DEQ PERMIT

NEIL GOLDSCHMIDT
GOVERNOR

Department of Environmental Quality

O[redacted]

811 SW SIXTH AVENUE, PORTLAND, OREGON 97204-1390 PHONE (503) 229-5696

SEP 26 1990

RECEIVED
OCT 1 1990
CITY OF
Klamath Falls

City of Klamath Falls Kent Cobban
Attn: Mr. Jim Keller, City Manager
P.O. Box 237
Klamath Falls, OR 97601

Re: Waste Disposal Permit
File No. 46763
Klamath County

We have completed our review of your application and the comments received regarding the preliminary draft permit which was mailed to you for final review on September 5, 1990, and have issued the enclosed NPDES Permit.

Please note that specific conditions of the permit are superceded by the Stipulation and Final Order finalized between the City and the Department on September 26, 1990. Both the enclosed permit and the Order establish the conditions under which your wastewater treatment facilities must be operated and maintained. Please, attach the permit to the Order for future reference.

The enclosed permit will be considered as the final action on the permit application number 999126.

You are urged to carefully read the permit and Order, and take all possible steps to comply with the conditions contained therein so there shall not be any pollution to the environment.

If you have any questions please contact Dick Nichols or Ralph Funk at this office.

Sincerely,

Lydia R. Taylor

Lydia R. Taylor
Administrator
Water Quality Division

Sign: Timothy J. Alling
Bob White
DD Dalrymple
Jeff Frick
Robert Carlson
Mike Sparks
Dwight Pratt
Mike Crutchfield

REF:crw
MW\WC7194
Enclosures: NPDES Permit
Stipulation and Final Order
cc: Central Region, DEQ
USEPA

cc: City Mgr.

SCHEDULE A

1. Waste Discharge Limitations not to be Exceeded After Permit Issuance.

a. Outfall Number 001 (Sewage Treatment Plant Discharge)

(1) June 1 - October 31:

Parameter	Average Effluent Concentrations Monthly	Weekly	Monthly* Average lb/day	Weekly* Average lb/day	Daily* Maximum lbs
a. BOD-5	20 mg/l	30 mg/l	1000	1500	2000
b. TSS	20 mg/l	30 mg/l	1000	1500	2000
c. FC/100ml	200	400			

(2) November 1 - May 31:

Parameter	Average Effluent Concentrations Monthly	Weekly	Monthly* Average lb/day	Weekly* Average lb/day	Daily* Maximum lbs
a. BOD-5	30 mg/l	45 mg/l	1500	2250	3000
b. TSS	30 mg/l	45 mg/l	1500	2250	3000
c. FC/100ml	200	400			

*Based on average dry weather design flow to the facility equaling 6 MGD.

(3) Other parameters

a. pH (year-round)	Shall be within the range 6.0 - 9.0
b. BOD and TSS Removal Efficiency	Shall not be less than 85% monthly average

c. Chlorine and ammonia nitrogen shall not be discharged at rates or in quantities that create acute toxicity within or chronic toxicity outside the allowable mixing zone specified in condition (4) of this Schedule.

(4) Not withstanding the effluent limitations established by this permit, no wastes shall be discharged and no activities shall be conducted which violate Water Quality Standards as adopted in OAR 340-41-965 except in the defined mixing zone:

The allowable mixing zone shall not extend beyond that portion of the Klamath River (Lake Ewauna) within a radius of 100 feet from the point of discharge.

Toxics: (continued)

Total Phenols (See Note 1/)	Semi Annual using 3-consecutive days between Monday and Friday.	24-hr daily composite (See note 2/)
Toxics Removal	Annually	Calculation 3/
Biomonitoring	Bioassay of effluent from Outfall 001 2 times per year	Acute and chronic bioassay.
Nutrients: NO_2+NO_3-N, TKN Total Phosphate as P, Dissolved Ortho-Phosphate as P.	Monthly between May 1, and ending October 31 of each year.	Grab
Ammonia-Nitrogen	Monthly	Grab

c. Sludge Management

Item or Parameter	Minimum Frequency	Type of Sample
Drying Bed sludge analysis including: Total solids (% dry wt.) Volatile solids (% dry wt.) Nitrogen NH_3-N; NO_3-N; & TKN (% dry wt.) Phosphorus (% dry weight) Potassium (% dry wt.) Total metals content for Ag; As; Hg; Pb; Zn; Cu; Cr; Ni; Cd; Cyanide; and total Phenols (mg/kg) pH (standard units)	Semi-annually	Composite sample to be representative of the drying bed product to be land applied (See Note 4/)

2. Reporting Procedures

Monitoring results shall be reported on approved forms. The reporting period is the calendar month. Reports must be submitted to the Department by the 15th day of the following month.

b. Following agreement between the permittee and the Department on appropriate test procedures, the permittee shall initiate bioassay testing on Outfall 001 in accordance with Schedule B and the approved test procedures. Any change in bioassay test procedures must be approved by the Department.

c. The bioassay tests shall be conducted semi-annually beginning in 1991, using the approved chronic and acute bioassay tests on the selected species. After 1991 and for the duration of the permit, testing shall be conducted semi-annually using the most sensitive test species approved by the Department. If any one test indicates that the effluent sample is toxic, another toxicity test using the same species and the same methodology shall be conducted within two weeks.

5. Unless required otherwise by the Environmental Quality Commission (EQC), within twelve (12) months following adoption of a total maximum daily load for the Klamath River, the permittee shall submit a complete facilities plan report for providing upgraded and expanded wastewater treatment facilities as needed to:

a. Meet waste load allocations determined by the Department for attaining water quality standards in the Klamath River pursuant to a Total Maximum Daily Loan established by the EQC;

b. Accommodate the sewage load from the Kingsley Field Sewage treatment Plant if the proposal to take that plant out of service is implemented;

c. Determine the remaining useful life of the existing facility and the alternative for upgrading and/or replacing worn out equipment and facilities.

d. Assure that any toxic impact of the permittee's discharge complies with Oregon Administrative Rule (OAR) 340-41-965(2)(p) for toxic substance and OAR 340-41-965(4) for mixing zone.

e. The facility plan report shall include a design and construction schedule for upgrading and expanding the wastewater treatment facilities.

6. The permittee is expected to meet the compliance dates which have been established in this schedule. Either prior to or no later than 14 days following any lapsed compliance date, the permittee shall submit to the Department a notice of compliance or noncompliance with the established schedule. The Director may revise a schedule of compliance if he determines good and valid cause resulting from events over which the permittee has little or no control.

c. When the designated supervisor(s) are not available, have an operator available who is certified no less than one grade level below the system classification. This condition applies to system owners who designate supervisors to be fully responsible for system operation in lieu of the designated supervisor (if any are designated by the permittee) and any temporary supervisor so designated by the permittee. A system shall not be without an individual certified at the classification of the system for more than 30 days.

d. Notify the Department in writing within 30 days of replacement or redesignation of operators identified as responsible for supervising the operation of the wastewater systems.

e. File with the Department at the time of permit renewal the name of the properly certified operator(s) designated the responsibility of supervising the operation of the wastewater treatment and collection systems.

4. The permittee shall implement the bioassay toxicity testing program specified in Schedules B and C of this NPDES permit. If the results of the bioassay tests indicate toxicity, the permittee shall further evaluate the effluent and its effect on the receiving stream. If these tests confirm toxicity of the effluent, the permittee will evaluate methods and develop a plan to eliminate the toxicity. Upon approval by the Department, the permittee will implement the plan and the process will be continued until the toxicity has been eliminated.

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Technical Memorandum 1
Condition Assessment

1.1 Introduction

In assessing the current condition of the Spring Street Wastewater Treatment Plant (WWTP), CDM with treatment staff performed a site evaluation of the treatment plant. This site evaluation involved walking through the site and visually observing the WWTP processes and developing a baseline condition that represents the "as is" condition for plant assets.

Although no recognized industry standard grading system exists in the United States, the common method is to assign a numerical rating or grade to each process at the WWTP. While the process is subjective, it is a consistent approach and methodology that results in similar outcomes regardless of who assigns the condition grade.

During the assessment, CDM with staff from the City established a condition grade for each process located at the site. This involved two parts: 1) taking a color photo of the equipment showing its general type; and 2) providing a description of the general condition including a numeric score as described in Table 1-1.

Figure 1-1 provides a summary of the condition assessment scores and timeline for the recommended improvements at the Spring Street WWTP.

Figure 1-1: Condition Assessment Summary

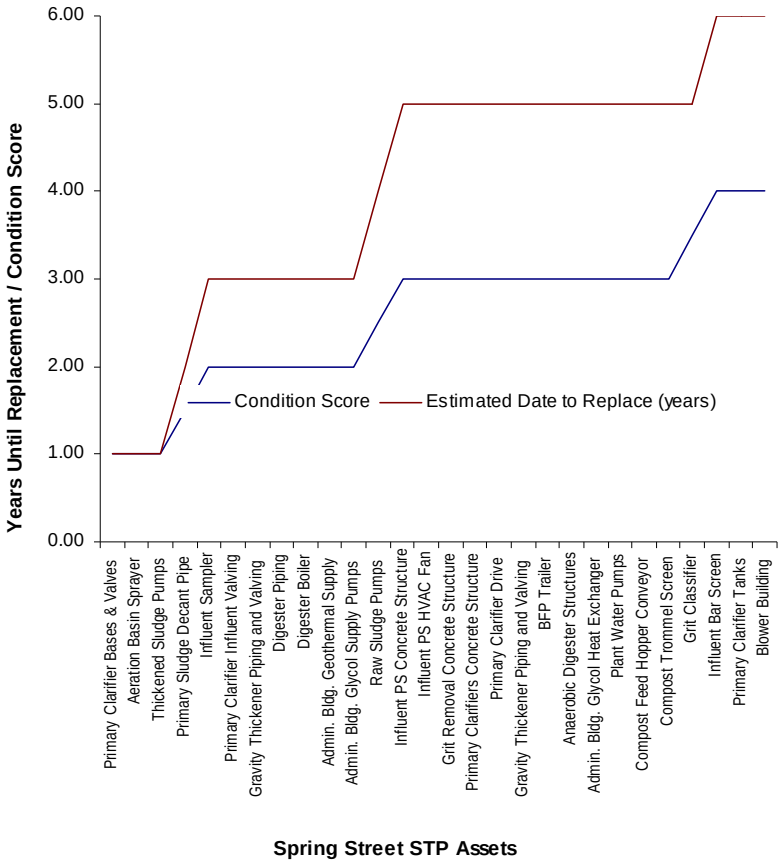


Table 1-1: Condition Grade Description

Score	Condition	Description	Short-Term Failure Risk	Expected Service Life
10	Very Good	Meets all operational, functional, safety, and regulation requirements. All individual components are operable and maintained.	Not Applicable	Expected to perform adequately with routine maintenance for at least 15 to 20 years.
8	Good	Exhibits signs of minor wear that results in minimal impact on performance and/or operating and maintenance costs.	Minimal	Potential for further deterioration or impaired performance over next 10-15 years. Renewal or replacement should be considered within 15 years.
6	Acceptable	Operationally and functionally sound, but exhibiting signs of wear that result in diminished performance and/or moderate impact on operating and maintenance costs. Corrective maintenance required but asset is serviceable.	Moderate	Further deterioration or impaired performance expected over next 5-10 years. Renewal or replacement should be considered within 10 years.
4	Fair	Functional and operational but exhibiting signs of substantially diminished performance and/or high impact on required level of maintenance or high operating cost. Substantial rehabilitation work required, asset barely serviceable.	High	Further deterioration expected renewal or replacement should be considered within 3-6 years.
3	Poor	Functional and operational exhibiting signs of imminent failure. Excessive maintenance work required. Significant operational, functional, health, and safety hazard.	Very High	Further deterioration or impaired performance expected over next 1-3 years. Renewal or replacement should be considered within 3 years.
1	Very Poor	Non-operational or exhibiting unacceptable extreme signs of failure.	Failed	Asset failed or failure is imminent. Excessive maintenance required. No further service life expectancy. Major work or replacement is required.

1.2 Headworks

The Department of Environmental Quality (DEQ) considers the capacity of a pump station to be the combined capacity of all pumps minus the capacity of the largest pump. The influent lift station is rated at 7.8 MGD. Sufficient capacity exists in the pump station. The overall wet well concrete structure is in good shape; however, the ladder should be replaced based on its poor condition. The actual pump house is beginning to show deterioration. The parts list and headworks condition are described in Table 1-2 and the condition grade summary is described in Table 1-3.

