators Lab area within the new lab.

Partial Needs for the Operator's Laboratory include:

- Operators control testing area, separate from other areas of the laboratory;
- (1) 6'-0" fume hood;
- 20'-0" counter space;
- Sink area;
- Refrigerator, slide across style;
- Flammable storage cabinet; and,
- Ventilated chemical storage cabinet under fume hood.

Metals Module: Currently all metals testing is located within a room in the newer portion of the existing lab. This testing equipment is quite sensitive and should be located within a dedicated area with high quality air and tight temperature control. Surfaces around this equipment should be easily cleaned, with laboratory technicians following stringent protocol for any metals testing. Any contemporary laboratory space containing sensitive equipment testing for trace metals (ICP-MSD) requires environmental separation and airflow must be kept clean (air particulate 1 micron or larger) within this area. Currently, the environment is not sterile and the flooring material is carpet. Therefore, a new dedicated metals testing "module" area with high purity air and hard washable surfaces on the floors and walls is recommended. Additional needs for the metal testing module are as follows:

- (2) technician work areas;
- 20'-0" counter space for sample prep;
- (1) 6'-" Fume Hood w/ sash;
- (1) 8'-0" Laminar Flow Hood for trace metals / acid prep;

- Sample prep area for digestion;
- Gas storage/point of use: Argon, Helium and hydrogen; and,
- Future wall space for point-of-use wall-mounted, ultra-pure distillation unit.

Instrumentation Lab: This area has two instruments on the desktop for nutrient testing, an IC, and an FS 3000. Raw data is also stored in this room, which should also be stored in a central records area. Partial need for the instrumentation lab include:

- Gas Storage: Helium;
- Bench space for instruments and separator area, length, to be confirmed;
- Sample prep area;
- (1) 6'-0" Fume hood with sash;
- Lab sink – 8" deep;

Microbiology Lab: In the current lab configuration, this area is enclosed within a separate room. As discussed with the Lab Manager, and one other lab technician, there is some reluctance to not enclose this area in the future for fear of cross contamination. This area is within the 2001 expansion of the lab and is one of the few areas where the HVAC system seems adequate, but is isolated from the rest of the lab space. Partial needs include a small lab sink; autoclave – snorkel vent of canopy hood; two refrigerators; and an incubator.

Tech Work Area: There are currently three FTE laboratory technicians and the Lab Manager. Along with managerial duties, the Lab Manager also performs required testing and serves as a working supervisor. It is anticipated that one additional FTE/ laboratory technician will be added in two years and roughly six total laboratory technicians will be added in 20 years. Given the scope of this facility planning document, the new laboratory area shall be sized through the year 2030 planning horizon. The Tech Work Area should be designed as an office environment with cubicles or carrels for technicians to fill out reports or enter data, with some of this work space serving as "flex space" for occasional intern usage. With generally less stringent air quality and environmental controls than the adjacent t hard-lab space, it is less costly to build. This area should have a direct view into the laboratory and should remain secure with card key access only from the outside. Lighting and environmental controls shall be consistent with an office environment; however, more air flow will be noticeable in the adjacent laboratory areas due to the additional fume, canopy, and snorkel hoods.

Partial Needs – Tech Area/ Office Environment:

- (6) Technician Work Areas – (4 + 2) carrels or cubicles;
- Dedicated library area, full-height book shelves;
- Xerox, copier and document control area – 6'-0" of counter space; and,
- Quiet room, space for one staff member to have privacy, when needed.

- **Lab Manager's Office:** This room should be approximately 220 square feet with room for the laboratory managers work desk (adjustable height + tilt), two lateral file cabinets, bookshelves, and a small conference table for impromptu meetings with staff. A lockable/secure door and file cabinets are required. Ideally, this room should also have a view into the laboratory.

LIMS System: A Laboratory Information Management System (LIMS) is in place and operational. This system is used to keep records and track samples for chain-of-custody requirements of laboratory certification. Currently, the centralized server and rack system is located in a non-secure closet within the main corridor, outside of the laboratory. For the new laboratory area, we recommend a separate and secure LIMS & IT room be provided within the laboratory or as part of a central, secure communications room shared with Operations. This space shall include the LIMS server, UPS, and should be zoned to allow for fairly tight air temperature requirements.

Deionized Water: The staff would like a central system for deionized water in the new laboratory with separate, wall-mounted, systems for ultra–pure water within areas such as metals analysis. Staff has said that a budget for a smaller, wall-mounted system has already been established.

Uninterrupted Power Supply (UPS): Local UPS units are used for specific desktop PC's and instruments. It was mentioned that there are frequent outages at the plant (mostly in the summer time) and that power is somewhat unreliable. Future back-up power and UPS systems should be coordinated with the general upgrades for the plant and consistent with MWA's laboratory design criteria.

Glassware Cleaning: It has been agreed to have glassware washing within each lab module, compared to a centralized cleaning station or area which would necessitate more space within a dedicated room.

Acid Recovery System: Currently, there is an area for bio-solid waste that cannot be released to the laboratory drain. MWA's laboratory criteria calls for a dedicated acid neutralization system with limestone medium in-line with drainage to a dedicated sump or POTW. Any other acid recovery or bio-solid waste shall be managed in accordance with state disposal criteria.

Bottled Gasses: Bottled/ compressed gasses in bulk (dewars) or smaller vessels shall be brought into specific areas of the laboratory and used where needed. Provisions will be made for code required restraint systems, with piping and manifolds as required for each specific gas type. Bulk storage and storage of spent vessels shall be within an outside, fire-rated room.

Chemical Storage: Although bulk chemicals are kept and distributed from a central chemical storage room, it is recommended that chemicals be brought into the laboratory and distributed to various testing areas and kept in either flammable storage cabinets or ventilated chemical storage cabinets under fume hoods. This scenario for storing and distributing chemicals is generally known as a *point-of-use* chemical storage. Although smaller quantities are within each of these zones, this scenario alleviates the need for a central storage area with bulk chemicals, which often requires a separate fire separation and may drive an “H” or Hazardous Occupancy as defined by the 2007 OSSC (Oregon Structural Specialty Code), the IFC (International fire Code), NFPA 45, and NFPA 30. These codes and standards govern the storage of flammable, combustible and health and safety risks of specific chemical compounds. If necessary, provisions will be made for space on an outside wall to store excess or empty gas cylinders. Given the climate in Bend, this room may need climate control and will most likely require rated or fire proof walls separating it from adjacent spaces.

Locker Rooms: Laboratory staff working with wastewater samples frequently take showers after their shifts and should have access to locker rooms.

Hot Water System: An “on-demand” hot water (electric/propane/methane) or solar (pre-heat, etc.) heating system was requested by City staff. MWA will investigate this strategy for hot water use within the lab as well as within the operations center.

In general, the existing laboratory space is consistent with many other laboratories within this building vintage. Laboratory and plant staff have been creative in using specific areas to accomplish monthly testing, but the general layout and building systems make for inefficient and, often times, unsafe working conditions. Alternatives to provide new laboratory space designed to contemporary codes and standards are evaluated in Section 3.2.

3.3 Existing Training

The existing Training Building is located to the northeast of the Operations Building. The concrete block building was constructed in 2001. As shown in Figure 3, it houses the current training room with storage space, services (i.e. restrooms, janitor closet), the “bull pen”, map room, and three offices. The administrative/office spaces previously used by the Collections Crew are now vacant. The building is in good condition with no current maintenance issues.

3.4 Existing Maintenance Facilities

The existing maintenance facilities include the following structures

- One five-bay concrete building;
- One three-sided pole barn;
- One insulated metal building;
- One residential two car garage.

Each of these structures is evaluated below for its current suitability and long-term utility.

3.4.1 Maintenance Building – Five-bay Concrete and CMU Building

The five-bay building is the only maintenance structure consistent with the concrete and block style of the process facilities at the WRF. The building was originally designed to support maintenance activities in each bay via wide roll-up doors. Maintenance group activities have changed over time and have facilitated the following modifications to the building:

- ADA rest room installation;
- Office space inserted into one bay and roll-up door opening closed with block construction;
- Stick Frame construction storage mezzanine in work bay;
- 2 Exterior roll-up doors removed and openings closed with block construction; and,
- Two work bays converted to office space.

The existing maintenance building is illustrated in Figure 4.