Table 1-2: Headworks Condition

No.	Part List	Condition Grade	Comment
1	Concrete Structure	3.00	Wear and structural problems based on age.
2	Raw Sampler – ISCO 2700	2.00	Sampler showing age. Refrigeration unit has failed, and parts are difficult to acquire.
3	Influent Pump No. 1	7.00	Auto lead lag & hours recorded by plant staff.
4	Influent Pump No. 2	9.00	Auto lead lag & hours recorded by plant staff. (Rehabilitated 3/04).
5	Influent Pump No. 3	7.00	Auto lead lag & hours recorded by plant staff.
6	Sump Pump	6.00	Acceptable condition.
7	HVAC Fan	3.00	HVAC system for Headworks Building consists of a squirrel cage fan (see photo).
8	Manual Hoist	5.00	Original Equipment (OEM).
9	Bar Screen	4.00	Manual bar screen. Needs replacing and automated once replaced.
10	Recycle Sampler	8.00	Improvements were made 6/05.
11	Raw Pumps / Primary Sludge Pumps	6.00	Drives are new – 6/05. Sidewalk drains are not draining.

Photo 1-1: Headworks Building

The headworks is clean and well organized. Maintenance staff routinely inspects and performs basic maintenance on pumps and motors. There is a manual bar screen that requires an operator to clean it. The overall condition assessment score for the headworks is 5.45. This score indicates that the headworks is operationally and functionally sound, but continues to exhibit signs of wear.

Photo 1-2: Headworks Building Ventilation Fan

Photo 1-3: Influent Pumps

1.2.1 Condition Grade Overview

The condition grade summary in Table 1-3 indicates the top priority for rehabilitating or replacing headworks assets within the next 3 to 6 years.

Table 1-3: Headworks Condition Grade Summary

No.	Part List	Condition Grade	Comment
1	Concrete Structure	3.00	Wear and structural problems based on age. Based on Asset Register, no improvements have been budgeted for this equipment.
2	Raw Sampler – ISCO 2700	2.00	Sampler showing age.
7	HVAC Fan	3.00	No comment.
9	Bar Screen	4.00	Manual bar screen. Needs replacing and automated once replaced.

The headworks is the original 1956 structure. It has been well maintained but likely will become a problem for the City within the next 5 to 10 years. Additional structural testing may be necessary, and a plan should be developed to replace the current structure. In a previous study it was recommended that a new influent pumping station be built on the south side of the existing structure. This still appears to be an option and should be considered when making a decision.

1.2.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for replacement of the existing structure.

1.3 Grit Removal

The grit channel is designed to provide a velocity of 1 foot per second (ft/s) at a flow of 18 MGD. The Grit Channel condition and recommended replacement parts list are described in Table 1-4.

Photo 1-4: Grit Channel

Table 1-4: Grit Removal Condition

No.	Part List	Condition Grade	Comment
1	Concrete Structure	3.00	Crumbling concrete (structural wear).
2	Grit Collector / Channel	8.00	Operates satisfactorily. Fiberglass recently replaced.
3	Heliseive (Screening)	7.00	Good shape. The Heliseive was manufactured in Germany and there is a long turnaround time for replacement parts. Maintenance personnel recognize the long lead time for parts.
4	Heliseive Bypass MOV	6.00	Motor Operated Valve – Ultrasonic control level in good shape.
5	Grit Classifier	3.50	Chain needs replacing – flights are missing.

The grit removal area is clean and well organized. Maintenance staff routinely inspects the location and performs basic maintenance on the grit channel. This is the original grit channel and there are several noticeable cracks. The screening process is in good shape. Maintenance personnel recognize that replacement parts must be ordered far in advance.

Photo 1-5: Crack in Grit Channel Structure

Photo 1-6: Crack in Concrete Stairs

There is significant amount of separation at the expansion joint where approximately three inches of separation exists. The overall condition assessment score for the grit channel is a 5.50.

1.3.1 Condition Grade Summary

The following condition grade summary indicates the top priority for rehabilitating or replacing the following grit removal assets within the next 3 to 6 years.

Table 1-5: Grit Removal Condition Grade Summary

No.	Part List	Condition Grade	Comment
1	Concrete Structure	3.00	Crumbling concrete (structural wear).
2	Grit Classifier	3.50	Chain needs replacing – flights are missing.

1.3.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for replacement of the existing Grit Removal Structure.

1.4 Primary Sedimentation Basins

The rectangular primary sedimentation basins have an average hydraulic loading rate of 600 gallons per day per square foot (gpd/sf). Basin hydraulic loading is 2,300 gpd/sf at a flow of 18 MGD. The basins were constructed approximately 50 years ago. The condition and recommended parts list of the Primary Sedimentation are described in Table 1-6.

Table 1-6: Primary Sedimentation Condition

No.	Part List	Condition Grade	Comment
1	Concrete Structure	2.00	Aggregate is showing below water line.
2	Primary Sludge Decant Piping	1.50	Very poor condition. Significant rust and corrosion visible.
3	Primary Clarifier Bases & Valves	1.00	Valves have failed.
4	Influent Valving	2.00	Poor condition, but still operable.
5	Primary Clarifier Drive	3.00	Drive in poor condition – Replacement drives on shelf.
6	Effluent Weir	6.00	Fiberglass replaced in 1990 – not level and leaking.
7	Scum Collector	6.00	Leaking.
8	Primary Effluent Sampler	5.00	Difficult to get replacement parts.
9	Effluent Sampler Building	5.00	Buildings showing wear.
10	Primary Tanks	4.00	Tanks showing wear. Short circuiting is evident.
11	Raw Sludge Pumps	2.50	Impeller worn in one pump; both pump volutes need repair/replacing. One motor needs repair/replacement.

Chain and flight sludge collection mechanisms transport the sludge to the upstream ends of the basin. The sludge is continuously drawn by gravity into the sludge hopper. Two centrifugal sludge pumps transfer the sludge to the gravity thickener. The pumps are rated at 200 gallons per minute (gpm) and are automatically activated once the sludge reaches a certain level in the hopper.

The primary clarifiers were rehabilitated in 1991 and 1992. The rehabilitation work involved patching concrete to cover exposed reinforcing steel, sandblasting and coating concrete surfaces, installing new non-metallic chain and flight sludge collector mechanisms, repairing the scum skimmers, and installing new v-notch effluent weirs. Even though a significant amount of work was performed in 1991, the primary sedimentation basins are showing significant wear and deterioration.

Photo 1-7: Primary Sedimentation Basins

Photo 1-8: Primary Clarifier Effluent Weir

The overall condition assessment score for the sedimentation basins is 3.45. The structure is functioning and operational but is exhibiting significant signs of deterioration. The overall structure should be considered for renewal in the immediate future.

1.4.1 Condition Grade Summary

The condition grade summary in Table 1-7 indicates the top priority for rehabilitating or replacing primary sedimentation assets within the next 3 to 6 years.

Table 1-7: Primary Sedimentation Condition Grade Summary

No.	Part List	Condition Grade	Comment
1	Concrete Structure	3.00	Aggregate is showing below water line.
2	Primary Sludge Decant Piping	1.50	Significant rust and corrosion visible. Very poor condition.
3	Primary Clarifier Bases & Valves	1.00	These valves have failed.
4	Influent Valving	2.00	Poor condition but still operable.
5	Primary Clarifier Drive	3.00	Drive in poor condition – Replacement drives on shelf.
8	Primary Effluent Sampler	5.00	Difficult to get replacement parts.
9	Effluent Sampler Building	5.00	Buildings showing wear.
10	Primary Tanks	4.00	Primary tanks showing wear / losing efficiency.
11	Raw Sludge Pumps	2.50	Impeller worn in one pump; both pump volutes need repair/replacing. One motor needs repair/replacement.

Photo 1-9: Primary Sedimentation Basins - Exposed Aggregate on Concrete Catwalk

1.4.2 Budget

There is approximately $250,000 budgeted in the Annual Facilities Plan/Capital Improvement Program to provide structural and mechanical rehabilitation for the 50 year old units.

1.5 Secondary Treatment System

The six aeration basins have a total combined volume of 100,000 cubic feet. Three 1,000- cfm positive-displacement blowers provide air to the diffusers. The aeration basins are in good structural condition. The basins interior and exterior concrete was sealed and recoated in 2001.

In 2001 the aeration basins were upgraded to include a selector zone, consisting of anoxic basins that mixed the wastewater without introducing any oxygen. This zone served to "select" against filamentous organisms that interfered with settling in the secondary clarifiers. The anoxic zones are equipped with submerged mixers and surface sprayers to reduce the buildup of foam on the wastewater surface. The sprayers are inoperable.

The aeration basins are equipped with dissolved oxygen (DO) probes that automatically control the DO level in each basin. The local control boxes have suffered water damage due to improperly installed electrical conduit.

The steel motor control center (MCC) building is in excellent structural condition. The parts list and condition of the Secondary Treatment System are described in Table 1-8.

Table 1-8: Secondary Treatment System Condition

No.	Part List	Condition Grade	Comment
1	Aeration Basin Concrete Structures	8.00	No structural issues.
2	Air Diffusers (WYSS Diffusers)	6.00	Acceptable condition.
3	DO Control	6.00	Acceptable condition.
4	Header Piping	8.00	Good shape / no problems.
5	DO Probes (6 probes)	7.00	Good shape / no problems.
6	Blower Building	4.00	Building showing its age.
7	Blower 1	9.00	New motor controls.
8	Blower 2	6.00	New blower and motor.
9	Blower 3	9.00	New blower and motor.
10	DO Control Panels	6.00	Water damage in local control panels.
11	Aeration Basin Sprayers	1.00	Inoperable.
12	Piping	6.00	Acceptable condition.
13	Motor Hoist	5.00	Original Equipment.
14	MLSS Recycle Pump	9.00	Good shape / no problems.
15	Anoxic Basin Mixers	6.00	Acceptable condition.
16	Air Diffusers	6.00	Acceptable condition.

The overall condition assessment score for the sedimentation basins is 6.38. The structure is functioning and operational but is exhibiting signs of minor wear that has not affected the overall process. There are no significant maintenance costs.

1.5.1 Condition Grade Summary

The condition grade summary in Table 1-9 indicates the top priority for rehabilitating or replacing the following secondary treatment system assets within the next 3 years.

Table 1-9: Secondary Treatment System Condition Grade Summary

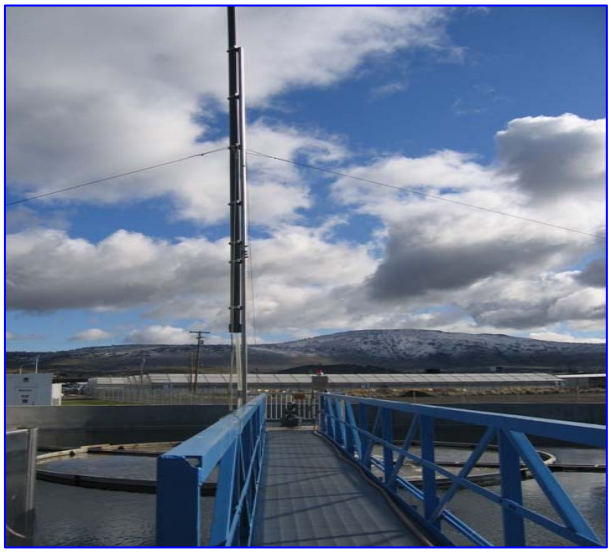
No.	Part List	Condition Grade	Comment
11	Aeration basin sprayers	1.00	Inoperable.

1.5.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for any secondary treatment system improvements.

1.6 Secondary Clarifiers

Based on existing information, the newest secondary clarifier serves as the lead clarifier during most flow conditions. It has a hydraulic loading rate of 390 gpd/sf. The loading increases to 1,160 gpd/sf when operating at its design flow rate of 11 MGD. Scum is collected with a full-diameter skimmer and is pumped to the dissolved air flotation thickener (DAFT). The parts list and condition ratings of the secondary clarifiers are described in Table 1-10.



Photos 1-10: Secondary Clarifiers

Table 1-10: Secondary Clarifiers Condition

No.	Part List	Condition Grade	Comment
1	Concrete Structure	8.00	No structural issues.
2	Existing Offline	6.00	Acceptable condition.
3	Existing RAS Pumps	3.00	Fair condition. DC drive units are in poor condition (Rating of 1.50).
4	Scum Pumping System	8.00	Vaughn Chopper Pump.
5	Secondary Effluent Sampler	6.00	Acceptable condition.
6	WAS 1	8.00	Good shape / no problems.
7	WAS 2	8.00	Good shape / no problems.
8	WAS 3	8.00	Good shape / no problems.
9	Piping	8.00	Good shape / no problems.
10	MCC Building 2A	8.00	Good shape / no problems.
11	New RAS Pump 1	8.00	Good shape / no problems.
12	New RAS Pump 2	8.00	Good shape / no problems.
13	Old RAS Pump 1	3.00	Old, drive unit in poor condition.
14	Old RAS Pump 2	3.00	Old, drive unit in poor condition.