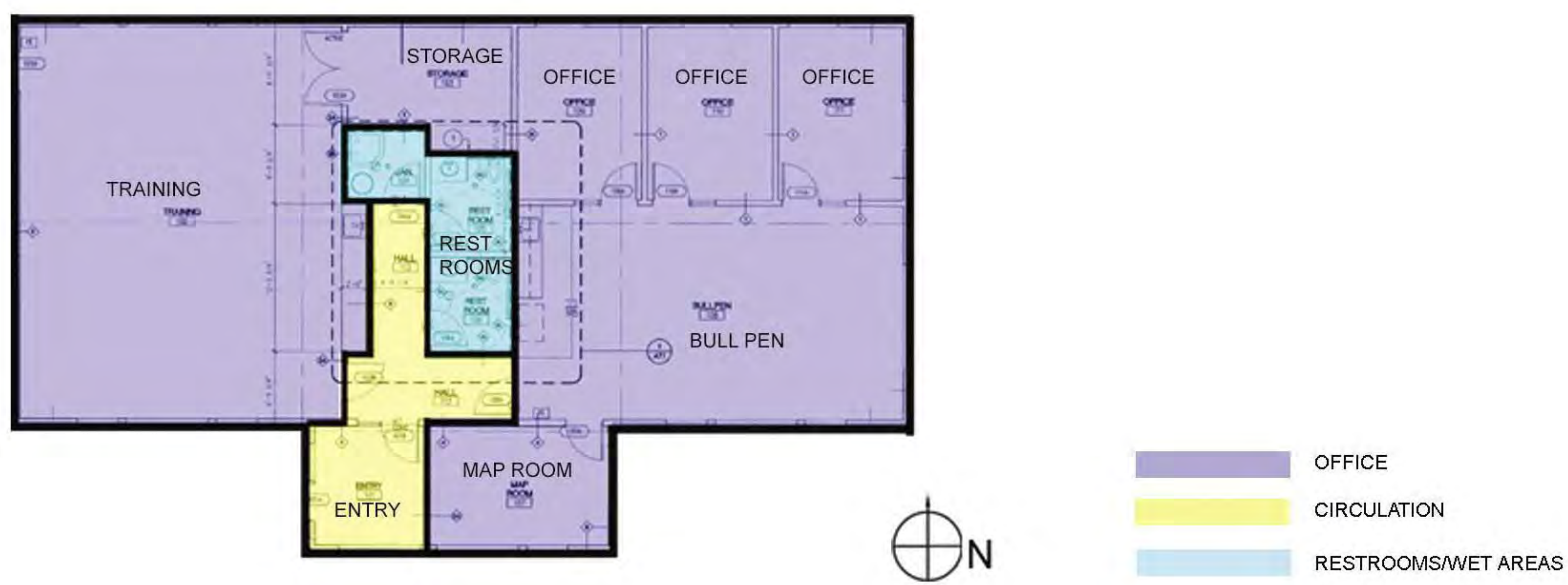

Figure 3 **Existing Training Building**

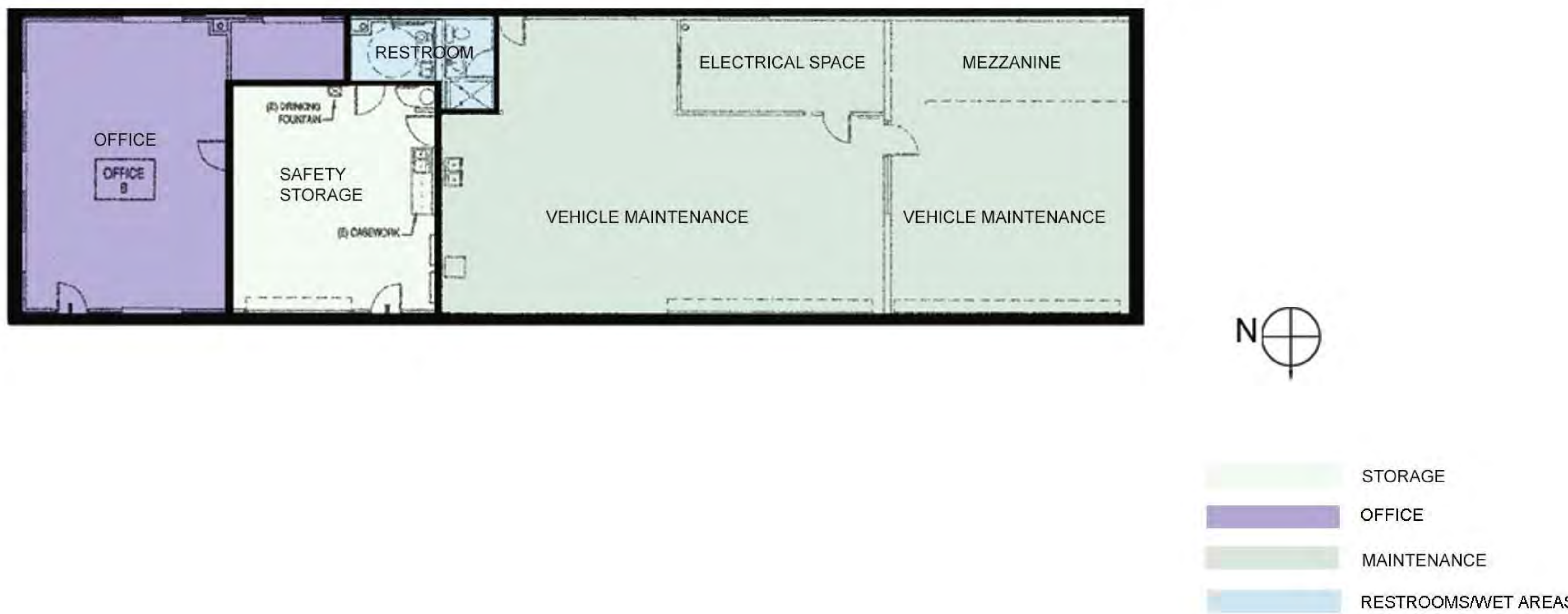

Figure 4 **Existing Maintenance Building**

Although the Maintenance Building was not designed to accommodate office uses, conversion to office is simpler than conversion to intensive servicing spaces such as a lubrication bay. Only one bay of the existing building could be considered 'high bay' space. Clearance is approximately 18'-0" above concrete floor. Office space in this building consists of a windowed end bay with an acoustical tile, dropped ceiling. The space is not designed for specific work desk spaces or lighting for desk tasks. The corral-style office layout with focus on a conference area is preferred by the staff; however it requires much more space per desk than would normally be necessary.

There are currently four staff located in the Maintenance Building. Typically, open office in this style with more than four staff gathered unintentionally becomes noisy and disruptive. This has been experienced in the Administration Building control room/break room. The office space in its current location remains the preferred space for occupied space because of the opportunities for natural light, and could stay this way with additional services provided.

Conversion of work bays into office space has a side-effect: loss of work bays. Three functional work bays remain in the maintenance building. One is encumbered by a small, inadequate electrical repair space. The electrical space is inadequately sized and may have exiting violations under current code. The single high-bay space is impacted by a timber storage mezzanine, which is accessed by a pull-down attic stair. Although organized, the area is low and long and work space is minimal when multiple projects are in progress. These spaces are also expected to provide indoor parking for site electric vehicles.

3.4.2 Pole Barn – Existing

A three-sided, timber pole barn is adjacent to the east side of the maintenance building. This structure has six bays and is used currently as covered storage for large equipment and some smaller items. There is no security for any materials, vehicles, or equipment stored within the pole barn. The sole purpose of the barn is to provide cover for large equipment, such as back-hoes. Although this structure is adequate for current use, long-term use for an unsecured space may be limited. Theft and vandalism are not a current problem. However, regional and local growth will likely result in increased site exposure and a need for more secure storage areas. This space is also within view of the main public entry to the facility, which could increase risk of theft and/or vandalism.

3.4.3 Pre-fabricated Metal Building – Existing

Directly next to the pole barn is an insulated metal building. There are five roll-up doors and two man doors provided. Chemicals, waste oil, and trailer mounted equipment are stored in this freeze-protected space. The space is divided by an interior, unfinished wood stud wall. Some space in this building is utilized by the conveyance group and will become available after they move to other facilities in Bend. This structure has a gable roof system. In snow-heavy climates a gable sloped over building access points can sometimes be a burden or hazard, as snow and ice slide off the roof to the ground around doors. This building appears to be in good condition and suitable as a storage building.

3.4.4 <u>Residential Two-car Garage – Existing</u>

A smaller storage structure is south of the metal building. This structure has a single, residential-style garage door and approximately ten feet high clearance. The space is freeze-protected and is used to store some chemicals and/or flammable materials in cabinets. This space is also used as the facility wood-working shop. The metal shop is in the main maintenance building. Gas-powered, smaller site maintenance equipment is also stored in this space. This building has limited future uses and is not designed to be an occupied building.

4.0 NEEDS ASSESSMENT

The following discussion identifies the recommended approach to meet the non-process facility needs through the planning period. Programming is performed for the operations, maintenance, laboratory, and training areas to identify the space allocation needed to support these activities. This programming is then used, along with the findings of the condition assessment, to develop the various alternatives. 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.

4.1 Proposed Operations

The Operations Building overall layout is inefficient for its current use, and more area is needed to house all of the functions required to serve the operational needs of the Bend WRF. Our first suggestion to improve working conditions within the Operations Building and provide the additional space is to remove the water quality laboratory. Two relocation options are suggested for a proposed new laboratory . One option attaches to the laboratory to the existing Training Building (Option A), and the second option attaches it to the east face of the Operations Building (Option B). The options are evaluated in Section 3.2.

With the extra space provided by moving the lab space, almost 3,000 square feet, and extensive remodeling to the interior of the existing building, it is possible to fit the following space needed for additional administrative program requirements:

- Three (3) new offices for engineering staff;
- Two (2) new conference spaces, large and small;
- Break room;
- Mud room with building services located adjacent;
- Copy center/supply storage;
- ADA restroom located near the front entrance for visitors and occasional tour traffic;
- Dedicated IT and UPS area;
- Dedicated quiet room;
- Dedicated records and storage;
- Mechanical room;
- Emergency gear room.

The overall Operations Building space allocation for the new and remodeled spaces is shown in Figure 5. A comparison of space allocation for existing and proposed alternatives is provided in Table 1.

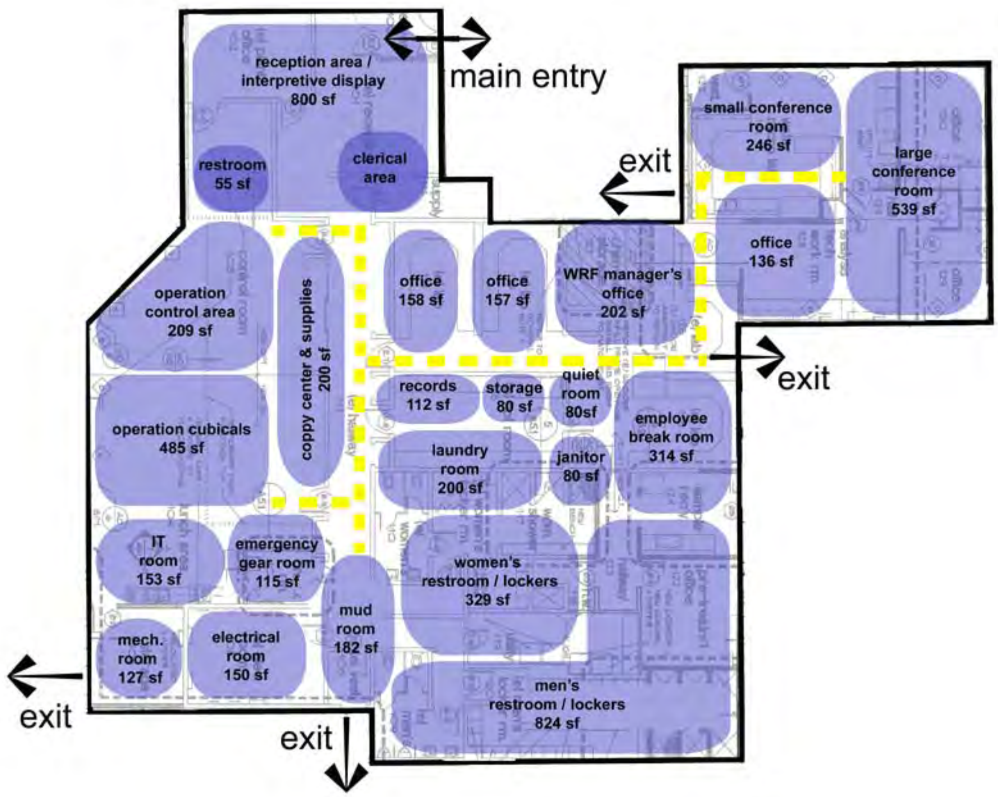

Figure 5 Operation Building Space Allocation Diagram

Table 1 Operations Programming
Water Reclamation Facility Plan
City of Bend

	Existing Area	Lab Option A	Lab Option B
Operations	sq ft	sq ft	sq ft
WRF Manager's Office	250	202	202
Plant Engineer Office		158	158
Office		157	157
Office		136	203
Conference - Large		539	586
Conference - Small		246	202
Operation Control Room	600	209	209
Operation Cubicles		485	485
Quiet Room/Crisis Center		80	80
Employee Break Area/ Room	750	314	314
Reception / Interpretive Center	450	776	776
Lockers/Restroom/Showers - Men	540	824	824
Lockers/Restroom/Showers - Women	400	329	329
Janitor's Closet		80	80
ADA Restroom	70	55	55
Laundry Room	160	200	200
Storage		80	80
Records	100	112	112
Mud/Coat/Boot Closet		182	182
IT Room		153	153
Emergency Gear		115	115
Mechanical		127	127
Electrical	200	150	150
Circulation - includes air lock	600	747	677

Table 1	**Operations Programming Water Reclamation Facility Plan City of Bend**		
	Existing Area	Lab Option A	Lab Option B
Copy Center		100	100
Office Supplies	70	100	100
Total	4,190	6,656	6,656

The proposed layout for the remodel of the existing Operations Building spaces is similar for both Options A and B, and is shown in Figure 6. The airlock-style main entrance to the building remains in its existing location, adjacent to established parking areas. The reception area is enlarged, allowing room for educational displays and space for a receptionist and some clerical storage. The control room remains in its current space. It is downsized, but optimized for 3-4 work spaces. An open office area is adjacent to the control room, with 4-6 office carrels for staff access to email and administrative needs. A new copy center/ supply room is located centrally along the main corridor. New offices and conference rooms are grouped together along the north corridor of the building. A quiet room and record storage will be added across the hall from theses offices. The quiet room will be used as a space to recover from stress and/or health issues, such as headaches. The previous addition will hold the new conference rooms and an office. A new mud room is provided with an adjacent services core housing electrical, mechanical, emergency gear, and laundry. Both the men's and women's locker/shower rooms are expanded. They are also located off the new mud room for operator convenience and share a common plumbing wall for construction efficiency. This efficiency can also lower costs by reusing lockers and existing infrastructure in the men's showers. If the laboratory is added to the Operations Building, Option B, the aesthetics of this addition will be changed to match that of the new addition to help the flow on the exterior of the building.