Two 2,100- gallon per minute (gpm) return activated sludge (RAS) pumps return sludge to the aeration basins. Three 70-gpm waste activated sludge (WAS) pumps (two duty, one standby) remove a small portion of waste sludge each day and pump it to the DAFT. Alternatively, WAS may be returned to the headworks and co-thickened with raw sludge in the gravity thickener. All pumps have DC motors with variable speed drives, although these pumps are not used. Mixed liquor recycle pumps are provided at the Spring Street Facility to promote denitrification. Submerged mixers in each of the two anoxic basins provide mixing without introducing air into the basins to select against filamentous growth.

The older secondary clarifier (Secondary Clarifier #1) is placed in service during high wastewater flow to the plant (>7.0 MGD). This clarifier has two 2,100-gpm RAS pumps located in the lower level of the Old Chlorine Room.

Photo 1-11: New RAS Pumps for Secondary Clarifier #2

Photo 1-12: Old RAS Pumps for Secondary Clarifier #1

WAS is diverted from the RAS pipe and is pumped with a 115-gpm centrifugal WAS pump to the plant headworks. The RAS pumps for Secondary Clarifier #1 are equipped with variable speed DC motor drives.

The concrete structure is in good condition. In 2001, there was sandblasting and recoating of steel structures that have minimized the rusting in the area. The overall condition assessment score for the secondary clarifiers is 6.64.

1.6.1 Condition Grade Summary

The condition grade summary indicates assets are considered beyond 15 years in terms of needing rehabilitation or replacement.

1.6.2 Budget

Currently, as appropriate, no budget exists in the Annual Facilities Plan/Capital Improvement Program for the secondary clarifiers.

1.7 Disinfection System

A single chlorine contact basin provides approximately two hours of contact time at average flow and 30 minutes of contact time at a flow of 18 MGD. There is no backup chlorine contact basin at the facility. A structural evaluation has never been performed since the tank has never been emptied for testing. A sludge pump, called the Humus Pump, periodically pumps sludge that has accumulated on the bottom to the head end of the primary clarifiers. The parts list and condition ratings of the disinfection system are described in Table 1-11.

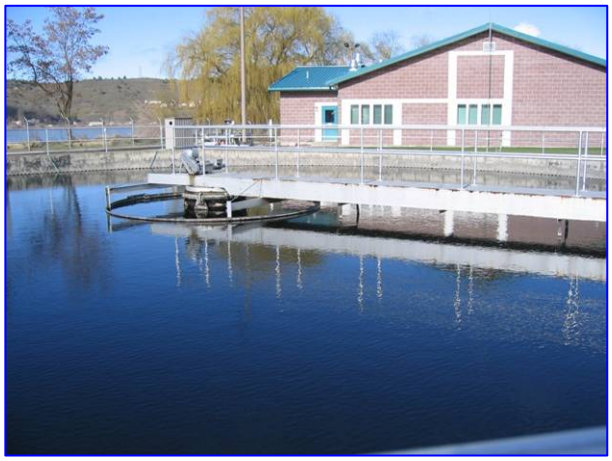


Photo 1-13: Chlorine Contact Tank

Table 1-11: Disinfection System Condition

No.	Part List	Condition Grade	Comment
1	Chlorine Contact Basin	6.50	There is no backup basin for disinfection.
2	Effluent Flow Meter	6.00	Calibrated twice per year as required by permit.
3	Humus Pump	7.00	Humus pump.

The overall condition assessment score for the chlorine contact tank is 6.50.

1.7.1 Condition Grade Summary

The condition grade summary indicates assets are considered beyond 10-15 years in terms of needing rehabilitation or replacement.

1.7.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for disinfection system improvements.

1.8 Effluent Cogeneration System

The cogeneration plant is located in southwest Klamath Falls and provides electricity for the region. The cogeneration plant requires a steady flow of 3.4 MGD of cooling water which is provided from the Spring Street Plant's treated effluent. The cogeneration structure consists of the following assets and condition ratings, listed in Table 1-12.

Photo 1-14: Effluent Cogeneration Plant

Table 1-12: Effluent Cogeneration System Condition

No.	Part List	Condition Grade	Comment
1	Cogeneration Diversion Structure	8.00	Good condition – no problems indicated.
2	Blowdown Piping	8.00	Good condition – no problems indicated.
3	Blowdown Valves	8.00	Good condition – no problems indicated.
4	Altitude Valves	8.00	Good condition – no problems indicated.
5	Blowdown Flow Meter	8.00	Good condition – no problems indicated.

The overall condition assessment score for the effluent cogeneration system is 8.00.

1.8.1 Condition Grade Summary

The condition grade summary indicates assets are considered beyond 10-15 years in terms of needing rehabilitation or replacement.

1.8.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for the effluent cogeneration system.

1.9 Effluent Sampler / Flow Meter

The plant flow is measured at the inlet to the chlorine contact basin with a propeller meter. The plant discharge permit requires accuracy of meters be verified. The meter is removed semi annually and sent to the manufacturer for calibration. The effluent sampler and flow meter consists of the following assets and condition ratings listed in Tables 1-13 and 1-14.

Table 1-13: Effluent Sampler Condition

No.	Part List	Condition Grade	Comment
1	Structure	8.00	Good condition.
2	ISCO Model 3710 Sampler	6.00	Acceptable condition.

Table 1-14: Effluent Flow Meter Condition

No.	Part List	Condition Grade	Comment
1	Structure	8.00	Good condition.
2	Sparling Flow Meter	6.00	Acceptable condition.

Photo 1-15: Effluent Flow Meter

The overall condition assessment score for the effluent sampler and flow meter is 7.00.

1.9.1 Condition Grade Summary

The condition grade summary indicates assets are considered beyond 10-15 years in terms of needing rehabilitation or replacement.

1.9.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital improvement Program for the effluent sampler and flow meter.

1.10 Effluent Pump Station

The effluent pump station consists of the following asset and condition rating listed in Table 1-15.

Table 1-15: Effluent Pump Station Condition

No.	Part List	Condition Grade	Comment
1	Effluent Pumps – 2	8.00	Variable Frequency Drive (VFDs).

Photo 1-16: Effluent Pump Station

The overall condition assessment score for the effluent pump station is 8.00.

1.10.1 Condition Grade Summary

The condition grade summary indicates the asset is considered beyond 10-15 years in terms of needing rehabilitation or replacement.

1.10.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for the effluent pump station.

1.11 Sludge Thickener

The gravity thickener receives raw sludge and raw scum. Effluent from the gravity thickener passes over a v-notch weir and flows by gravity to the influent pumping station wet well via the tank drain manhole. Scum and thickened sludge are pumped to the anaerobic digester by three progressive cavity pumps. Raw sludge and scum also may be pumped to the dissolved air flotation thickener (DAFT). This is the

preferred method of thickening raw sludge. The sludge thickening consists of the following assets and their condition ratings listed in Table 1-16.

Photo 1-17: Gravity Thickener

Table 1-16: Sludge Thickener Condition

No.	Part List	Condition Grade	Comment
1	Gravity Thickener Drive	6.00	Rebuilt in 2006.
2	Gravity Thickener Structure	6.00	Acceptable condition.
3	Gravity Thickener Piping And Valving	2.00	Very poor condition. All valves difficult to operate.
4	Thickened Sludge Pumps	1.00	Very inefficient and in poor condition.

The overall condition assessment score for the gravity thickener is 3.75.

1.11.1 Condition Grade Summary

The condition grade summary in Table 1-17 indicates the top priority for rehabilitating or replacing sludge thickening assets within the next 3 to 6 years.

Table 1-17: Sludge Thickener Condition Grade Overview

No.	Part List	Condition Grade	Comment
3	Gravity Thickener Piping And Valving	2.00	Very poor condition. All valves difficult to operate.
4	Thickened Sludge Pumps	1.00	Very inefficient and in poor condition.

1.11.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for the gravity thickener.

1.12 Dissolved Air Flotation Thickener (DAFT)

The U.S. Filter DAFT receives waste activated, and primary thickened sludge, plus a small fraction of scum. The two-meter DAFT operates continuously, with the combined thickened sludge pumped to the digester by a single thickened sludge pump. No backup pump is available, although, with minor pipe modification, the thickened bottom sludge (TBS) pump could provide backup pumping of thickened sludge. Currently, the TBS pump only operates a few hours per week. The dissolved air flotation thickener consists of the following assets and conditioning ratings listed in Table 1-18.

Photo 1-18: Dissolved Air Flotation Thickener (DAFT)

Table 1-18: Sludge Thickening Condition

No.	Part List	Condition Grade	Comment
1	DAFT	8.00	24/7 operation. No backup DAFT exists.
2	Air Saturation Tank	7.00	Good condition – no problems indicated.
3	DAFT Subnatant Pump #1	5.00	Pump has history of bearing failure.
4	DAFT Subnatant Pump #2	6.00	Good condition – no problems indicated.
5	Thicken Sludge Pump	6.00	No problems indicated.
6	Bottom Sludge Pump	8.00	Operates once per week.
7	Flow Meter	7.00	Good condition – no problems indicated.
8	Polymer Feed System	5.00	Handling of 55-gal drums performed manually.

The overall condition assessment score for the effluent pump station is 5.78.

1.12.1 Condition Grade Summary

The condition grade summary indicates assets are considered not in any immediate need of rehabilitation or replacement.

1.12.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for the dissolved air flotation thickener.

1.13 Sludge Dewatering System

There is a single trailer-mounted belt filter press (BFP). The 1.5 meter Alrick BFP is capable of dewatering all the digested sludge produced by the Spring Street Facility. A small polymer make-down system provides polymer solution to the BFP to aid in dewatering the digested sludge, using plant effluent as the source water for making the polymer solution. The BFP and polymer feed system are in good condition. Dewatered sludge cake is conveyed to a dump truck that is used to transport the cake to the composting facility located adjacent to the WWTP. The sludge dewatering system consists of the following assets and conditioning ratings listed in Table 1-19.

Photo 1-19: Belt Filter Press

Photo 1-20: BFP Polymer Feed System

Table 1-19: Sludge Dewatering System Condition

No.	Part List	Condition Grade	Comment
1	Belt Filter Press Building	3.00	Structural problems.
2	Belt Filter Press	7.00	Good shape.
3	Poly Feed System	6.00	Acceptable condition.
4	BFP Washwater Pump	6.00	Need better water supply / pumping.
5	BFP Trailer	3.00	Wood planking becoming warped.

The overall condition assessment score for the sludge dewatering system is 5.00.

1.13.1 Condition Grade Summary

The condition grade summary in Table 1-20 indicates the top priority for rehabilitating or replacing sludge dewatering system assets within the next 3 to 6 years.

Table 1-20: Sludge Dewatering System Condition Grade Summary

No.	Part List	Condition Grade	Comment
1	Belt Filter Press Building	3.00	Structural problems.
5	BFP Trailer	3.00	Wood planking becoming warped.

1.13.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for the sludge dewatering system.

1.14 Anaerobic Digestion

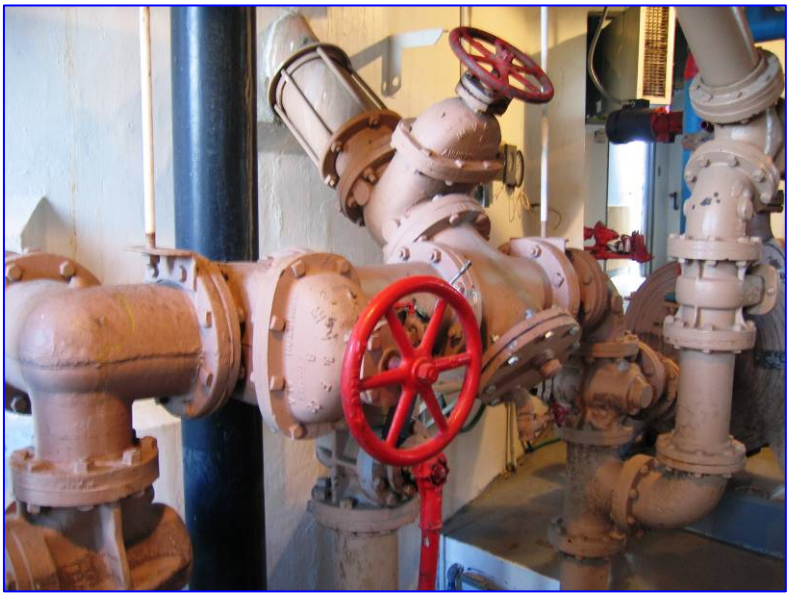
The anaerobic digester receives thickened raw sludge, raw scum and thickened waste activated sludge. Thickened sludge is pumped to the one of two anaerobic digesters at the Klamath Falls WWTP.