Figure 6 **Proposed Operations Building Renovation**

4.2 Proposed Laboratory

4.2.1 Alternatives Development

As previously discussed, two alternatives were developed to meet the laboratory requirements. Both options assume that a new laboratory addition or stand-alone building can be justified, and that the existing Operations Building will remain in place. As discussed in Section 3.1, the Operations Building will undergo major renovation to bring this building up to current codes and address program needs.

The options were developed based upon the programming needs defined in Table 2, space allocation diagram shown in Figure 7, and design criteria summarized in Appendix A. Both options will require some reallocation of parking and slightly impact parking and traffic circulation zones. The options are described below.

Table 2 Laboratory Programming
Water Reclamation Facility Plan
City of Bend

	Existing Area	Option A	Option B
Water Quality Laboratory	sq ft	sq ft	sq ft
Lab Manager	130	198	198
Offices & Library		683	664
Records Storage		93	100
ADA Restroom		64	98
Quiet Room/Crisis Center		92	
Break Room		136	
Hood Room	200		
Lab 1 - Metals		256	256
Lab 2 - Wet Chemical	120	256	256
Lab 3 - Microbiology	475	256	256
Lab 4 - Nutrients		256	256
Operators Lab		160	160
Sample Receiving	120	160	160

Table 2	**Laboratory Programming Water Reclamation Facility Plan City of Bend**		
	Existing Area	Option A	Option B
Chemical Storage	120		
Lab Mechanical		196	143
Lab Electrical		133	
Bottled Gasses			
Instrumentation Lab	210		
Lab - Tech Room	265		
ICP - MS Room	130		
Other Anylitical Space	700		
Circulation - includes air lock	500	340	732
Subtotal	2,970	3,279	3,279

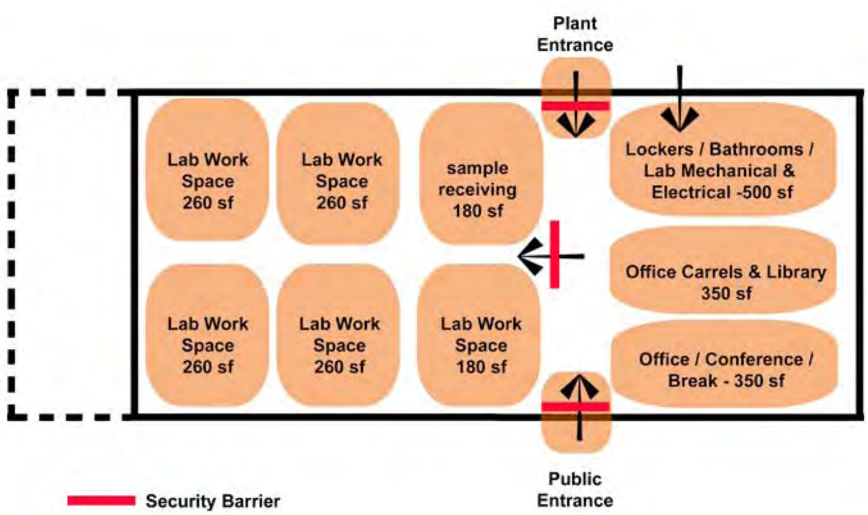

Figure 7 Laboratory Proposed Space Allocation Diagram

Option A assumes that the existing Training Building, now half vacant, can be used to address the office-like or non-analytical needs of the laboratory staff. Approximately half of the area required by the laboratory is an office environment. Option A assumes that an addition to the training building would also require some interior tenant improvements to make the existing building work for non-analytical laboratory needs. As the area left vacant by the collections crew, (now relocated closer to town) is not quite big enough, two additions are required within this option. Option A is illustrated in Figure 8.

Option B assumes that the laboratory addition can be placed along the east side of the existing Operations Building (Figure 9). This location is adjacent to the most recent addition to the Operations Building. This option attempts to streamline circulation, share some common program spaces and potentially share some building systems. Both options have minor grade issues and with soil conditions in this area, will require some rough excavation of native volcanic soils. Option B allows for an interior ramp to address roughly two-feet of grade change with minimal excavation for foundations. This option also provides an outdoor, south-facing courtyard between new and existing buildings, also allowing closer access to the operator's laboratory.

4.2.2 Alternatives Comparison

Site plans for the two options are shown in Figure 10.

Two site options are shown below. The first option (Option A, Figure 15) shows the Water Quality Lab addition attached to the existing Training Building and adds a New Maintenance Building east of the existing Operations/Admin Building. The second option (Option B, Figure 16) places the Water Quality Lab as an addition on the existing Operations/Admin Building with the new Maintenance Building just east of this.

Both of these options consist of additions to existing buildings which results in the need for earth work to address grade cross slope conditions. They both also have site access implications; Option A is extended south which places some of the addition into the current HC Parking area, this may cause the need to move an existing fire pump. Option B extends east placing some of the addition very close to plant circulation.

Option B is recommended for the following reasons:

- Due to its proximity to the existing Operations/Admin Building Option B, allows for some functions to be shared, such as the Quiet Room and Conference Rooms;
- Although mechanical and electrical systems will need upgrades in both options, Option B only requires upgrades to one building;
- This option offers a better *cultural* connection between staff with interactions in the Conference spaces, Break Room, and throughout the Circulation zones;
- The existing Training Building can be used during construction for phasing purposes, lessening the need for temporary trailers to be built while construction is taking place, which may save money on construction costs (please see Section 6.3 Phasing for more information).

Figure 8 Proposed Training Building Option A

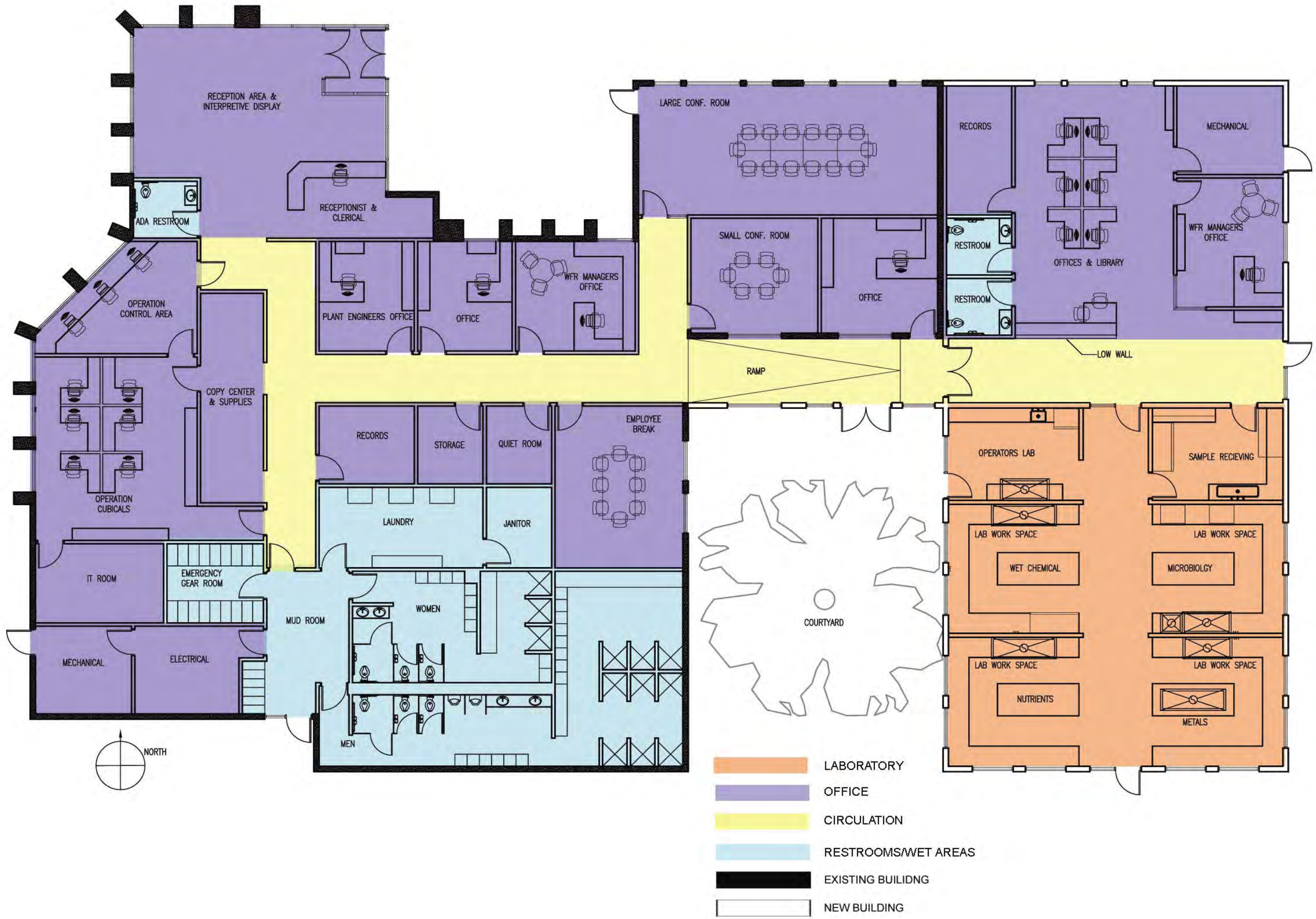

Figure 9 Proposed Operations Building Option B

SITE PLAN OPTION A

SITE PLAN OPTION B

Figure 10 Laboratory Alternatives Site Plan

Table 3	**Laboratory Alternatives Comparison Water Reclamation Facility Plan City of Bend**		
Matrix	Option*		Comments
1 Bad------------------5 Good	A	B	
General building placement on site - lab addition	3	4	Option B allows some functions to be shared within the existing Operations Building, slightly less sf requirements
Adjacencies to other functions.	2	4	Option B allows lab staff close access to locker rooms, control areas, storage and the main lobby
Cultural advantages to program placement.	2	4	With the current configuration, the lab addition to the existing maintenance facility will provide a better cultural connection to staff
Constructability	3	3	Both options require additions to existing building. Both options have grade difficulties in site work and access.
Phasing advantages.	2	4	Option B allows the vacant space with the Training Building to be used for Operations Building phasing, lessening the need for temporary trailers while the Ops Building is under construction.
Use of existing systems.	2	4	Option B allows more opportunity for building system upgrades to be shared regarding electrical and mechanical (chilled water) systems.
Site disturbance.	3	3	Earth work has similar challenges for both options

Table 3	**Laboratory Alternatives Comparison** **Water Reclamation Facility Plan** **City of Bend**		
Matrix	Option*		Comments
1 Bad------------------5 Good	A	B	
Aesthetics	2	1	Both options have similar challenges as to responding to existing architecture. Option B requires more façade work to blend the new lab addition to the existing multi-leveled façade of the Operations Building
Code/Zoning issues.	3	3	Both Options require building separations for the new lab addition. Both Options connect the lab to newer building parts requiring similar seismic isolation and area separations.
Cost	4	3	Although construction costs are fairly close with Option A somewhat lower, Option B allows for use of the Training Building for phasing construction of the Operations Building remodel.
Total Score	26	33	
1 Bad------------------5 Good	2.6	3.3	Average

4.3 Proposed Training Building

The existing Training Building was constructed recently and is not in need of repair. Since the collections staff has relocated to different facilities, there is more administration space available to the WRF. If Option A is chosen for the placement of the Water Quality Laboratory, the addition would be added to the Training Building (see Option A). If Option B is used, the available space will be available for miscellaneous administrative use, as well as phasing for construction of the operations/laboratory renovation.