Photo 1-21: Anaerobic Digesters

A blend of thickened raw and waste activated sludge is intermittently fed to the digesters following thickening in the DAFT. The sludge is mixed in the digester by a circulation pump (see Photo 1-20).

No other means of circulating the digesting sludge is available since the gas mixing system has been removed. All methane gas produced in the anaerobic digestion process is flared, and none is used as fuel in the boiler for heating the digesters. The boiler itself is in poor condition. Primary heat for the digesters is from the geothermal pumping system, which transfers heat to the glycol supply pumps via a dedicated heat exchanger.

The digester structures are in poor condition as is the piping within the digester building. A significant number of valves are inoperable, or otherwise difficult to move, presenting a safety hazard to operators. The anaerobic digestion consists of the following assets and conditioning ratings listed in Table 1-21.



Photos 1-22: Circulation Pumps and Valving

Table 1-21: Anaerobic Digestion Condition

No.	Part List	Condition Grade	Comment
1	Anaerobic Digester Structures	3.00	Digester structure in poor condition.
2	Anaerobic Digester Exterior Piping	6.00	Recently rehabilitated.
3	Digester Piping/Valving – Interior	2.00	Very poor condition. All valves difficult to operate.
4	Digester Sludge Circulation Pump	4.00	No backup pump exists, and no other means of mixing the digester is available.
5	Boiler	2.00	In poor condition.
6	Digested Sludge Pump	7.00	Rotary lobe pump in very good condition.
7	Digested Sludge Grinder	7.00	Fairly new grinder in very good condition.
8	Digester Heat Exchanger	6.00	No significant problems.

The overall condition assessment score for the anaerobic digestion is 4.63.

1.14.1 Condition Grade Summary

The following condition grade summary in Table 1-22 indicates the top priority for rehabilitating or replacing anaerobic digestion assets within the next 3 to 6 years.

Table 1-22: Anaerobic Digestion Condition Grade Summary

No.	Part List	Condition Grade	Comment
1	Anaerobic Digester Structures	3.00	Digester structure in poor condition.
3	Digester Piping/Valving – Interior	2.00	Very poor condition. All valves difficult to operate.
5	Boiler	2.00	In poor condition.

1.14.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for the anaerobic digester.

1.15 Geothermal Heating System

All heat for the Klamath Falls WWTP is provided by geothermal means. Geothermal water circulation pumps are located throughout the plant. Glycol supply pumps and heat exchangers transfer heat from the geothermal heated water and supply the following areas of the plant using separate supply systems:

- Anaerobic Digesters
- Dissolved Air Flotation Thickener Building and Chemical Building
- Administration Building

A separate closed loop HVAC system for the Administration Building and Laboratory provides all heating, air conditioning and ventilation. There is no backup for the geothermal system and it has a history of high maintenance and poor performance. The geothermal heating system consists of the assets and condition ratings listed in Table 1-23.

Photos 1-23: Geothermal Supply Pumps and Glycol Supply Pumps

Table 1-23: Geothermal Heating System Condition

No.	Part List	Condition Grade	Comment
1	Anaerobic Digester Geothermal Supply Pumps	5.00	Acceptable – no problems.
2	Anaerobic Digester Glycol Supply Pumps	5.00	Acceptable – no problems.
3	Anaerobic Digester Glycol Heat Exchanger	5.00	Acceptable – no problems.
4	DAFT Building Geothermal Supply Pumps	4.00	Functional – showing signs of wear.
5	DAFT Building Glycol Supply Pumps	4.00	Functional – showing signs of wear.
6	DAFT Building Glycol Heat Exchanger	5.00	Acceptable – no problems.
5	Admin Building Geothermal Supply Pumps	2.00	Heating insufficient during winter.
6	Admin Building Glycol Supply Pumps	3.00	Chiller insufficient to cool building in summer. Fails to maintain optimum lab temperature.
7	Admin Building Glycol Heat Exchanger	3.00	Poor Condition.

The overall condition assessment score for the geothermal heating system is 5.14.

1.15.1 Condition Grade Summary

The following condition grade summary in Table 1-24 indicates the top priority for rehabilitating or replacing geothermal heating system assets within the next 3 to 6 years.

Table 1-24: Geothermal Heating System Condition Grade Summary

No.	Part List	Condition Grade	Comment
5	Admin Building Geothermal Supply Pumps	2.00	Heating insufficient during winter.
6	Admin Building Glycol Supply Pumps	3.00	Chiller insufficient to cool building in summer. Fails to maintain optimum lab temperature.
7	Admin Building Glycol Heat Exchanger	3.00	Poor condition.

1.15.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for the geothermal heating system.

1.16 Chemical Storage / Disinfection System

The sodium hypochlorite delivery system can inject up to 720 pounds per day of chlorine into the plant effluent. The system was installed in 2000 and is housed in the chemical storage building. Sodium hypochlorite is stored at 12.5 percent strength in three 7,000-gallon tanks in the chemical storage building. Chemical feed pumps pump the solution into the effluent while a sensor continuously monitors the dosage. There are two 2,000-gallon tanks of sodium bisulfite located in the chemical storage building.

Photo 1-24: Chemical Storage Tanks

The serviceability of the flow meters and the need to standardize the meters should be considered in the future. There is no bypass setup when performing maintenance on the flow meters. The chemical storage/disinfections system consists of the following assets and condition ratings listed in Table 1-25.

Table 1-25: Chemical Storage/Disinfection System Condition

No.	Part List	Condition Grade	Comment
1	Chemical Storage Building	9.00	Built in 2000 and in excellent condition.
2	3 – Chlorine Tanks	6.50	3 – 7,000 Gallon Tanks.
3	Sodium Bisulfate	6.50	2 - 2,000 Gallon Tanks.
4	4 - Chlorine Feed Pumps	5.00	Rubber hose on discharge needs replacing.
5	2 - Sodium Bisulfate Pumps	6.00	Acceptable condition.
6	ORP Control	8.00	Control is operated by SCADA.
7	Chemical Feed Piping	3.50	Leaks – no bypass pumping exists.

The overall condition assessment score for the chemical storage/disinfection system is 6.36.

1.16.1 Condition Grade Summary

The condition grade summary in Table 1-26 indicates the top priority for rehabilitating or replacing chemical storage/disinfection system assets within the next 3 to 6 years.

Table 1-26: Chemical Storage/Disinfection System Condition Grade Summary

No.	Part List	Condition Grade	Comment
7	Chemical Feed Piping	3.50	Leaks – no bypass pumping exists.

1.16.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for any upgrades to the chemical storage/disinfection system. The chemical feed piping may be an operating budget expense and not included in the Annual Facilities Plan/Capital Improvement Program.

1.17 Plant Water Pumps

There are two plant water pumps; one duty pump, and one serving as backup. The pumps are rotated weekly, and are equipped with dedicated basket strainers. The plant water pumps show considerable wear and should be replaced within the next 3 to 6 years. The overall water system for the plant should be evaluated and replaced based on poor pressure and flow. The plant water pumps consist of the following assets and condition ratings listed in Table 1-27.

Photo 1-25: Plant Water Pumps

Table 1-27: Plant Water Pumps Condition

No.	Part List	Condition Grade	Comment
1	Plant Water Pumps	3.00	Show significant wear. Provide low pressure and flow.
2	Basket Strainers	5.00	One dedicated for each pump.
3	Backflow Preventor	6.50	Annually tested.

1.17.1 Condition Grade Summary

The condition grade summary in Table 1-28 indicates the top priority for rehabilitating or replacing plant water pump assets within the next 3 to 6 years.

Table 1-28: Plant Water Pumps Condition Grade Overview

No.	Part List	Condition Grade	Comment
1	Plant Water Pumps	3.00	Show significant wear.

1.17.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for any upgrades to the plant water pumps.

1.18 Plant Generator

There is a 500-kw, diesel-powered standby generator. Installation of the generator was completed in 1992. The generator can supply enough power to run the entire plant during electrical power outages. The plant generator consists of the following assets and condition ratings listed in Table 1-29.

Photo 1-26: Plant Generator

Table 1-29:Plant Generator Condition

No.	Part List	Condition Grade	Comment
1	Generator Storage Building	4.00	Poor condition – structural age / problems.
2	Plant Generator	6.00	Acceptable condition.
3	Generator Piping	5.00	Acceptable condition.
4	Switch Gear	9.00	New switch gear for generator.
5	Air Compressor	5.00	Required to operate the generator to start the generator.

The overall condition assessment for the plant generator is 5.78.

1.18.1 Condition Grade Summary

The condition grade summary indicates assets are considered not in any immediate need of rehabilitation or replacement.

1.18.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for the plant generator.

1.19 Storm Water Pump Station

The storm pump station pumps storm water from the plant site into a discharge channel that runs to the Klamath River. The pump station is part of the original plant and has not experienced any significant maintenance problems. The pumps at this location are four hp with 16 inch diameter pumps. The station is well maintained and maintenance records indicate the rebuilding of the pumps and motors has occurred over the years to ensure reliability. The assets at this station and condition ratings are listed in Table 1-30.

Photo 1-27: Storm Water Pump Station

Table 1-30: Storm Water Pump Station Condition

No.	Part List	Condition Grade	Comment
1	Concrete Structure	7.00	Building and overall structure is in good shape and does not show any significant wear.
2	Pump Station Piping	7.00	Piping shows no sign of corrosion.
3	Pumps	7.00	Pumps well maintained. Pumps equipped with soft starts.
4	Level Control	7.00	Backup float, well maintained.
5	Wet Well	7.00	No structural problems noted during visual inspection.
6	Grates	7.00	No structural problem.

The overall condition assessment score for the storm water pump station is 7.00.

1.19.1 Condition Grade Summary

The condition grade summary indicates that assets are considered beyond ten years in terms of needing rehabilitation or replacement.

1.19.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for any upgrades to the storm water pump station.

1.20 Sludge Management Equipment

Primary and secondary sludge is aerobically digested to achieve at least 38% volatile reduction. To meet Class A pathogen reduction requirements, digested sludge is windrow composted. In this composting method, digested sludge and a carbon

source (wood chips) are mixed and placed in windrows. The temperatures in these windrows are monitored and must be 55 degrees Celsius or higher for 15 days or longer. During this period when the compost is maintained at 55 degrees Celsius or higher, the windrow is turned a minimum of five times. Quarterly, the finished compost is tested for both pathogens and pollutant concentration. Pathogen testing of the finished compost must indicate a Salmonella bacteria concentration of less than 3 MPN per 4 grams of total solids. Records of test results and finished compost distribution are kept and submitted with the City's annual Biosolids Report. The City provides compost to the community at no charge to the public. The sludge management equipment consists of the following assets and condition ratings listed in Table 1-31.

Photo 1-28: Compost Screen and Conveying System

Table 1-31: Sludge Management Equipment Condition

No.	Part List	Condition Grade	Comment
1	Feed Hopper Conveyor	3.00	Old. Maintenance and operator intensive. Unit is not designed for handling dewatered municipal biosolids, and requires constant operator supervision to avoid plugging.
2	Trommel Screen	3.00	Poor condition.
3	Waste Conveyor	4.00	Fair condition.
4	Finished Product Loader	4.00	Fair condition.
5	Temperature Probe	7.00	Good condition.

The overall condition assessment score for the sludge management equipment is 4.20.

1.20.1 Condition Grade Summary

The following condition grade summary in Table 1-32 indicates the top priority for rehabilitating or replacing sludge management equipment within the next 3 to 6 years.

Table 1-32: Sludge Management Equipment Condition Grade Summary

No.	Part List	Condition Grade	Comment
1	Feed Hopper Conveyor	3.00	Old. Maintenance and operator intensive. Unit is not designed for handling dewatered municipal biosolids, and requires constant operator supervision to avoid plugging.
2	Trommel Screen	3.00	Poor condition.

1.20.2 Budget

Currently, no budget exists in the Annual Facilities Plan/Capital Improvement Program for any upgrades to the sludge management equipment.

1.21 Condition Assessment Conclusions

Sections 1.2 through 1.20 discuss the condition of each of the primary wastewater systems at the Spring Street WWTP. Top priority improvements have been identified in each section, where improvements are needed. A summary of these top priority improvements are shown in Figure 1-1. As depicted in the Figure, several improvements are needed in the next few years. The City planning budget in the Annual Facilities Plan/Capital Improvement Program should be modified to include these improvements. Costs for these improvements will be identified over the course of completion of the larger wastewater Facility Plan of which this condition assessment is a part of.

CDM

Memorandum (Final Draft)

To: *Jeff Fritz*

From: *Janelle Rogers and Dick Nichols*

Date: *October 5, 2007*

Subject: *Technical Memorandum – Identify and Evaluate Effluent Disposal Options, Task 4A – Part 1*

The goal of this task, as specified in the facility plan scope of work, is to review the feasibility of alternative wastewater effluent disposal options, quickly identify those options which are most likely to get DEQ approval, and shortlist them to four options which will be considered in more detail.

In this memorandum, eight effluent disposal options identified in the scope of work have been considered and assessed specifically regarding permitting issues and meeting regulatory requirements.[1] These options are listed below and their approximate physical locations are shown in Figure 1.

- Effluent Discharge in to the River, but with Additional Treatment and New Diffuser
- Effluent Discharge in to the River, but with Additional Treatment (to background quality) and New Diffuser
- Agricultural Land Application with Winter Storage
- Constructed Wetland(s) with Indirect discharge to Surface Waters
- State Wildlife Refuge for Land Application
- Indirect Subsurface Discharge – Hyporheic Zone
- "A" Canal Discharge for Land Application
- Pollutant Load Offset Trading

[1] Management of cogeneration facility blowdown will be addressed in the overall facility plan and not in this memorandum.

In addition to the above, a ninth option, a "hybrid" solution has been added to this memorandum for consideration:

- Hybrid Solution – Advanced Treatment, Reuse, Some Land Application, Winter Storage, Summer River Discharge

Figure 1: Effluent Disposal Options

Each option is discussed separately in the subsections below and the acceptability to DEQ, flexibility and relative cost issues related to permitting and other regulatory concerns are summarized. Wintertime and summertime discharge issues are discussed for each option. The subsections are followed by a summary that presents the rationale for shortlisting the eight options to four options and the hybrid option.

A separate technical memorandum, Task 4A-Part 2, will be developed to more fully describe each of the final four (and hybrid) options. The four final options may include further combinations of some options where it makes best sense to do so. Evaluation criteria, weighting, ranking of options, costs, and technical feasibility will be determined for each of the four final options in technical memorandum Task 4A-Part 2.

1.1 Effluent Discharge into the River, but with Additional Treatment and New Diffuser

This option would continue the City's current practice of effluent discharge to the river, but would add increased treatment in the wastewater treatment plant to address the more stringent NPDES permit requirements likely to be implemented as a result of anticipated TMDL waste load allocations (WLAs). The key to this option, of course, is what will it take to meet the waste allocation imposed by the TMDL and to meet other applicable water quality standards?

TMDL Requirements: At this time, the City's waste load allocations are unknown. Further, the period of the year that the WLAs may apply is also not known. Ideally, seasonal WLAs would only apply for the low-flow portions of the year.

Water quality problems in the river are mainly due to excessive algal growth that could be controlled by reducing the load of the limiting nutrients during the algal growing season. From the City's perspective, a WLA limited to phosphorus might be best as the allocation is probably reasonably achievable especially since the City's discharge contributes less than 1% of the total load. If the WLA also includes total nitrogen, depending on the nitrogen allocation, meeting the requirements could be more difficult because treatment requirements would be more complicated. The WLA could also include BOD-5, but meeting a BOD-5 waste load allocation should be relatively easy to achieve compared to the other parameters that may be addressed in the TMDL. Fortunately, the City's WLAs should be tentatively known by the end of December, 2007.

Temperature: The recently adopted temperature criteria for the Klamath River should be relatively easy to meet with a new diffuser. Design of the diffuser will have to take into account DEQ's thermal mixing zone requirements. Although not currently applicable, the

diffuser should also consider future potential temperature criteria that may include cold water protection requirements should anadromous fish be reintroduced to the river.[2]

Ammonia-nitrogen: This pollutant will likely be addressed in the TMDL. Ammonia is actually a near-field issue. Near field includes the areas within the initial mixing zone of the discharge plume where elevated ammonia concentrations can potentially impact aquatic life toxicity. By comparison, far field assumes complete mixing with receiving waters. Ammonia toxicity varies with pH and temperature. Because river pH levels can be quite high, under the current ammonia standards approved by EPA, the target ammonia concentration under a future WLA could be very low (<1 mg/l). And, because background ammonia levels are also high, initial dilution provided by the diffuser may not be very helpful. On the other hand, EPA is considering new ammonia standards that have been submitted by DEQ for EPA approval. If these are approved, the ammonia limit will be much higher and reasonably achievable, even at high river pH levels.

In 2004, EPA announced its intent to re-evaluate the current aquatic life criteria for ammonia to determine if a revision is warranted based on new toxicity data for aquatic organisms including unionid mussels found in the Klamath River. According to the manager of EPA's Region 10 Water Quality Standard Section, EPA has no firm date to complete this review. Should EPA adopt new ammonia criteria, they will not become applicable to the Klamath River until the Oregon Environmental Quality Commission adopts the criteria by administrative rule. Based upon this, it will likely be several years before new ammonia criteria are adopted in Oregon.

Dissolved oxygen, toxic metals, pH: These constituents are also primarily near field water quality issues. As shown in Figure 2, DEQ rules prohibit acute toxicity outside an acute mixing zone (an initial zone of initial dilution or ZID, however, is allowed) and chronic toxicity outside an allowable mixing zone.[3]

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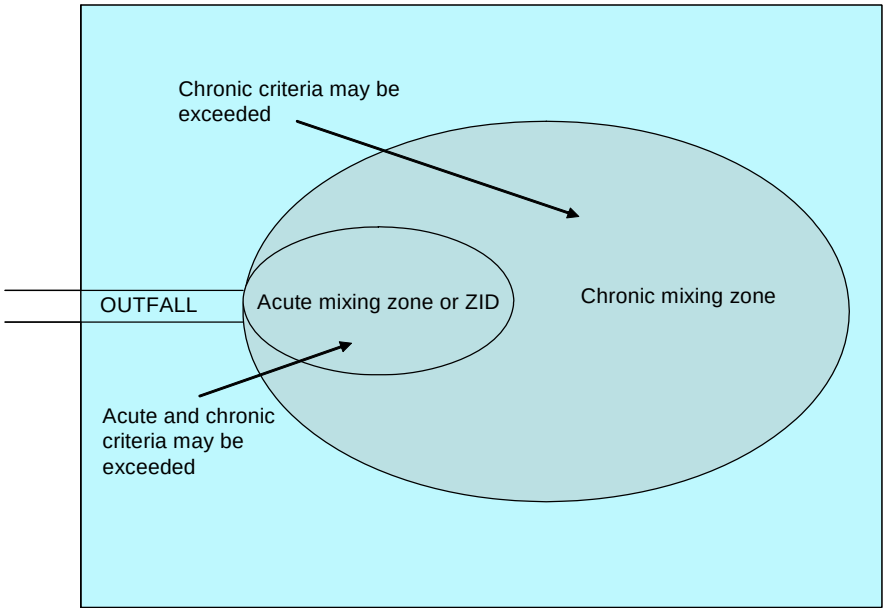
[2] PacifiCorp owns four hydroelectric dams on the Klamath River below Keno Dam. Three are in California; one in Oregon. Their FERC licenses may not be renewed and the dams may be removed. If this happens, water quality standards as they apply to upstream wastewater agencies could possibly change because of anadromous fish introduction.

[3] The chronic mixing zone is the area encompassed by the entire regulatory mixing zone as described in an NPDES permit. Water quality criteria in OAR 340-041 Tables 20 and 33A to 33C must be met outside the chronic mixing zone. Chronic criteria may be exceeded in the chronic mixing zone provided a number of protections are maintained and it is sized to protect the integrity of the water body as a whole. The acute mixing zone or "zone of immediate dilution (ZID)" is a component of the regulatory mixing zone. If allowed, the ZID is the area immediately surrounding the outfall and within the chronic mixing zone. In this area, the acute and chronic criteria may be exceeded.

Figure 2: Allowable Mixing Zone



The City's facility plan will need to demonstrate how a combination of treatment and dilution provided by the diffuser will meet water quality standards inside and outside the allowable mixing zone. DEQ's dissolved oxygen standard must be met outside the mixing zone. Currently, the dissolved oxygen standard applicable to this section of the Klamath River is for cool water species. If anadromous fish are re-introduced, the criteria may be changed to cold water and would be more stringent. Current Oregon in-stream water quality standards for toxic metals are very low. Revised standards pending EPA approval are likely to be even more stringent.

Wintertime and Summertime Discharge

Depending on when the various WLAs within the TMDL apply, the City could be allowed less restrictive effluent limits during the winter period. The City could also be allowed less restrictive limits during periods of relatively high flow in the river.

DEQ acceptance, flexibility, and relative cost considerations for this alternative are discussed below:

Acceptance

- DEQ Acceptance: Without knowing the City's TMDL waste load allocations and until in-depth water quality impact analyses are completed, it is hard to know how viable this option is.

- Long-term Permitability: An NPDES permit is required and renewal of this permit will present the City with uncertainty regarding future potentially more stringent permit requirements. If the permit requirements become too stringent, the City may eventually have to remove the discharge from the river.

Flexibility

- This system would be solely reliant on treatment plant and diffuser upgrades, and as a result would provide the City with the initial flexibility of being designed to meet permit requirements, but any future changes to the permit could only be managed by refining and optimizing unit processes within the plant (i.e., no outside unit processes such as wetlands or reuse to help attenuate or address seasonal flow issues).

Relative Cost

- This would be among the most inexpensive alternatives, if viable from a water quality perspective.

1.2 Effluent Discharge into the River, but with Additional Treatment (to TMDL target concentrations) and New Diffuser

This option is similar to the option in Section 1.1 above. The difference is that the pollutants covered by the TMDL would be treated to levels anticipated by DEQ at the outlet of Upper Klamath Lake, after the TMDL for Upper Klamath Lake has been achieved. Since the TMDL defines the assimilative capacity of the river, the City's goal under this option would be to meet the allowable target concentrations at the outlet of Klamath Lake.[4] The advantage of this approach is that the TMDL for the Klamath River in large part becomes resolved for the City. If the City discharges pollutants at concentrations equivalent or below the target concentration related to the assimilative capacity of the river, the City would be able to legitimately argue that they could not be contributing to the water quality problems attributed to anthropogenic sources. While this arrangement would provide a very defensible position for the City, it may still be subject to much interpretation (and potentially even litigation.) Treating to TMDL target concentration for phosphorous and nitrogen as well as other non-TMDL regulated pollutants such as metals and temperature could be extremely expensive.

Wintertime and Summertime Discharge

Under this option, there are seasonal periods of the year when the TMDL-regulated WLAs are likely to be moot. This situation may vary by chemical constituent. For non-TMDL pollutants such as metals and temperature, DEQ may allow less stringent effluent limits depending on in-stream flow and temperature conditions.

[4] DEQ will likely consider the target concentrations as natural background because DEQ's WQ standards state where natural background exceeds numeric criteria, natural background becomes the standard.

DEQ acceptance, flexibility, and relative cost considerations for this alternative are discussed below:

Acceptance

- DEQ Acceptance: An important aspect to this option is that the City treats to TMDL target concentrations determined by DEQ. This alternative is likely to be approved by DEQ (with no required attenuation plans or other onerous preconditions) since it will provide a very high degree of treatment.

- Long-term Permitability: If the City's effluent is equivalent to allowable TMDL target concentrations, then meeting the TMDL requirements becomes resolved from the City's perspective. This would allow the City to proceed years into the future knowing that TMDL and NPDES requirements would be met, and to proceed with upgrading its wastewater control facilities without needing to know its pending waste load allocations. As part of the additional treatment, the City still will need to deal with toxic metals and other water quality standards not being addressed by the TMDL.

Flexibility

- Because the degree of in-plant treatment will be extensive to meet background conditions, the necessary amount of flexibility will be reduced, and as a result, the flexibility associated with this alternative can be considered to be high.

Relative Cost

- Treating to TMDL target concentrations will likely be much more expensive than just meeting the TMDL waste load allocations.

1.3 Agricultural Land Application with Winter Storage (Pond or ASR)

Effluent disposal via agricultural irrigation is an easily approvable option for DEQ to permit depending on how effluent is stored during the winter, non-growing season. The only restriction is that DEQ approve a reclaimed water use plan and that the effluent (reclaimed water) be sufficiently treated for the crop upon which it is irrigated. Effluent can only be irrigated during the growing season at agronomic rates, however. During the non-irrigation season, effluent would either have to be stored in a lined pond or, possibly, in an underground aquifer for later recovery.

A pond(s) for winter storage would have to be large enough to provide sufficient storage volume. The cost for a pond would include excavation (unless some existing ponds could be used), as well as lining. To further consider this option, a better understanding is needed of what DEQ will accept as a "lined" pond during the winter and prevents either directly or indirectly discharging to the river. Perhaps lining ponds with bentonite might work, and would significantly cut down on expense as well as adding a community amenity.