4.4 Proposed Maintenance Building

The existing maintenance building usefulness as a total maintenance facility has decreased over time. Work bays converted to office space and the remaining bays are not sufficient to service all facility needs. Renovation of the existing maintenance building includes dismantling the mezzanine so that the 18’-0” work bay may be used for vehicle storage and moving the electrical repair shop so that it takes over an entire work bay. Newspaces for existing impacted activities and un-served activities are needed. These new spaces are as follows:

- New drive-through bays specifically designed for high bay, heavy equipment are required;
- New lubrication and service bay is required for maintaining facility vehicles on site;
- Electrical repair shop needs additional area for work table space and storage (renovation in existing bldg);
- A separate fabrication shop space with exhaust system;
- An organized storage facility for flammable and toxic chemical storage, complete with code compliant cabinets;
- Secure tool storage; and
- Secure and accessible parts storage.

Drive-through bays are also needed, and allow for additional flexibility. Bridge cranes can be installed in the drive through bays with maximum usability. Truck beds can be positioned in the bay space so as to maximize safe use of jibs and cranes and minimize injury. Maintenance Building programming is summarized in Table 4, and programming for the recommended approach is shown in Figure 11.

Table 4 Maintenance Programming
Water Reclamation Facility Plan
City of Bend

	Existing Area	Option A	Option B
Maintenance	sq ft	sq ft	sq ft
Maintenance Bays	1,920	1,440	1,440
Lube Bay		768	768
Heavy Equipment Bay		768	768
Office	720	1,000	1,000

Table 4	**Maintenance Programming Water Reclamation Facility Plan City of Bend**		
	Existing Area	Option A	Option B
Restroom 1	56	56	56
Restroom 2		56	56
Electrical Workshop & Storage	240	624	624
Tools Storage	600	667	667
Parts Storage	600	934	934
Covered Storage	3,300	3,300	3,300
Freeze Protect Storage	3,400	3,400	3,400
Subtotal	10,836	13,013	13,013

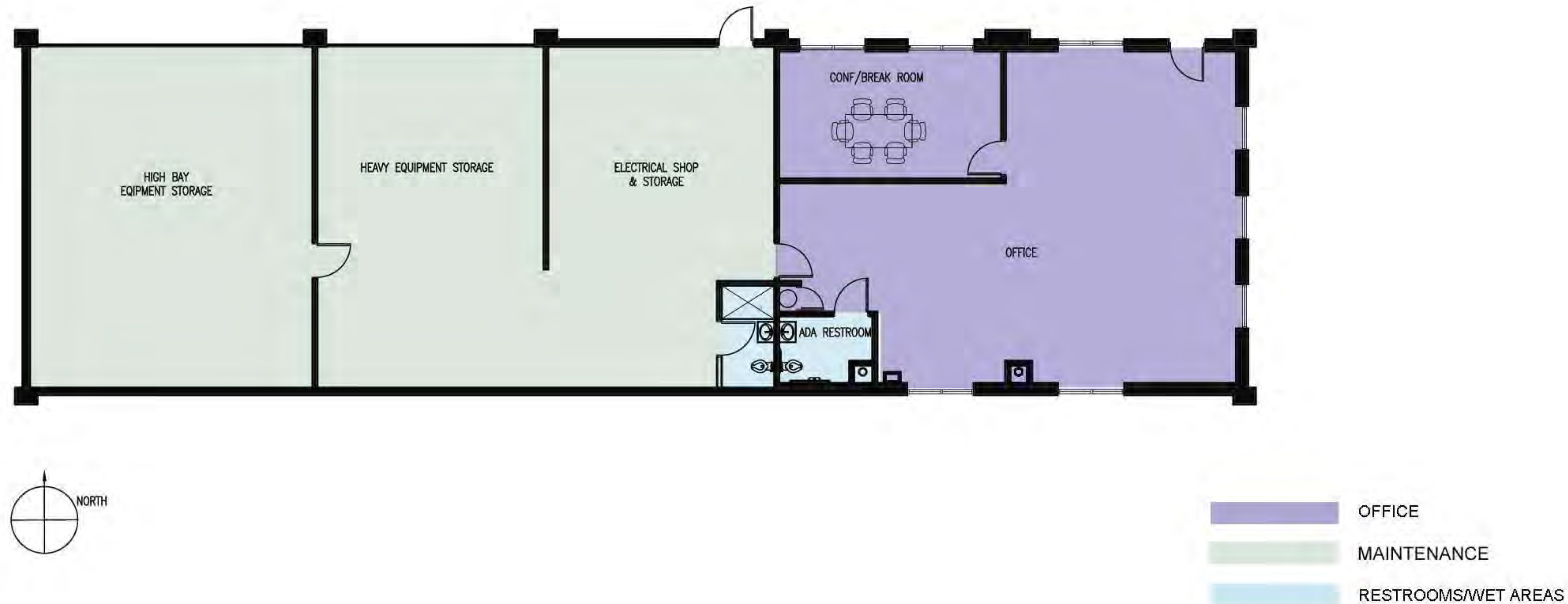

Figure 11   Proposed Maintenance Building Renovation

5.0 ARCHITECTURAL DESIGN

Designing facilities within a plant context involves designing buildings which are purpose-built, functional and elegant in their simplicity. New structures should relate and respect the positive features of existing buildings but should not replicate dated or badly comprised design features. New buildings and additions to existing buildings will be constructed of similar materials and will be guided by the following architectural criteria:

- Functional for staff and visitors;
- Contextual to environment and existing adjacent/city structures;
- Cohesive building designs for new buildings and building additions;
- Healthy environment for staff and visitors.

The Water Quality Lab addition will be a flat roofed structure and be constructed of a pattern of various sized honed face concrete masonry structural walls. If added to the Operations Building (Option B), the exterior of the existing 2001 addition will be updated to match the new lab to help the flow and aesthetics of the elevation. An elevation for the Operations Building is provided in Figure 12. A perforated mesh mechanical screen will fit on the roof to screen HVAC equipment. Vertical metal siding will surround the operable storefront windows in a horizontal strip to speak back to the existing Operations Building (see Proposed Operations Building North Façade). These windows will be inset a few inches to add depth and shadow to the facade, while also offering some sun shading. Steel canopies will also be used to protect interiors from the sun. The renovated Operations Building will need updated windows and doors to match the lab addition.

The lab environment needs to be very clean, as testing requires purity of samples. Access to the lab infrastructure; including air systems, air filtration, water and power systems is frequent and should be designed for ease of maintenance. Easy access to the roof top maintenance areas are required to maintain air handlers, chillers and fume hood exhaust systems. Related to building volume, suspended ceilings are roughly 9’-0” above the finish floor. A higher floor to structure height is required to accommodate layers of overhead duct work, electrical, lighting, security, telecom and plumbing ventilation systems, pushing the bottom of structure somewhere between 14 to 16 feet above finish floor (for more detailed information see the Lab Criteria Memo).

Figure 12 Proposed Operations Building Option B - Preferred Option, North Facade-Main Entrance

The new Maintenance Building will match the construction of the existing Maintenance Building. It will be constructed of load bearing tilt-up concrete perimeter walls; natural in color with the same scoring patterns. The infill will either match the concrete design or the concrete masonry suggested for the Water Quality Lab addition. The roll up doors will be of a contemporary model similar to the existing roll up doors. Steel canopies will be placed above man doors for protection from the weather with consideration to the sunny and snowy conditions that occur at Bend. The Existing Maintenance Building renovation will be done to match current aesthetics and structural integrity. One roll up door will be closed off (see floor plans) and a man door added. As roll up doors, windows and accessories come to the end of their useful life, they should be replaced to match those of the new Maintenance Building. Windows will be added to the exterior to improve the office environment on the interior, and will be placed within the bays keeping the current structural integrity intact. They will also be similar in proportion to existing, matching the elevation. Mechanical systems will need to be reviewed and updated to match the appropriate space uses inside. Steel canopies will be added above man doors for protection.

6.0 SUMMARY

A summary of findings and recommendations for the Operations, Laboratory, and Maintenance areas is provided below. An opinion of cost is also included, along with a potential phasing plan.

6.1 Recommended Plan

Operations. The operations group shares the existing Operations Building with the laboratory group. This building is well-maintained; however, existing building systems, space planning, materials and finishes are well-worn and often beyond their useful life. Current and projected Operations and Laboratory needs exceed the total building area. We recommend the entire building be converted to solely serve operations. This would provide more organized space, separate rooms for control, break and operator areas, more locker and shower room space, more conference rooms and more offices to suit the needs of plant staff.

Laboratory. The water quality laboratory group is currently located within the existing Operations Building. Some of the older lab spaces are not being used to their full potential, while spaces within the 2001 addition are being used frequently. This has resulted in inefficient space usage. Based upon discussion with City staff, it was determined that the existing lab should be replaced rather than renovated. It is far more efficient to renovate the existing office building to office use rather than renovating it to serve the contemporary needs of a certified water quality laboratory. The preferred approach (Option B) places the new lab as an addition to the Operations Building.

Storage and Maintenance. Maintenance staff has been quite resourceful at serving their needs. The existing Maintenance Building is being used for more than maintenance, and has been renovated to add additional office space. Current needs call for a new maintenance bay to house fabrication, flammable storage, tools and parts storage. Two additional drive-through bays are recommended to serve the needs of servicing heavy equipment and lubrication.

6.2 Project Cost

Estimated project cost to upgrade the non-process facilities is summarized in Table 5. The cost for both options are included. However, Option B is the recommended approach based upon the non-economic benefits previously described.