Depending on the crop type upon which effluent would be irrigated and/or if the City wants the public to have access to the pond for possible recreational uses, effluent may have to be treated to meet reclaimed water requirements, possibly up to Level IV.

One idea for winter surface water storage includes using Long Lake. Currently, Long Lake is a dry depression that can be seen on a topographic map adjacent to Upper Klamath Lake. In proceeding forward with this option, more information would be needed on the porosity of the lake bottom and whether it would need to be lined, the volume of holding capacity available, what pumping costs would be (since the elevation is higher than Lake Ewauna, and what the net evaporation is versus precipitation.

Aquifer storage and recovery (or ASR) for effluent management apparently is gathering interest in other parts of Oregon. The basic concept is that effluent is treated to federal drinking water standards (this is required by rules promulgated by the Oregon Water Resources Commission), injected into an aquifer for storage, and recovered for municipal, industrial or agricultural uses. The benefit of aquifer storage is that the City would not need to construct and maintain a lined winter storage pond. Injection into an aquifer may be less expensive than above ground storage although further analysis is needed to verify this. A suitable aquifer must be available to provide ample storage. A significant cost, of course, is meeting all federal drinking water standards. Treating to drinking water standards, however, may be less expensive than meeting DEQ's in-stream criteria which are much more stringent than the drinking water standards.

To meet DEQ requirements, irrigation water must be applied through spray irrigation rather than flood irrigation (due to groundwater contamination concerns). Spray irrigation costs include the apparatus for spraying water. Sufficient agricultural land must be available for irrigation.

Wintertime and Summertime Discharge

Under this option, effluent is irrigated during the summer and stored, in some fashion, during the winter.

DEQ acceptance, flexibility, and relative cost considerations for this alternative are discussed below:

Acceptance

- DEQ Acceptance: Assuming effluent is stored in a lined, above ground storage pond during the winter, this option would negate the need for an NPDES permit and would be easy for DEQ to permit.

- DEQ Acceptance: If effluent is stored in an aquifer, extensive and expensive hydrogeologic analyses would be necessary to determine if aquifer storage was viable

and would meet the requirements of the Oregon Water Resources Department. For ASR, a permit from the Oregon Water Resources Department would be needed.

- Long-term Permitability: If effluent were stored in an aquifer, an NPDES permit would also not be needed.

- Long-term Permitability: ASR would be subject to the provisions of the federal Safe Drinking Water Act (SDWA). Because effluent would be treated to meet federal drinking water standards prior to ASR storage, compliance with SDWA should be straight forward.

- Long-term Permitability: In a water-short basin like the Klamath River basin, effluent may be reused for a beneficial purpose (aquifer recharge and aesthetic community amenity), which would seem to produce a win-win outcome.

- Other: If a pond were used, it could be designed to be an aesthetically pleasing community amenity (e.g., a water feature).

- Other: Persons with domestic wells near the storage aquifer might object to the proposal although, again, effluent would be treated to drinking water standards.

Flexibility

- Having ASR and/or ponds available would provide additional flexibility during the spring and fall seasons as well as winter, and as such would not rely solely on in-plant treatment solutions to meet permit.

Relative Cost

- If an above ground effluent storage pond is large and has to be lined with membrane, this alternative would be expensive.

- Treating to Level IV may not be needed if ponds were used for storage as opposed to ASR. This would have to be determined. If Level IV is required, this alternative would become much more expensive.

- Extensive hydrogeologic analyses to determine if aquifer storage is viable would drive up costs. The distance of the aquifer to the treatment plant may drive up costs. Costs for injection/recovery wells or spreading basins could be significant.

- Wastewater may be appropriate for growing hay or alfalfa since these are crops for cattle feed, and therefore do no have to be treated to cost intensive Level IV reuse requirements.

- Auxiliary irrigation piping costs may make irrigation economically unviable. The cost for water being supplied by existing water irrigation districts is fairly low. If the wastewater treatment agencies were to provide water, they would need to pick up all conveyance costs including pipe and pumping costs to central field locations, canals to farms, and spray irrigation equipment.

1.4 Constructed Wetland(s) with Indirect Discharge to Surface Waters

DEQ has indicated that any indirect discharge to surface waters will require an NPDES permit. If the indirect discharge is to a surface water that is covered by a TMDL, the TMDL allocations will have to be addressed in the permit issued by DEQ as well as other applicable water quality standards. Constructed wetlands may not provide sufficient treatment to be permitted. However, effluent limits for discharge into the wetlands could potentially be increased if DEQ can be convinced that some attenuation of pollutants will occur between the wetlands and the river. This would require an attenuation plan, pollutant monitoring, and monitoring results showing successful pollutant mitigation.

Further, a constructed wetland could be added as a unit process similar to other unit processes in a sewage treatment facility. A means for addressing the TMDL and water quality standards may be to treat the wastewater to higher water quality standards within the plant, and then to add wetlands to provide wastewater effluent polishing and final treatment. Care would be needed to ensure that the wetland was not constructed on land that would be considered a natural (i.e., jurisdictional) wetland, as this would require approvals from the U.S. Army Corps of Engineers under fill and removal requirements of Section 404 of the federal Clean Water Act.

The proximity of property available for constructed wetlands to both wastewater treatment agencies is good. Currently, the FAA wants to build wetlands on Modoc property adjacent to the Spring Street Treatment Plant. In fact, the City is making an offer on the property based on the Airport's ability to obtain funding.

Wintertime and Summertime Discharge

This option would likely be a year round disposal option. Because TMDL discharge requirements and in-stream water quality standards may consider seasonal flow patterns, it is possible that effluent limits would be less stringent in the winter period than in the summer time.

DEQ acceptance, flexibility, and relative cost considerations for this alternative are discussed below:

Acceptance

- DEQ Acceptance: May provide benefit as a unit process that adds pollutant attenuation between the wetland and the adjacent surface water, although DEQ will likely require technical studies to demonstrate performance.

- DEQ Acceptance: It may be difficult to find areas along the river that are not considered jurisdictional wetlands upon which to site constructed wetlands.

- Long-term Permitability: Renewal of the NPDES permit may expose the City to increasingly stringent permit requirements, and at some point, there is a risk that attenuation may be insufficient to meet the permit requirements.

Flexibility

- Since this option would rely on an in-plant treatment combined with wetland solution to meet permit, it would be a year round disposal option, and would not add much additional flexibility during the spring, fall, and winter seasons.

Relative Cost

- A technical water quality analysis (e.g., monitoring and modeling) would be required to demonstrate attenuation of pollutants within the wetlands prior to indirect discharge to the river.

- If the attenuation plan is acceptable and sufficient space is available, compared to other alternatives, this option may provide cost-effective final treatment for wastewater effluent.

1.5 State Wildlife Refuge for Land Application

This option assumes that effluent would be applied to the State Wildlife Refuge on Miller Island. An uncertainty is how the effluent would be applied. If the effluent were applied at agronomic rates (as discussed in section 1.3), this would be easy for DEQ to permit. Because Oregon Department of Fish and Wildlife (ODFW) allows public access to the refuge, the treated effluent may need to meet Level IV quality.

Alternatively, if the effluent were discharged into constructed wetlands, as discussed in section 1.4, the concern or issue would be relative to the potential for an indirect discharge into the Klamath River that borders the refuge. DEQ has indicated that an indirect discharge would require an NPDES permit and that future TMDL allocations for the Klamath River would apply to the resulting indirect discharge. The effect of TMDL requirements, may be

reduced if DEQ can be convinced that some attenuation of pollutants will occur between the constructed wetlands and the river.

ODFW considers the wetlands that exist on Miller Island as constructed wetlands because ODFW developed them. The U.S. Army Corps of Engineers, however, may believe that these wetlands are under its jurisdiction. The actual status of the wetlands should be determined early in the review process if this alternative is considered one of the final four options.

For this option to work, the City would need to negotiate a contract with ODFW to ensure that effluent was properly managed consistent with the City's NPDES permit. Based upon previous discussions with ODFW, ODFW appears to want more flexibility in the handling of effluent than the City or DEQ would desire. For instance, ODFW refuge staff wanted to be able to drain effluent from the wetlands directly into the river, if necessary.

Further, because ODFW allows public access to the refuge, the treated effluent disposed in the constructed wetlands may need to meet Level IV quality.

Wintertime and Summertime Discharge

If effluent is to be applied at agronomic rates, it could only be applied during the growing season at application rates consistent with agronomic needs of the vegetation to which it is applied. During the non-growing season, effluent would either have to be stored, discharged to the river, or disposed in some other manner.

DEQ acceptance, flexibility, and relative cost considerations for this alternative are discussed below:

Acceptance:

- DEQ Acceptance: Acceptance is contingent on many variables, e.g., effluent application. Applying effluent at agronomic rates would be acceptable, but if public access is needed and granted, Level IV treatment may be required. If wetlands are used for effluent application, with indirect charge to the river, an NPDES permit will be required.

- Long-term Permitability: Others besides DEQ must accept and permit the arrangement. Requires negotiating a suitable contract with ODFW which will likely be difficult. In addition, the existing wetlands on Miller Island could be considered jurisdictional wetlands in which case, use of them may require a permit from the U.S. Army Corps of Engineers. Further, loss of existing wetlands may need to be mitigated.

- Long-term Permitability: An NPDES permit would be required and renewal of this permit may expose the City to increasingly stringent permit conditions. The effluent

quality of discharges to a State Refuge and land application, could over time, be insufficient to meet permit requirements. Further, OFDW may wish to exercise refuge management options that conflict with City permit obligations.

- Other: Potentially replaces water demands of the refuge that would otherwise have to be pumped from the river i.e., a beneficial use.
- Other: Provides the Miller Island Refuge with a firm water supply to meet demands for existing and future wetlands restoration and enhancement projects.
- Other: The refuge may not provide sufficient space for the quantities of effluent disposal needed.

Flexibility

- Requires additional winter management of effluent if effluent application is limited to agronomic rates. If effluent is able to be stored, discharged to the river, or disposed in some other manner during the winter, this option may provide some additional flexibility during the spring and fall seasons, and as such would not rely solely on in-plant treatment solutions to meet permit.

Relative Cost

- If ODFW allows public access to the refuge, the treated effluent may need to meet Level IV quality, which could be costly.
- Conveyance to Miller Island would be needed.
- A technical water quality analysis (e.g., monitoring and modeling) would be required to demonstrate attenuation of pollutants within the wetlands prior to indirect discharge to the river.

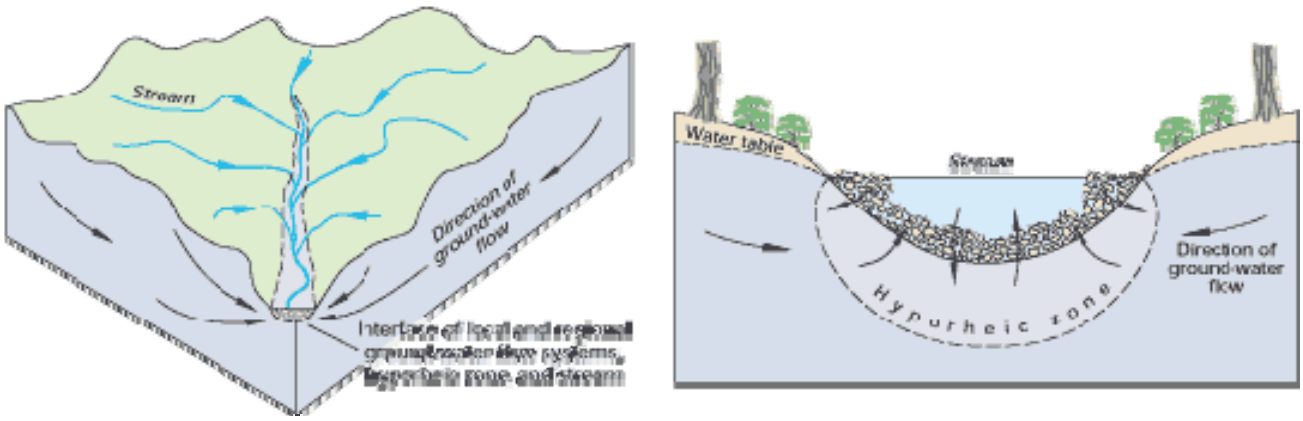
1.6 Indirect Subsurface Discharge – Hyporheic Zone

As shown in Figure 3, this option involves shallow sub-surface discharge to the hyporheic zone which is typically located in the gravel or sediment deposits along the river bank. The hyporheic zone includes the areas under or beside a channel or floodplain that contributes water to the river. The benefit of this option is that discharge to a hyporheic zone could remove/reduce some water quality constituents. DEQ has indicated that any indirect discharge to surface waters via the hyporheic zone would require an NPDES permit. If the indirect discharge is to a surface water that is covered by a TMDL, the TMDL as well as other applicable water quality standards will have to be addressed in the permit issued by DEQ. A means for addressing the TMDL and water quality standards may be to partially treat the wastewater to help address the TMDL and other applicable water quality standards prior to

discharge to the river bank. Effluent limits for discharge into the subsurface disposal system could be increased if DEQ can be convinced that some attenuation of pollutants will occur in the hyporheic zone between the plant and the river.