6.3 Phasing

Although construction is not scheduled at this time, a phasing plan was developed to insure the constructability of the recommended approach. Major sequencing steps are described below:

1. Build new lab addition - 11 months;
2. Move to new lab - 1 month;
3. Move out Operations staff to Training Building, supplement with trailers if necessary - 1 month;
4. Renovate Operations Building (not phased) - 12 months;
5. Move staff into remodeled Operations Building - 1 month;
6. Open connection to lab space with attention to indoor air quality shifts (check HVAC systems); and,
7. Build additional Maintenance facilities, no known scheduling constraints - 12 months.

Table 5	**Estimated Cost Water Reclamation Facility Plan City of Bend**						
	Total	No Change	Light TI	Renovation	New Construction	Option A	Option B
	sq ft		sq ft	sq ft	sq ft	$	$
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	1,623		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

Note: Budget Costs per square foot:

New Lab = $585/sf

New Office = $370/sf

TI-Light Renovation = $125/sf

Renovation Office = $ 290/sf

Renovation Maintenance = $125/sf

New Maintenance = $210/sf

New Maintenance Bays = $335/sf

Budget cost numbers are derived from MWA’s benchmark data of covering 15 years of projects with similar requirements. We have escalated costs to 2008 values and added a cost factor for projects done within this plant. Factors increasing cost data include the remote location and the lab requirements for a small, highly-technical addition to an existing building. MWA is contracted to provide an opinion of probable cost based on projects we have designed in Oregon, California and Washington. If more thorough cost data is required for budgeting, we will retain a cost engineer to assist us and confirm or budget numbers.

LABORATORY DESIGN CRITERIA

Laboratory Design Criteria – Proposed new Water Quality Laboratory for the Bend WWTP

This memorandum outlines proposed design criteria for the Bend WWTP Laboratory.

APPLICABLE CODE REFERENCES

References:

- **ADA** — Americans With Disabilities Act
- **ANSI/AIHA Z9**.5 — American National Standards Institute/American Industrial Hygiene Association, American National Standard for Laboratory Ventilation, current Edition
- **IBC/Oregon Specialty Code** — International Building Code, current Edition
- **IMC Section 510** — International Mechanical Code, Hazardous Exhaust Systems, 1998 Edition
- **NFPA 45** — National Fire Protection Association, Fire Protection for Laboratories Using Chemicals, current Edition
- **NFPA 30** — National Fire Protection Association, Flammable and Combustible Liquids, current Edition
- **ANSI Z358.1** — American National Standards Institute, Emergency Eyewash and Shower Equipment, current Edition
- **ASHRAE 110** — American Association of Heating, Refrigerating, and Air-Conditioning Engineers, Method of Testing Performance of Laboratory Fume Hoods
- **OSHA** — Occupational Safety and Health Administration, General Industry Standards, 1910.106, and Occupational Exposures to Hazardous Chemicals in Laboratories (Laboratory Standard), 1910.1450
- **UPC** — Uniform Plumbing Code, current Edition

Basis For Design

Design Criteria

General

The design will meet the needs to perform the analyses included in the WWTP laboratory mission

This design criteria only apply to this laboratory

Applicable Occupancy Ratings

NFPA, Number 45, establishes a Class C Occupancy for the laboratory with maximum quantities of flammable and combustible liquids not to exceed maximums delineated in Tables 2-2 and 8-1, regardless of the information in this table, any new laboratory would likely be sprinklered as required by local jurisdictions.

IBC, 304.2.2.1, establishes a **Group B Occupancy**, Laboratories—testing and research, with quantities of hazardous materials not to exceed maximums delineated in Tables 3-D and 3-E requiring an “H” or Hazardous Occupancy

Construction

One hour separation from non-laboratory areas recommended as response to non-combustible construction between lab and non-lab areas per NFPA 45, Table 3-1(a) – recommended but not required.

Structure

Minimum 100 pounds per square foot (488 kg/m2) live load [150 pounds per square foot (732 kg/m2) is better]

Minimum 14-foot floor to floor clearance for utility infrastructure (air supply/exhaust ducting, communications, lighting) 15 to 16 foot clearance is optimal.

Flexibility on laboratory column spacing to avoid conflicts with laboratory planning module or structural module dimensioned to span both dimensions of laboratory planning module plus an allowance for wall thickness

Coordinate structural bay spacing with cabinet and aisle sizes

Meet seismic requirements and consider need for vibration constraints on sensitive equipment and scales.

In seismic sensitive zones, anchor open ends of double sided cabinets on islands (mounted on reagent shelves) to the structure; anchor vertical service chase to structure as well (other end of double sided cabinet anchored to service chase)

Interior

Floor

Resilient and, acid and solvent resistant. Suggest Nora/Noraplan type rubber floor with cork backing for comfort under foot, thereby eliminating abrupt floor surfaces for standing areas. Suggest welded seam tile application where floor must be seamless and liquid tight. This floor also is acoustically better than vinyl products

Vinyl Composition floor – although cost effective, it is not recommended.

Carpeting in some non-analytical areas

Baseboard — Rubber/resilient or integral sanitary base with flooring, as required if “H” Occupancy, otherwise, not required.

Walls

Drywall or drywall furred over concrete masonry units with moisture resistant enamel finish, except where noted

Properly insulated for air conditioning needs and to meet Oregon Energy code.

Washable sound attenuation will be considered when selecting surface treatments

Ceiling

Suspended acoustical system, high quality, high acoustic rating

9-foot minimum height

Hard ceiling where required for soffits, lighting and room edges

Access panels as required for easy access to HVAC, strategically located in areas where maintenance personnel can safely place ladders. Appropriately sized for function and frequency of maintenance.

Laboratory Casework

Chemical resistant plastic laminate or catalyzed lacquer surface over wood veneer, over plywood or monolithic flake board. Consider and recycled or FSC certified core for all lab casework.

Knee spaces as needed for instruments, specific operations, or desk work – 24” deep minimum.

Shelving for reference materials - 10” deep, no seismic lip. If possible, cant shelves 5% away from primary access.

Sliding glass door wall cabinets and double sliding glass door reagent shelf cabinets or swinging glazed doors for islands and peninsulas

Lab Counters

1.125 -inch thick epoxy resin with integral sinks and welded back-splashes and corrosion resistant stainless steel where designated or requested by tri-City lab staff; Microbiology module

Drip groove along underside of exposed edges of epoxy resin

To prevent sagging, provide support for epoxy resin tops not supported by underlying cabinets

Height for standard base cabinet at 36 inches and height for desk cabinet at 30 inches <u>without</u> counter top as identified.

Windows

Appropriate for visual relief and for natural light requirements, coordinated with wall use requirements

Double glazed exterior and reinforced interior (relites) where needed. Windows to be clear, non-tinted, with minimum solar ban 60, max 70 for thermal performance without UV transmission.

Windows (in analytical areas) fixed/non-operable for heating, ventilating, and air conditioning (HVAC) control

45 to 48-inch height above floor for standard base cabinets or 39 to 42-inch for desk cabinets to allow for back splash, electrical service and communication connections (phone and PC network).

85-inch height above floor for above standard wall cabinets

Exterior and interior window light control to darken or provide privacy where needed

Doors

Standard 36-inch wide or double wide as needed for access for large equipment; consider 42-inch for one door for large equipment, refrigerators or deliveries as discussed with Bend WWTP lab staff

Side light or “relite” style windows in high traffic areas

Sound rated where needed

Vestibule to separate labs from exterior and, perhaps, non-lab areas as needed to maintain pressure differentials described below

Suggest open lab areas with minimal use of doors into separate rooms or testing areas

Exits

Minimum two means of egress per NFPA 45 and UBC

Door swing in direction of egress per NFPA 45

Security — Controlled vendor and visitor access through key card or alternative system to maintain chain-of-custody for lab accreditation purposes

Space and Accessibility

Sufficient aisle and hall width to allow two persons to work back to back with one person passage between, two person passage, and movement of large equipment. Five feet minimum as discussed with Bend WWTP lab staff.

Sufficient for accessibility required by ADA, including door clearances

The majority of the lab space will be designed for able bodied personnel, suggest at least one work area designed as fully accessible with under-counter or side wheel chair access. All services (water, gas, vacuum, air, should be side access as required by ADA.

Wide or double door at one location for delivery or removal of large equipment and delivery of samples as required by Bend WWTP Lab staff

Sound

Acoustical isolation for labs and individual non-lab areas

High quality suspended acoustical ceiling material addresses airborne noise as well as noise generated in above ceiling areas containing ductwork and plumbing.

Locate exhaust fans for room, hoods, and vents remote from the laboratory and design ducting for sound reduction

Vibration and Seismic Forces

Seismic lips or earthquake edges on wall shelves and reagent shelves to meet applicable seismic requirements

Screw anchor shelf clips to meet applicable seismic requirements

Acoustic engineer to address structure-born vibration from rooftop mounted mechanical equipment; fans, chillers, etc.

Lighting

Direct/Indirect Fluorescent lighting

Design for 69 foot-candle (750 lux) at lab bench level and at desk height [for non-lab areas] and Owner provide as needed 92 foot-candle (1,000 lux) task lighting for demanding work (low contrast, fine detail)

Two level or dimmable lighting for energy savings in most areas. Coordinate with other energy management and DDC systems to address changing lighting level with from windows and skylights.

Consider compact fluorescent or other energy saving source in direct/indirect mode (perforated bottom, reflective top

Augmentation with natural light where possible using windows, sky lights, or light wells

Emergency lighting for all areas as required by code.

Communications

General use telephones with capability for transferring and conference calls

Data/communication J125 outlets at selected locations; consider combination data/telephone outlets in lieu of data outlets

Divided, multi-service Wire mold 4000 with data/communication RJ45 receptacles at selected locations

Call system for outside deliveries, bell or speaker per Owner's consideration.

Radio communications with mobile staff

Phone jacks and data/communication outlets for potential use at all computation (desk) spaces and selected instrumental work spaces

Electrical

Unclassified per NFPA 45, 3-6.2

120/208 volt, single phase, 3-wire and 20- to 30- amp circuits to service all areas with capacity for additional circuits in the future

Wall mount or vertical service chase mount receptacles for free standing equipment (refrigerators, incubators) and for counter top placed equipment requiring 208 volt or 120 volt 20-30 amp circuits (autoclave, oven, instruments)

Multi-outlet assemblies (plug mold) mounted on walls above back splashes and mounted on fascia of reagent shelves for islands with two alternated circuits for each multi-outlet assembly all GFCI protected at breaker panel

If feasible, uninterruptible power supply (UPS) for computer locations, sample storage refrigerators, and microbiological incubators in designated areas.

Emergency generator – Bend WWTP staff have confirmed the design for a new emergency power/ stand-by gen-set for use when this lab is built.

Ground-fault circuit interrupter (GFCI) protection near water sources in designated areas (designated on architectural plans). Code requires GFCI if outlet with 6 feet of water source typically a sink. Since cup sinks are placed in areas not having sinks, consider GFCI protection of circuits at the 120-volt receptacles and at the panel board for multi-outlet assemblies and special circuits such as 120-volt, 30-amp and 208-volt, 20 to 50 amps.

Emergency power disconnect at lab exit door outside lockable area, except HVAC power

Electrical panels located convenient to the whole lab, not within the lab areas.

Heating, Ventilating, and Air Conditioning

Climate control at 70$\pm$ 6^{O}F (21 $\pm$ 1^{O}C) for labs; proper temperature control is critical for proper instrument operation, volume measurements, and other factors necessary the generation of high quality data.

Relative humidity control to less than 60 percent; 30 to 50 percent. Relative humidity control to less than 60 percent

Labs have negative pressure relative to adjacent non-lab areas; lab areas positively pressurized relative to outside to inhibit infiltration.

Independent HVAC system for lab portion of building per IMC, Section 510

Constant volume exhaust for hoods, canopy hoods, and instrument vents ganged together. Consider Berkeley Hood design, LBNL for considerably less air flow and subsequent energy savings. Sufficiently sized HVAC system for heat loads to be determined, often greater than 25-watts per square foot based on equipment loading (270 W/m^2)]; lab manager to verify heat loads anticipated within the planning horizon as more and more bench-top equipment becomes necessary.

Exhaust stack heights appropriate to disperse contaminated air. ASHRAE guide and ANSI/AIHA Z9.5 require 10 feet above highest point and discharge velocity of at least 3,000 fpm for stack without internal condensation

100 percent outside air supply with no recirculation of lab exhaust with lab or non-lab areas

Pre-filter air supply with 95 percent efficient filter that would be approximately 98 percent efficient for air particulate 1 micron and larger

Required minimum 6 changes of lab air per hour when space is occupied per UBC 1203.6; preferred minimum 8 to 12 air changes per hour (ACH) (heat loads and exhaust sources will cause ACH to significantly exceed minimum)

Fume hoods located, installed, and operated per NFPA 45, ASHRAE 110, and other codes with proper face velocity, manifolding, and consideration for energy conservation, see reference to LBNL Berkeley Hood design.

Conventional bypass air fume hoods (not auxiliary air or variable air volume fume hoods)

Fume hood face velocity monitor with audible and visible alarm mounted on face rail in front or on wall beside the fume hood

Spot and instrument vent hoods at 25-450 CFM as required by instrument heat rejection

Canopy hoods at specified CFM for removal of heat (approximately 50 percent), moisture, and unpleasant odors, but not used for hazardous or corrosive fumes

Biosafety or other equipment with self-contained HEPA filter each on separate exhaust systems

Corrosion resisting, type 316 stainless steel exhaust ducting and exhaust fan(s)

Air handling system (supply and exhaust fans) continuous operation 24 hours, 7 days per week with automatic set-back to reduce air flow to 50 percent to save energy during unoccupied periods; manual override switches for after-hours operation

To meet energy saving requirements, consider heat recovery system to preheat or precool air; heat (enthalpy) wheels, variable air volume systems, and make-up air fume hoods are not appropriate for this project for reasons of performance, safety, and cross-contamination.

Face velocity monitor (FVM) inter-connection with the exhaust fan system in a manner that will disable the audible, but not visible, alarm when the exhaust fans reduce the to 50 percent during unoccupied periods (and enable the audible alarm when the night reduction timer is overridden for work during off-hours)

Plumbing

Cold water and hot water from a separate large hot water heater at 140^{O}F (60^{O}C) with recirculation to maintain fast, hot water at all lab locations

Reduced pressure (RP) back flow prevention devices on cold water to entire lab and to **¾"** supply to central reagent water system

Vacuum breaker fixtures

Corrosion resistant floor and hub drains with acid/solvent resistance and primed traps (consider Duriron or polypropylene depending on practice)

Acid neutralization system with limestone medium in-line with drainage to Publicly Owned Treatment Works (POTW)

Air gap for indirect wastes such as refrigerator drain, ice machine, still, sterilizer, etc with minimum vertical distance from lowest point to the flood level of the rim of the receptor not less than 1 inch per UPC 801

Safety shower(s)/eyewash(es)

Wall or ceiling mounted safety shower in designated lab areas with shutoff valve upstream of unit's valve and nearby floor drain;

Tempered or tepid water to safety shower(s)/eyewashes as required by ANSI Z358.1; tepid temperature 60 to 95^{O}F, though 78 to 92^{O}F eye surface temperature is better

Hand-held eye/body wash fixtures at designated sinks on separate, RP protected, water supply

Reagent Water

Central reagent water system consisting of 10 gallons per minute (expandable to 20 gallons per minute) mixed bed demineralization to minimum 10 megohm-cm resistivity and 0.2 micron post-filtration

Compressed Gas

Provision for point-of-use gas cylinders not to exceed maximums in accordance with NFPA 45, Table 8-1 for flammable gases, oxygen, liquefied flammable gases, and those with health hazard ratings of 3 or 4

Consider special piping and manifolding of inert instrument carrier gases (argon(Metals), nitrogen, carbon dioxide) in bulk quantities (dewars)

Provision for proper restraint of point-of-use cylinders as required

Provision for restrained storage of extra gas cylinders inside or outside the lab building separating oxidant and flammable gases per NFPA requirements; gas cylinder safe transportation caps are to remain in place preventing use in or plumbing from this space. As requested by lab staff, provide outside access with louvered doors to avoid special precautions for gas cylinder storage

Chemical Storage

Separate, vented flammables storage cabinets under fume hoods in accordance with NFPA 30, 4-3, and OSHA 1910.106 and separate, vented acids and/or corrosives storage under fume hoods with provision for spill containment (properly constructed, one cabinet can store acids or flammables)

Where appropriate, dry chemicals can be stored in clear glass reagent racks within lab modules allowing point of use distribution and inventory per lab module. Quantity of chemicals not exceeding quantities specified in NFPA 45.

Additional Authors and references for this Lab Criteria memo:

Excepts from this Lab Design Criteria have come from:

Mr. Earl Hadfield, Lab Planner, Ch2mhill

NELAC

ELAP

Jeffrey J. McGraw, AIA/ MWA

Faez Soud, AIA, CSI, LEED – MWA specification writer

MWA has also incorporated information, comments and construction related info from completed MWA projects in California, Oregon and Washington.

ARCHITECTURAL DESIGN CRITERIA MATRIX

Section	Title
Div. 3	**Concrete**
03200	Reinforcing: Furnish and install steel reinforcing as required for a complete concrete installation.
	Concrete Accessories
03300	Cast In Place Concrete foundations and shear walls. Vapor Barrier under concrete slab. Green Spec.: High fly-ash (15%) content.
Div. 4	**Masonry**
	Unit Masonry: ▪ Provide various sized honed face CMU at perimeter of lab addition.
Div. 5	**Metals**
05700	Ornamental Metal: ▪ Canopies. ▪ Miscellaneous metals such as wall protectors at trash room. ▪ Metal bollards incorporated into the wall corners at the garage entrance.
05720	Railings and Handrails: Galvanized steel pipe railings at stairs complying with all codes and ordinances.
05810	Expansion Control: Horizontal and vertical expansion joint covers where the building abuts adjacent structures.
Div. 6	**Wood and Plastics**
06100	Rough Carpentry: Only as required for construction processes.
06200	Finish Carpentry: ▪ Provide transparent finish chair rail at Conference Rooms, Offices, and Break Room Rooms.
Div. 8	**Doors and Windows**
08100	Metal Doors and Frames: ▪ Exterior emergency egress, exterior mechanical room, exterior electrical room. Insulated steel doors. Face gage: 18. Stiffener gage: 16. ▪ Frames: Exterior doors: Hollow metal (steel). Exterior gage: 16. Interior gage: 18. ▪ Aluminum and glazed storefront doors at Main Entries ▪ Provide rated assemblies as required.
08200	Wood and Plastic Doors and Frames Interior Doors: ▪ Interior office, and other doors on corridors: Doors: Solid core, veneered doors with transparent finish. ▪ Interior door frames, Corridors and Public Areas: Solid wood with transparent finish. ▪ Provide rated assemblies as required.
08310	Access Doors and Panels: Where required for access to equipment. Provide rated assembly where required.
08520	Windows: ▪ Aluminum frame, double insulated
08800	Glazing: ▪ Double insulated, clear glass
Div. 9	**Finishes**
09110	Non-Load bearing steel framing: Furnish and install at all demising and exterior wall framing
09250	Gypsum Board, Framing, and Accessories: Exterior: Densglass Gold or approved equivalent exterior sheathing. Interior: 5/8" thick. Regular, Type "X" fire-rated and/or water-resistant where indicated. General interior level of finish is GA Finish Level 4.
09300	Tile:

Section	Title
	▪ Flooring and wainscoting at restrooms. Section to include membrane for under-tile installation.
09510	Acoustic Ceilings: Provide suspended 2' x'2 acoustic ceiling throughout. Suspension system. Tile: Non-directional moisture resistant wet-formed mineral fiber with factory applied finish.
09650	Resilient Flooring: Rubber base throughout.
09688	Tile Carpet: Glue down using low VOC adhesive. Carpet to be CRI Green Label Plus to meet TCAC requirements.
09900	Paints and Coatings: Finish systems and quality levels to be determined. Low VOC content for interiors (e.g.: "Healthspec" by Sherwin Williams, Kelly-Moore "Enviro-coat", or Benjamin Moore "Ecospec").
Div. 10	**Specialties**
10100	Visual Display Boards: ▪ Provide dry-erase marker boards with integral tray and tack strip at office 0117, 0116, 0119, at conference rooms and lab offices/library. ▪ Provide tackable bulletin boards at break rooms.
10200	Louvers and Vents:
10400	Identification Devices: ▪ Signs at public spaces (Common/Community rooms, etc.), and at service areas. ▪ Project Identity Signage: Metal "can" letters incorporated into design of entry canopy. ▪ Comply with all Codes and Regulations, including requirements of the Conditions of Approval.
10800	Toilet, Bath and Laundry Accessories: ▪ Restrooms/Locker Rooms: Mirror/shelf unit, surface mounted paper towel dispenser, toilet paper dispenser, soap dispenser, seat cover dispenser, grab bars, and coat hook: Commercial quality (Bobrick, or approved equivalent).
Div. 11	**Equipment**
11110	Laundry Equipment: Provide stub-ins for rented laundry room equipment by Owner. Owner to provide cut-sheets for equipment.
Div. 12	**Furnishings**
12484	Floor Mats and Frames: Recessed aluminum rail-and-carpet walk-off mats at Main Entry.
12490	4" vertical blinds at Public Areas.
Div. 13	**Special Construction**
13700	Security Access and Surveillance: ▪ Design, furnish, and install complete door entry security system. ▪ Surveillance: To be determined.