Because this option may only partially address discharge needs, it may perhaps be considered a subset of the overall treatment improvements.

Figure 3: Hyporheic Zone for a Typical Stream[5]



Wintertime and Summertime Discharge

This option would likely be a year around disposal option. Because TMDL discharge requirements and in-stream water quality standards would still have to be met, it is possible that effluent limits would be less stringent in the winter period than in the summer time.

DEQ acceptance, flexibility, and relative cost considerations for this alternative are discussed below:

Acceptance

- DEQ Acceptance: The hyporheic zone may provide additional water quality treatment and temperature buffering. Acceptance of this option will depend on whether or not DEQ can be convinced that pollutant attenuation will occur between the subsurface disposal site and the surface water. Further, this is a new concept, and there is to track record or history of acceptance of this alternative being permitted in Oregon.

[5] Graphic provided by USGS

- Long-term Permitability: An NPDES permit is required and renewal of this permit will face ever-changing requirements, most of which will likely impose more stringent conditions on the City. Also, it may be difficult to find areas along the river that are not considered jurisdictional wetlands upon which to place a subsurface disposal system.

- Other: This option returns water directly to the river which could help with fish flow.

Flexibility

- This option would only be done in combination with plant treatment solutions, and as such would act as a unit process that may provide some additional flexibility during the spring and fall seasons, and as such would not rely solely on in-plant treatment solutions to meet permit.

Relative Cost

- This option may be less expensive than other options, since little conveyance would be needed, and no wetlands would need to be constructed.

- A technical water quality analysis (e.g., monitoring and modeling) would be required to demonstrate attenuation of pollutants within the wetlands prior to indirect discharge to the river.

1.7 "A" Canal Discharge for Land Application

Although the water in A canal is intended almost exclusively for agricultural irrigation, it is currently considered waters of the U.S. for the purpose of the federal Clean Water Act. Therefore, any discharge into the canal would require an NPDES permit. The permit would have to ensure that the discharge did not contribute to violations of water quality standards in the canal. (The standards for A Canal are more stringent than the Klamath River from Link River to Keno because it is considered a salmonid fish bearing water body.) Also, because water in the canal eventually makes its way back to the Klamath River, a permit application would likely have to demonstrate that the discharge would not violate limitations imposed by the pending TMDL for the Klamath River. An assessment of water quality standards attainment and the potential impact on the TMDL would require an evaluation that would likely include additional monitoring and modeling. Since there is little historical water quality data for A canal upon which to develop a model, the data collection effort would be significant.

In addition to the above, it is highly likely that both the Bureau of Reclamation and the irrigation districts that receive water from A canal would object to the discharge. This is because irrigation return flow is excluded from NPDES permit requirements as long as the

discharge is made up entirely of irrigation return flow or agricultural non-point source stormwater. The addition of treated effluent into A canal could void this exclusion.

Wintertime and Summertime Discharge

Water from Upper Klamath Lake is only diverted into A Canal from April 1 to September 30. During the remainder of the year, treated effluent would either have to be stored or discharged to the Klamath River.

DEQ acceptance, flexibility, and relative cost considerations for this alternative are discussed below:

Acceptance

- DEQ Acceptance: In order to get DEQ to issue a permit for this option, an extensive water quality analysis will be required to demonstrate that in-stream water quality standards will not be violated in the canal and that the TMDL for the Klamath River will be met.

- Long-term Permitability: The Bureau of Reclamation and the irrigation districts that use the water from A canal will likely resist effluent disposal into the canal since this would trigger issuance of an NPDES permit.

- Long-term Permitability: An NPDES permit would become required and renewal of this permit will face ever-changing requirements, most of which will likely impose more stringent conditions on the City, BOR, and irrigation districts.

- Other: In the water-short Klamath basin, effluent suitable for irrigation could be made available for that purpose, i.e., a beneficial use.

Flexibility

- Since water from Upper Klamath Lake is only diverted into the A Canal during summer, the remainder of the year, treated effluent would with have to be stored or discharged to the Klamath River. As a result, this option would likely also depend on plant improvements necessary to meet permit in the winter. However, if effluent is able to be stored, discharged to the river, or disposed in some other manner during the winter, this option may provide some additional flexibility and not rely solely on in-plant treatment solutions to meet permit.

Relative Cost

- This option would be moderately expensive since conveyance piping to the A canal would be needed and some in-plant improvements would be still be necessary to meet permit requirements in the winter.

- An extensive water quality analysis will be necessary to get DEQ to issue a permit for this option. There is virtually no data available for this analysis which means that a very time-consuming and expensive data collection and water quality modeling effort will be needed.

1.8 Pollutant Load "Offset Trading"

The trading option only applies for meeting the TMDL allocations. The City will be given a specific waste load allocation. Some nonpoint source entity (perhaps PacifiCorp or the Bureau of Reclamation) will be given a load allocation presumably for the Strait Drain discharge, the Lost River Diversion or an impounding dam like Keno. So, the City would have to find a cost-effective means for further reducing a specific nonpoint source's discharged load below its allocation.

Another option would be for the City to eliminate its discharge and then sell its allocated load to another point source (South Suburban, perhaps) or a nonpoint source. In this case, the City's trading partner could discharge thereby reducing its cost to meet the TMDL. This is essentially what is occurring on the Snake River where Idaho Power is buying up the allocated load from the Heinz potato processing plant in Ontario, Oregon, that is eliminating its discharge.

In addition, the traders would have to be in close proximity so that the overall improvements in water quality expected from implementation of the TMDLs are still realized and the economic tradeoff in conveyance and other costs would be equitable. For instance, the City could not make a trade with a source in Kalamazoo, Michigan or even in another basin in Oregon.

In theory, DEQ would have no problem with a trading approach. In practice, however, DEQ might have problems establishing positive accountability that the trade would actually last forever. This could possibly be done through a permit or contract. In reality, DEQ's biggest problem may be getting designated nonpoint sources to stand up and be accountable for just meeting their load allocations.

Again, pollutant trading works only for TMDL allocations. The City will still have to meet limitations required at the edge of the mixing zone such as toxicity and temperature.

DEQ acceptance, flexibility, and relative cost considerations for this alternative are discussed below:

Acceptance

- DEQ Acceptance: While potential trading partners can be identified, the City will have to wait until the TMDL is finally completed before a potential trading partner can be absolutely identified (except perhaps for South Suburban). The NPDES permit

will address other water quality limitations other than those in the TMDL. These constituents will also have to be addressed and considered in the "total solution."

- DEQ Acceptance: A contract between the trading partners will be needed to ensure that a trade is faithfully carried out in perpetuity. Accountability and enforceability may be difficult to define. The contract will have to be carefully constructed to make sure the City's interests are protected.

- Other: There may be too many aspects/components of the agreement to make it viable (in terms of various water quality constituents and players).

Flexibility

- The flexibility of this option will depend on the trade and actions taken to make the trade viable. Implementation of a solution that completely removes the City's effluent from the river will provide the City with the greatest amount of flexibility.

Relative Cost

- Depending on the trade, the City's costs of meeting the TMDL and NPDES permit requirements might be reduced. If the City intends to eliminate its effluent to the river, in order to have sufficient trading credits, this option would be very expensive. If the City can sell its credits to another agency such as SSSD, this option would become more financially viable.

1.9 Hybrid Solution – Advanced Treatment, Reuse, Some Land Application, Winter Storage, Some River Discharge

Given the uncertainties facing the City with respect to DEQ acceptance, flexibility, and cost considerations, a hybrid solution could be devised that includes several elements of the most viable options. The hybrid option might include advanced treatment, agricultural land application during the growing season, reuse, winter storage, and river discharge when possible. The hybrid might also be designed to address high wet weather flows and/or include modular units that could be added to handle flow from other point sources, should these point sources desire another avenue for discharge. One reuse opportunity might include providing treated wastewater to the Reams Gold Course from the pipeline going to the co-gen plant or the effluent return line.

Acceptance

- DEQ Acceptance: This alternative is likely to be approved by DEQ since it will provide a very high degree of treatment.

- Long-term Permitability: Given overall system flexibility and potential redundancy (via several unit processes) in meeting permit conditions, this option is likely to have a high-degree of permitability.

Flexibility

- This option would be the most flexible since several alternatives would be implemented and the system would have the greatest agility in its operation.

Relative Cost

- This option would be moderately expensive since advanced in-plant treatment would be necessary, however some plant expansion costs could be eliminated by implementing land application, reuse, and storage options to reduce the amount and degree of in-plant treatment needed.

Summary

A table summarizing several important aspects of each alternative is shown in Table 1.

Table 1: Viability of Effluent Alternatives[6]

	Will DEQ readily accept?*	Relative Cost	Long-term permitability, assuming initially accepted	Flexibility	Likely to still require Advanced Treatment
1. Effluent Discharge in to the River, but with Additional Treatment and New Diffuser	Medium	Medium	Medium	Medium	High
2. Effluent Discharge in to the River, but with Additional Treatment (to target TMDL concentrations) and New Diffuser	High	High	High	High	High
3. Agricultural Land Application with Winter Storage (ASR or pond)	High	High	Medium	High	High
4. Constructed Wetland(s) with Indirect discharge to Surface Waters	Low	Medium	Medium	Medium	High
5. State Wildlife Refuge for Land Application	Low	High	Medium	Medium	High
6. Indirect Subsurface Discharge – Hyporheic Zone	Low	Medium	Low	Low	High
7. "A" Canal Discharge for Land Application	Low	High	Low	Low	High
8. Pollutant Load Offset Trading	Low	Medium	Low	Low	Low
9. Hybrid Solution – Advanced Treatment, Reuse, Some Land Application, Winter Storage, Some River Discharge	High	Medium	High	High	High
*includes viability of acceptance from others (e.g., OFDW, BOR, Corps, etc.)					

As highlighted in the table, the following four options are recommended for further study:

- Agricultural Land Application with Winter Storage (ASR or Pond)
- Continue Current Practice of Effluent Discharge into the River, but with Additional Treatment and New Diffuser

[6] Note that in all the 8 treatment and disposal options under consideration, the best way to manage the blowdown waster would have to be evaluated.

- Continue Current Practice of Effluent Discharge into the River, but with Additional Treatment (to TMDL target concentrations) and New Diffuser

- Constructed Wetland(s) with Indirect Discharge to Surface Waters

In addition, the hybrid solution is also recommended for further study:

- Hybrid Solution – Advanced Treatment, Reuse, Some Land Application, Winter Storage, Some River Discharge

These options have been selected for the following reasons:

- There is a higher likelihood that DEQ could permit the option and that it could be implemented it in a relatively short time.

- The option has a relatively good, long-term future. In other words, future changes to water quality standards, TMDLs, or other state or federal requirements will not render the option obsolete in the short term.

- Implementation of the option exposes the City to minimum amount of potential liability under the Clean Water Act or other federal or state statute.

cc: Mark Willrett
Don Wilcox

CDM

Memorandum (Draft 9-26-08)

To: *Jeff Fritz*

From: *Janelle Rogers, Dick Nichols and Ed Fernbach*

Date: *September 26, 2008*

Subject: *Technical Memorandum – Identify and Evaluate Effluent Disposal*

On May 22, 2008, the Oregon Department of Environmental Quality (ODEQ) met with representatives of the City of Klamath Falls (City)and South Suburban Sanitary District (District) to present initial, tentative Klamath River total maximum daily load (TMDL) waste load allocations (WLA) for the City and District.

The Klamath River (including Lake Ewauna) from Link River to Keno does not meet water quality standards for dissolved oxygen and ammonia-toxicity year around, and pH and chlorophyll *a* during the summer. The Klamath River below Keno does not meet dissolved oxygen standards year around or the temperature standard during the summer. Hence, pursuant to the federal Clean Water Act, TMDLs are needed.

To address the water quality standards violations, ODEQ, with assistance from the U. S. Environmental Protection Agency (EPA), has tentatively proposed TMDLs and associated waste load allocations which would limit the discharge of heat (temperature), carbonaceous biochemical oxygen demand (CBOD), ammonia-nitrogen, and total phosphorus. In addition, the proposal also includes a minimum effluent dissolved oxygen concentration. The temperature WLA is intended to prevent violation of the temperature standard below Keno. The WLAs for CBOD, total phosphorus, ammonia-nitrogen and dissolved oxygen are intended to deal with dissolved oxygen, pH, and chlorophyll problems in the river.