BUILDING CODE CLASSIFICATION SUMMARY

BEND WRF CODE CLASSIFICATION TABLE - OPTION B

PROJECT INFORMATION		CODE REFERENCES		
Owner:	City of Bend	**Building Code:**	2007 Oregon Structural Specialty Code	**Completed by:**
Plant:	City of Bend WRF	**Mechanical Code:**	Oregon Mechanical Specialty Code	**Project Engr:** Carollo
Location:	Bend, Oregon	**Plumbing Code:**	Oregon Plumbing Specialty Code	**Civil:**
Project:	City of Bend WRF	**Fire Code:**	International Fire Code	**Architect:** MWA
Dates (Estimated)		**Electrical Code:**	Oregon Electrical Specialty Code	**Chemical Feed:**
Design:	**N/A**	**Energy Code:**	Oregon Structural Specialty Code	**Mechanical:**
Construction:	**N/A**	**Other:**	2004 National Fire Protection Association NFPA 45 Fire Protection in Wastewater Treatment and Collection Facilities	**Electrical:**

Building	BUILDING CODE											FIRE PROTECTION		VENTILATION		
Name	Occup Class	Type of Const	Area Allowed*	Area sq ft	Occup Load	ADA Access	Exits Reqd	Exits Actual	Building Height Allowed	Building Height Actual	Stories	Sprinkler Type	Smoke Detection	Cont/Int	Rate	Rec. Airflow
			sq ft	sq ft					ft	ft					AC/HR	
Administration Building																
Reception/ Interperative Center	B	VB	---	776	7.76	Yes	---	---	---	---	---	---	---	Int	---	---
ADA Restroom	B	VB	---	55		Yes	---	---	---	---	---	---	---	Int	---	---
Operation Control Area	B	VB	---	209	2.09	Yes	---	---	---	---	---	---	---	Int	---	---
Operation Cubicals	B	VB	---	485	4.85	Yes	---	---	---	---	---	---	---	Int	---	---
Copy Center & Supplies	B	VB	---	200	2	Yes	---	---	---	---	---	---	---	Int	---	---
IT Room	B	VB	---	153	1.53	Yes	---	---	---	---	---	---	---	Int	---	---
Mechanical	B	VB	---	127		Yes	---	---	---	---	---	---	---	Int	---	---
Electrical	B	VB	---	150		Yes	---	---	---	---	---	---	---	Int	---	---
Emergency Gear	B	VB	---	115	1.15	Yes	---	---	---	---	---	---	---	Int	---	---
Mud Room	B	VB	---	182	1.82	Yes	---	---	---	---	---	---	---	Int	---	---
Restroom/Lockers - Men	B	VB	---	824	16.48	Yes	---	---	---	---	---	---	---	Int	---	---
Restroom/Lockers - Women	B	VB	---	329	6.58	Yes	---	---	---	---	---	---	---	Int	---	---
Laundry	B	VB	---	200	2	Yes	---	---	---	---	---	---	---	Int	---	---
Janitor	B	VB	---	80		Yes	---	---	---	---	---	---	---	Int	---	---
Records	B	VB	---	112	1.12	Yes	---	---	---	---	---	---	---	Int	---	---
Storage	B	VB	---	80		Yes	---	---	---	---	---	---	---	Int	---	---
Quiet Room	B	VB	---	80	0.8	Yes	---	---	---	---	---	---	---	Int	---	---
Employee Break Room	B	VB	---	314	3.14	Yes	---	---	---	---	---	---	---	Int	---	---
Plant Engineers Office	B	VB	---	158	1.58	Yes	---	---	---	---	---	---	---	Int	---	---
Office	B	VB	---	157	1.57	Yes	---	---	---	---	---	---	---	Int	---	---
Office	B	VB	---	203	2.03	Yes	---	---	---	---	---	---	---	Int	---	---
WFR Managers Office	B	VB	---	202	2.02	Yes	---	---	---	---	---	---	---	Int	---	---
Conference Room - Large	B	VB	---	586	5.86	Yes	---	---	---	---	---	---	---	Int	---	---
Conference Room - Small	B	VB	---	202	2.02	Yes	---	---	---	---	---	---	---	Int	---	---
Records - Lab	B	VB	---		0	Yes	---	---	---	---	---	---	---	Int	---	---
Circulation	B	VB	---	677		Yes	---	---	---	---	---	---	---	Int	---	---
Subtotal-net square footage	B	VB	*27,000	6,656	67	Yes	2	5	40'	16'	1	NFPA 45	Throughout	Int	0	0.9

ABBREVIATIONS	
AC/HR	Air Changes per Hour
Cont	Continuous
Int	Intermittent
N/A	Not Applicable
Sqft	Square Feet

Net: Usable Sqft Calculation

* Assumed (E) remodeled administratibe building with sprinklers.

* Assumed (N) lab addition with sprinklers.

BEND WRF CODE CLASSIFICATION TABLE - OPTION B

Building	BUILDING CODE											FIRE PROTECTION		VENTILATION		
Name	Occup Class	Type of Cons't	Area Allowed*	Area sq ft	Occup Load	ADA Access	Exits		Building Height			Sprinkler Type	Smoke Detection	Cont/Int	Rate	Rec. Airflow
							Reqd	Actual	Allowed	Actual	Stories					
			sq ft	sq ft					ft	ft					AC/HR	
Water Quality Laboratory																
Offices & Library	B	IIB	---	664	6.64	Yes	---	---	---	---	---	---	---	Int	---	---
Lab Manager	B	IIB	---	208	2.08	Yes	---	---	---	---	---	---	---	Int	---	---
Mechanical	B	IIB	---	143	1.43	Yes	---	---	---	---	---	---	---	Int	---	---
Electrical	B	IIB	---		0	Yes	---	---	---	---	---	---	---	Int	---	---
ADA Restroom	B	IIB	---	56		Yes	---	---	---	---	---	---	---	Int	---	---
ADA Restroom	B	IIB	---	56		Yes	---	---	---	---	---	---	---	Int	---	---
Operators Lab	B	IIB	---	183	1.83	Yes	---	---	---	---	---	---	---	Int	---	---
Sample Receiving	B	IIB	---	183	1.83	Yes	---	---	---	---	---	---	---	Int	---	---
Lab - Wet Chemical	B	IIB	---	264	2.64	Yes	---	---	---	---	---	---	---	Int	---	---
Lab Microbiology	B	IIB	---	264	2.64	Yes	---	---	---	---	---	---	---	Int	---	---
Lab - Nutrients	B	IIB	---	264	2.64	Yes	---	---	---	---	---	---	---	Int	---	---
Lab - Metals	B	IIB	---	264	2.64	Yes	---	---	---	---	---	---	---	Int	---	---
Records	B	IIB	---	128	1.28	Yes	---	---	---	---	---	---	---	Int	---	---
Circulation	B	IIB	---	943		Yes	---	---	---	---	---	---	---	Int	---	---
Subtotal-net square footage	B	IIB	23,000	3,620	26	Yes	2	3	40'	18'	1	NFPA 45	Throughout	Int	6	8-12
Maintenance																
Existing Maintenance Building																
Maintenance Bays	S-2	II-B	---	1,920	6.4	Yes	---	---	---	---	---	---	---	Int	---	
Office	B	V-B	---	1,000	10	Yes	---	---	---	---	---	---	---	Int	---	
Restroom 1	B	V-B	---	56		Yes	---	---	---	---	---	---	---	Int	---	
Restroom 2	B	V-B	---	56		Yes	---	---	---	---	---	---	---	Int	---	
Electrical Workshop & Storage	F-2	II-B	---	624	2.08	Yes	---	---	---	---	---	---	---	Int	---	
Subtotal-net square footage				3,656	14		2	3	55'							
New Maintenance Building																
Lube Bay	F-2	II-B	---	768	2.56	Yes	---	---	---	---	---	---	---	Int	---	
Heavy Equipement Bay	F-2	II-B	---	768	2.56	Yes	---	---	---	---	---	---	---	Int	---	
Tools Storage	F-2	II-B	---	667	2.2233	Yes	---	---	---	---	---	---	---	Int	---	
Parts Storage	F-2	II-B	---	934	3.1133	Yes	---	---	---	---	---	---	---	Int	---	
Fabrication Shop	F-1	II-B	---	367	1.2233	Yes	---	---	---	---	---	---	---	Int	---	
Flamable Storage	F-1	II-B	---	367	1.2233	Yes	---	---	---	---	---	---	---	Int	---	
Subtotal-net square footage				3,871	13	Yes	2	5	55'	---	---	---	---	Int	---	
Subtotal-net square footage Maintenance				11,183												

ABBREVIATIONS	
AC/HR	Air Changes per Hour
Cont	Continuous
Int	Intermittent
N/A	Not Applicable
Sqft	Square Feet

Net: Usable Sqft Calculation

* Assumed (E) remodeled administratibe building with sprinklers.

* Assumed (N) lab addition with sprinklers.

City of Bend

Water Reclamation Facilities Plan

TECHNICAL MEMORANDUM NO. 10
ENVIRONMENTAL ASSESSMENT

April 2008

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

CITY OF BEND

WATER RECLAMATION FACILITIES PLAN

TECHNICAL MEMORANDUM
NO. 10

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ENVIRONMENTAL ASSESSMENT

1.0 PURPOSE AND NEED FOR THE PROJECT

As the City of Bend continues to experience rapid population growth, the need to expand its wastewater treatment system is imperative to continue to protect the surrounding environment. The Water Reclamation Facility (WRF), constructed in 1981, has served the community well, aided by timely upgrades to keep the facilities modern and in compliance with ever tightening regulations. Now, with Bend as the sixth-fastest-growing metropolitan area in the United States, the WRF is approaching its capacity limits and is due for a major expansion.

1.1 Project Description

A summary of the recommended improvements is provided below:

1.1.1 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. 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, two filtrate side stream aeration basins, and two secondary clarifiers.
- Addition of blowers, including expansion of the blower, and expansion of RAS and WAS pumping capacity.
- Addition of one chlorine contact basin and replacement of the existing gaseous chlorination system with liquid hypochlorite.

1.1.2 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.

1.1.3 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.

1.1.4 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.

A site plan showing the recommended improvements is provided in Figure 1.

1.2 Purpose and Need for the Project

Improvements to the WRF and collection system facilities are required for the following reasons:

- Increase the capacity and/or reliability of WRF liquid stream, solids stream, and ancillary facilities to serve future growth.
- Comply with regulatory standards pertaining to water quality.

The 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. Discharge permit requirements are summarized in Table 1 below. A portion of the WRF effluent is treated to Level IV reclaimed water standards; additional regulatory requirements for reclaimed water are included in the table.

The Facilities Plan included a detailed analysis of potential future groundwater impacts from the plant discharge. The evaluation found that the current discharge limit of 10 mg/L total nitrogen is protective of groundwater quality. As such, the recommended improvements identified in the Facilities Plan are based on continuing to meet the current requirements.

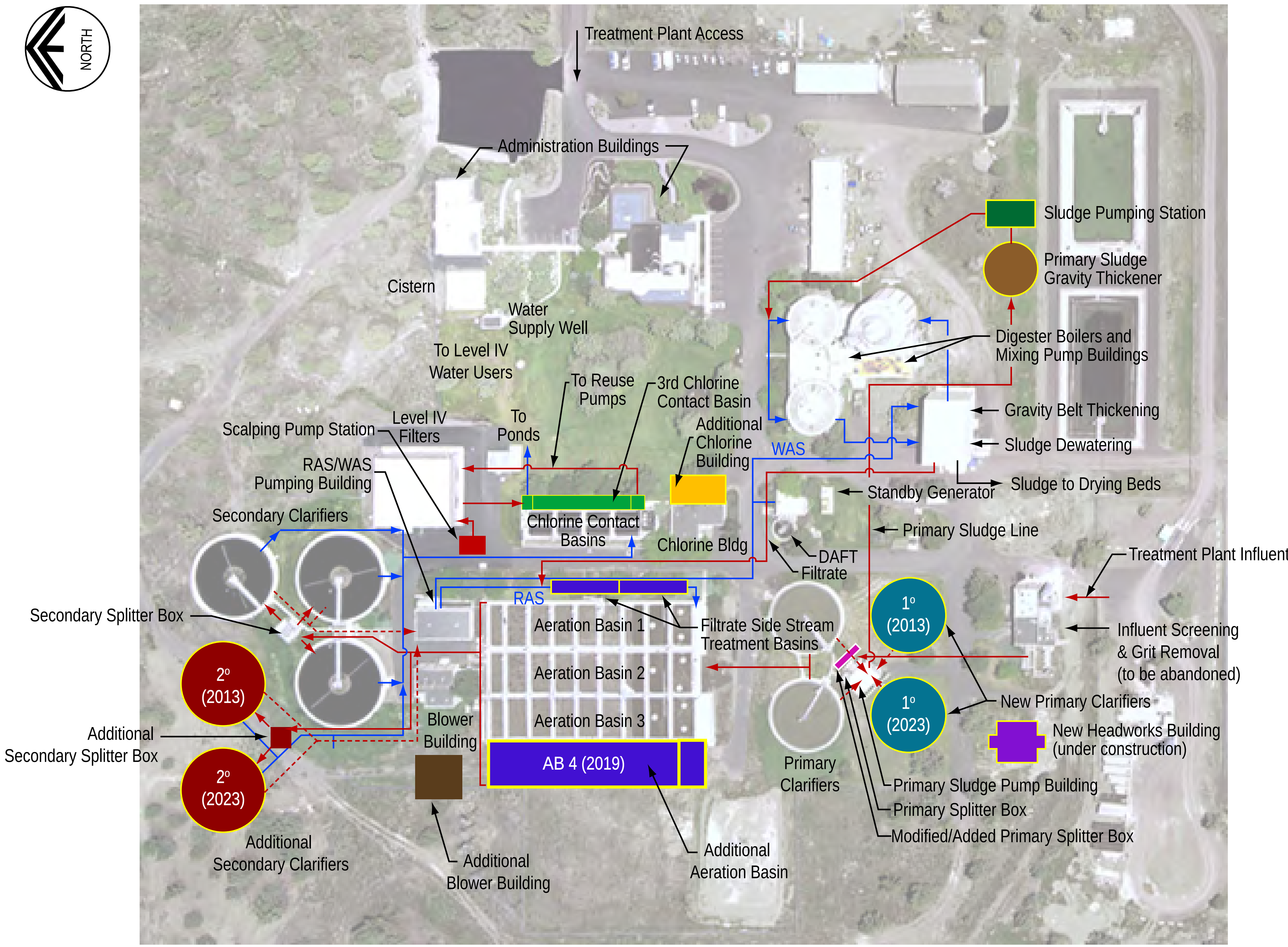

Figure 1
Recommended Facilities Expansion
WATER RECLAMATION FACILITIES PLAN
CITY OF BEND

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Table 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				
Additional Requirements for Level IV Reclaimed Water:					
Total coliform	Shall not exceed a 7-day median of 2.2 organisms/100 mL, and no single sample may exceed 23 organisms/100 mL.				
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.				

Notes:

1. Based on average dry weather design flow of 7.0 mgd

2. FC = Fecal coliform

The treatment facilities will be designed to accommodate all flows and loadings as listed above. Effluent from the WRF may be applied either to the evaporation/percolation pond system, or as reclaimed water. To conservatively assess the capacity requirements of the evaporation/percolation pond system, it was assumed that reclaimed water consumption would continue at current levels (260 acre-feet per year).

2.0 ALTERNATIVES TO THE PROPOSED ACTION

2.1 WRF Upgrade and Expansion Alternatives

Upgrade alternatives to proposed project for the liquids, solids, and support systems were evaluated during preparation of the City of Bend Water Reclamation Facilities Plan. This information and analysis is set forth in the Facility Plan. A comparison of major treatment upgrade options is presented below:

- Liquid treatment. Three different configurations for expanding the existing process were evaluated. The first alternative kept the existing aeration basins and continued expansion with identical basins. The second alternative reduced the anoxic volume of the basin, thereby increasing the aerobic volume and nitrification capacity. The final alternative involved a side stream treatment of the filtrate from the dewatering process. In this process, a small aeration basin is used to treat a blend of RAS and the high-ammonia dewatering filtrate, reducing loadings on and increasing capacity of the main aeration basins. The filtrate reaeration option was recommended. This option has the smallest basin footprint; therefore, it has the lowest environmental impact. The recommended filtrate reaeration option was also compared to a membrane bioreactor (MBR) approach. The filtrate reaeration and MBR options have comparable footprints, but the MBR has a much higher energy demand and requires a significantly greater maintenance requirement due to the need for membrane replacement. Both of these considerations make the filtrate reaeration an environmentally sound option compared to the MBR system. The MBR approach also has a present worth cost of $21 million compared to the present worth cost of $14 million for the filtrate reaeration option.

- Peak flow treatment: Options considered included adding piping and controls to provide a “contact stabilization” mode of operation to allow full secondary treatment, flow equalization, and bypassing peak flows around the secondary treatment process. The contact stabilization approach was recommended. This option provides the highest level of treatment, lowest cost, and minimal capital improvements. Therefore, it has the lowest environmental impact.

- Disinfection: Conversion from gaseous to liquid hypochlorite was recommended. Gaseous chlorination has the lowest cost, but the liquid system was recommended due to the reduced risk to human health and the environment. UV disinfection was also considered, but was eliminated because it is cost-prohibitive.

- Solids Treatment: The recommended approach includes constructing new gravity thickeners, which will increase the size of the anerobic digesters. This provides significant cost savings, largely through the reduction in concrete, piping, and mechanical equipment associated with the digesters. The City will continue its “beneficial use” land application approach for biosolids reuse.

As previously mentioned, the recommended approach includes continued use and maximization of the City’s existing reclaimed water program. The recommended improvements provide treatment capability to meet the WRF permit requirements for discharge to either the effluent disposal ponds or for Level IV reclaimed water.

2.2 No Action Alternative

The No Action alternative is presented to identify the possible implications if the City elects not to, or is unable to, implement the recommended improvements to the WRF. The implications of this option may include:

1) Regulatory violations due to inability to meet NPDES permit requirements.

2) Inability to produce Level IV reclaimed water and continue with the City’s beneficial use program.

3) Inability to adequately stabilize biosolids, which would prevent beneficial use via land application.

4) Growth restrictions due to the inability to treat additional wastewater flow and load.

Ultimately, the No Action alternative would result in a significant net negative impact on the environment compared to the current approach.

3.0 AFFECTED ENVIRONMENT/ENVIRONMENTAL CONSEQUENCES

3.1 Land Use/Important Farmland/Formally Classified Lands

3.1.1 Affected Environment

There are no formally classified lands that will be affected by any portion of this project and no additional land will be purchased. The project will not affect any areas of farmland, prime forest land or prime rangeland.

The WRF resides on Deschutes County 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.

3.1.2 Environmental Consequences

The upgrades are consistent with current land use designations. Improvements to the WRF are at the existing site. Therefore existing land use practices will not be affected.

3.1.3 Mitigation

Mitigation is not necessary as no detrimental impacts are anticipated.

3.2 Floodplains

3.2.1 Affected Environment

Potential natural hazards within the Bend area include floods from the Deschutes River. Official flood hazard maps for the Bend area and Deschutes County are published by the Federal Emergency Management Agency (FEMA). The WRF site is approximately six miles from the Deschutes River and well removed from any identified flooding areas.

3.2.2 Environmental Consequences

None of the WRF improvements of the project are located near floodplains. Therefore, there is no anticipated impact on floodplains from these improvements.

3.2.3 Mitigation

Mitigation is not necessary as no detrimental impacts to floodplains are anticipated.

3.3 Wetlands

3.3.1 Affected Environment

There are no known wetland areas that will be impacted during any part of the proposed improvements to the WRF.

3.3.2 Environmental Consequences

None of the WRF improvements are located near wetlands. Therefore, there is no anticipated impact on wetlands from these improvements.

3.3.3 Mitigation

Mitigation is not necessary as no detrimental impacts to wetlands are anticipated.

3.4 Cultural Resources

3.4.1 Affected Environment

An archaeological reconnaissance survey of the City of Bend's ultimate effluent ponds were completed in 1982 and presented in the 'Cultural Resource Reconnaissance and Assessment within the City of Bend: Sludge Disposal and Ultimate Effluent Pond Areas' report. In this report, several sites were investigated as possible historical sites. However, no sites were added to the National Register of Historic Places.

3.4.2 Environmental Consequences

No aspects of the project are located near any registered historical sites or structures. Furthermore, no sites have been identified as being eligible for inclusion in the National Register of Historic Places and there are no anticipated impacts on cultural resources.

3.4.3 Mitigation

Mitigation is not necessary as no impacts to cultural resources are anticipated.

3.5 Biological Resources

3.5.1 Affected Environment

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.

3.5.2 Environmental Consequences

None of the WRF improvements of the project are anticipated to effect biological resources.

3.5.3 Mitigation

Mitigation is not necessary as the project as no impacts to biological resources are anticipated.

3.6 Water Quality Issues

3.6.1 Affected Environment

The disposal of the WRF disinfected effluent is accomplished using two seepage ponds that were added to the WRF around 1983. When the EIS was completed, seepage ponds were found to be environmentally acceptable and their use was allowed to continue under an Oregon-issued Water Pollution Control Facilities (WPCF) Permit.

3.6.2 Environmental Consequences

An impact analysis from several monitoring wells near the seepage ponds focused on nitrate-nitrogen and metal concentrations, two major constituents of water quality. The analysis determined that there was no likely adverse impact on groundwater quality and that the City will be providing the best practicable control of wastewater through the use of the seepage ponds.

3.6.3 Mitigation

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. Therefore, mitigation is not necessary as there is no anticipated impact to groundwater. However, the following recommendations were made: (1) recondition seepage ponds 3A and 3B prior to prevent rapid infiltration from occurring and (2) continue to monitor groundwater quality and report that information on the WRF's discharge monitoring reports.

3.7 Coastal Resources

The City of Bend is not located near any coastal areas. Therefore, there will be no impact to coastal resources as a result of this project.

3.8 Socio-Economical/Environmental Justice Issues

This project is not expected to have any negative socio-economic impacts. All improvements are confined to existing sites and no adverse human health effects are anticipated. This project will increase the capacity of the WRF and, therefore, will allow new residential and commercial growth in businesses to enter the area.

3.9 Miscellaneous Issues

3.9.1 Air Quality

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). 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.

During construction at the WRF, there will be some emissions from construction equipment and fugitive dust from construction activities. The magnitude of those emissions is expected to be minimal due to the small amount of excavation that is required.

3.9.2 Noise

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. 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.

The WRF improvements will not have any adverse noise impacts as there no residences in the vicinity of the WRF that would be disturbed by noise generated during construction.

4.0 SUMMARY OF MITIGATION

The project involves upgrades to existing sites on WRF property. There is no expected environmental impacts or consequences associated with this project.

5.0 CORRESPONDANCE

No correspondence is included in this report as additional information was not required from outside agencies.

6.0 EXHIBITS/MAPS

There are no additional exhibits or maps to present with this project.