The waste load allocations for the City are:

Minimum Effluent Dissolved Oxygen Concentration	CBOD		Total Phosphorus		Ammonia Nitrogen	
mg/l	mg/l	Kg/day	mg/l	Kg/day	mg/l	Kg/day
5.7	24.22	266	0.41	5	3.34	37

These waste load allocations are based upon an effluent discharge flow of 2.90 million gallons per day (MDG) and river flows during the year 2000.

The mass load values (Kg/day and kilocalories/day) are fixed. Therefore, concentrations and temperature values in these tables will decrease as the City's effluent flow increases. The effluent discharge flow rate over the 20 year planning period will be higher than that used to derive the proposed waste load allocations. This means that the treatment plant will need to produce concentration levels lower than those indicated in these tables. The reduced effluent concentrations required by increasing flows is discussed in more detail later in this document, but are summarized in the following table. Because the minimum effluent dissolved oxygen has no proposed mass load, it assumed that is will be unchanged as effluent flow increases.

Concentrations Required by TMDL at Projected Design Flows				
		$CBOD_5$, mg/l	**Total Phosphorus, mg/l**	**Ammonia Nitrogen, mg/l**
TMDL Mass Load Limit		587 ppd*	11 ppd	82 ppd
2020	Average Dry Weather Flow, 4.4 MGD	16.0	0.30	2.23
	Average Wet Weather Flow, 6.6 MGD	10.7	0.20	1.49
2030	Average Dry Weather Flow, 5.2 MGD	13.5	0.25	1.89
	Average Wet Weather Flow, 7.8 MGD	9.0	0.17	1.26
*ppd means pounds per day Average Dry Weather Flow is May through October Average Wet Weather Flow is November through April				

The waste load allocations for heat vary by month as follows:

	June	July	August	September
Effluent Temperature, ^oC	32	32	32	21.31
Discharge Flow, MGD	3.04	3.00	2.85	2.74
Allocation, kilocalories/day	367,147,008	362,857,703	344,761,641	220,889,641

In addition to the requirement posed by the pending TMDLs, the City has to ensure that other water quality standards applicable to the Klamath River are not violated as a result of the discharge from its sewage treatment plant.

Under Task 4A, Part 1, eight effluent disposal options were identified in the scope of work to be considered and specifically assessed in regards to meeting State of Oregon and federal discharge permit and other regulatory requirements. These were:

- Effluent Discharge into the River, but with Advanced Treatment and New Diffuser
- Effluent Discharge into the River, but with Additional, More Stringent Treatment (to background quality) and New Diffuser
- Agricultural Land Application with Winter Storage
- Constructed Wetland(s) with Indirect Discharge to Surface Waters
- State Wildlife Refuge for Land Application
- Indirect Subsurface Discharge – Hyporheic Zone
- "A" Canal Discharge for Land Application
- Pollutant Load Offset Trading

After considering the draft TMDLs, all but two of these disposal alternatives have been discarded for further consideration. The two disposal alternatives that remain are:

A. Effluent Discharge into the River, but with New Diffuser and Advanced Treatment to meet TMDL waste load allocations and In-stream Water Quality Standards.

B. Summer Agricultural Land Application with Winter Storage.

The other six alternatives were discarded for the following reasons as noted below:

- *Effluent Discharge into the River, but with Additional, more Stringent Treatment (to background quality) and New Diffuser.* The concept behind this option was to treat wastewater to existing background nutrient concentrations in the Klamath River thereby making the requirements of the nutrient TMDL irrelevant. At the time this concept was developed, the City feared that an expanded treatment plant would be needed before DEQ finalized the TMDL. DEQ has released its tentative TMDL waste load allocations for the City and, therefore, there is no need to pursue this concept.

- *Constructed Wetland(s) with Indirect Discharge to Surface Waters.* This option would still require an NPDES permit and anticipated pollutant attenuation via the wetlands

would unlikely provide sufficient treatment to meet the TMDL and other water quality standards. Additional, advanced treatment would be required by a treatment plant prior to discharge into the constructed wetlands. As a result, it provides no real benefits over that provided by a direct discharge via a new outfall diffuser.

- *State Wildlife Refuge for Land Application.* Representatives from the Oregon Department of Fish and Wildlife (which owns the nearby refuge) have indicated that the Department would not be interested in pursuing this option.

- *Indirect Subsurface Discharge – Hyporheic Zone.* This option has similar problems and issues as encountered with a constructed wetland with indirect discharge and, therefore, has no real benefit over that provided by a direct discharge via a new outfall diffuser.

- *"A" Canal Discharge for Land Application.* The water in the "A" canal is distributed to farmers by various irrigation districts. Discharge of effluent into the "A" canal could eliminate the irrigation district's NPDES permit exemption for the discharge of irrigation return flows. Based upon this, it is highly likely that this option would be aggressively opposed by the U. S. Bureau of Reclamation and irrigation districts that obtain water via the "A" canal.

- *Pollutant Load Offset Trading.* At this time, there is no known source of pollutant loads that the City could obtain that would significantly increase the pollutant discharges required by ODEQ to meet the TMDL. If the City selects to eliminate its discharge by summer irrigation and winter storage, however, it may have discharge credits that it could sell to other pollutant sources that have been assigned restrictive load allocations under the TMDL for the Klamath River.

- *Injection into the geothermal aquifer beneath the City of Klamath Falls.* This option was not one of the original options under consideration, but was added because it seemed like a possible low cost option for effluent disposal. This option, however, has been discarded because the geothermal aquifer cannot be separated from the drinking water aquifer and direct injection into a drinking water aquifer is prohibited by ODEQ administrative rules.

A. Effluent Discharge into the River, but with New Diffuser and Advanced Treatment to meet TMDL waste load allocations and In-stream Water Quality Standards

This alternative must provide sufficient treatment to reduce specific pollutants to levels that meet waste load allocations specified in the Klamath River TMDL and to meet other in-stream water standards prescribed for the Klamath River. These pollutant levels will ultimately be established as National Pollutant Discharge Elimination System (NPDES) permit effluent discharge limitations. The following text relative to this alternative discusses each of these

specific pollutants and attempts to predict the permit effluent limitations at projected 2030 design flows. In some cases, the predicted effluent limitations will derive from the anticipated TMDL, the need to comply with other in-stream water quality standards not addressed by the TMDL, or both.

As previously stated, ODEQ used 2000 river flows and a discharge flow of 2.9 million gallons per day in determining waste load allocations for the Spring Street sewage treatment plant. For determining permit effluent limitations for toxic parameters and other pollutants with near-field or mixing zone restrictions, ODEQ will use river low flow statistics over the last ten years. One of these statistics is the 7Q10 which is the lowest 7 day average flow over 10 years. Sometimes this statistic is applied seasonally. For instance, in determining limitations for aquatic toxicity, ODEQ may determine both a summer and winter time limit and use a 7Q10 flow for the summer months and a different one for the winter months.

The specific pollutants that must be addressed are:

Dissolved Oxygen. Wastewater discharges can affect dissolved oxygen concentrations in the river through the metabolism of oxygen-demanding pollutants in the wastewater such as organic material including ammonia-nitrogen. The impact can be exerted miles downstream from the point of discharge and is considered a far-field effect. Wastewaters with very low dissolved oxygen concentrations can also reduce in-stream dissolved oxygen concentrations near the point of discharge. This effect is considered near-field and is addressed by increasing the wastewater dissolved oxygen concentration and/or improving the mixing of the wastewater into the river water.

Currently, ODEQ's cool water dissolved oxygen criterion applies to the Klamath River at the point (whether at the current outfall location in Lake Ewauna or downstream in the Klamath River) where the City would discharge its effluent. The criterion is 6.5 mg/l as an absolute minimum. At the discretion of the ODEQ, when the ODEQ determines that adequate information exists, the river dissolved oxygen may not fall below 6.5 mg/l as a 30-day mean minimum, 5.0 mg/l as a seven-day minimum mean, and 4.0 mg/l as an absolute minimum.

In the case of the Klamath River, the tentative TMDL proposes a minimum dissolved oxygen concentration in the discharge effluent. For the City of Klamath Falls' Spring Street Wastewater Facility, ODEQ is proposing a minimum dissolved oxygen concentration in the discharge effluent of 5.7 mg/l. This concentration in combination with other TMDL waste load allocations for other oxygen-demanding pollutants was determined (in a far field analysis) as needed to meet water quality standards for dissolved oxygen in the river. ODEQ used a flow of 2.90 MGD to determine the minimum effluent dissolved oxygen waste load allocations for the Spring Street facility. For dissolved oxygen, however, ODEQ did not also propose a minimum mass load limitation. Therefore, it is unclear if the City will have to meet a higher minimum dissolved concentration at the higher projected sewage treatment plant design flows in the facility plan.

This tech memo also analyzed the potential for a near field impact relative to dissolved oxygen. Using a mass balance equation and assuming that ODEQ will allow effluent dilution in 25% of the river flow, the effluent will have to maintain 6.0 mg/l of dissolved oxygen to stay within 0.1 mg/l of the 6.5 mg/l criterion at river low flow and at the projected dry weather design flow of 5.2 MGD. At the wet weather average flow of 7.8 MGD, the effluent will have to maintain 6.2 mg/l. This assumes that the river's dissolved oxygen is at the 6.5 mg/l criterion and river flow is 113 cfs which is the minimum daily average Klamath River flow for the ten years (1Q10) ending at the end of the 2006 water year. ODEQ may allow a 0.1 mg/l deficit based upon Oregon Administrative Rule (OAR) 340-041-0004(9)(a)(D)(iii) which states:

> "Effective July 1, 1996, in water bodies designated water-quality limited for dissolved oxygen, when establishing WLAs under a TMDL for water bodies meeting the conditions defined in this rule, the Department may at its discretion provide an allowance for WLAs calculated to result in no measurable reduction of dissolved oxygen (DO). For this purpose, "no measurable reduction" is defined as no more than 0.10 mg/L for a single source and no more than 0.20 mg/L for all anthropogenic activities that influence the water quality limited segment. The allowance applies for surface water DO criteria and for inter-gravel dissolved oxygen if a determination is made that the conditions are natural. The allowance for WLAs applies only to surface water 30-day and seven-day means."

If ODEQ does not allow a 0.1 mg/l dissolved oxygen reduction, the effluent will have to contain at least 6.5 mg/l dissolved oxygen when river dissolved oxygen concentrations are 6.5 mg/l or less.

To meet any of these dissolved oxygen targets, aeration of the effluent will be necessary. In addition, the effluent may need to be cooled to make the aeration process more efficient. A diffuser that provides complete mixing of the effluent in 25% of the river flow within 100 feet of the point of discharge will also be needed. This assumes ODEQ will allow up to 100 feet for an allowable mixing zone in setting permit discharge limitations.

Ammonia-Nitrogen. Ammonia-nitrogen affects water quality two ways: it is an oxygen demanding pollutant and can contribute to reductions in dissolved oxygen concentrations in the receiving stream. It is also toxic to fish and increases in toxicity as pH levels increase. The proposed TMDL does specify an ammonia-nitrogen waste load allocation to address far field in-stream oxygen concentrations. The proposed effluent mass load limitation for ammonia is 37 kilograms/day (83 #/day). ODEQ calculated the resulting ammonia-nitrogen concentration (at treatment plant flow of 2.90 MGD) to be 3.34 mg/l. At the projected 2030 dry weather and wet weather average design flows of 5.2 MGD and 7.8 MGD, the effluent concentration limitation would drop to be 1.89 mg/l and 1.26 mg/l. Apparently, the waste load allocation applies all year.

The water quality analysis in this tech memo also evaluated potential aquatic toxicity due to ammonia-nitrogen. Using a toxicity reasonable potential analysis spread sheet provided by ODEQ, at minimum river flow (113 cfs) for the past ten years, a treatment discharge dry and wet weather flow of 5.2 and 7.8 MGD, respectively, and assuming salmonid fish are not present, the treatment process will need to produce an ammonia-nitrogen concentration as indicated in the following table.

		Concentration Limits		Mass Limits	
AMMONIA-NITROGEN	# Samples/month	Monthly, mg/l	Daily, mg/l	Monthly, #/day	Daily, #/day
Low Flow Season	4	2.7	5.3	115	231
High Flow Season	4	12.5	25.1	542	1090

For the toxicity analysis for ammonia, non-salmonid criteria were used because ODEQ does not protect this part of the Klamath River for salmonid fish (trout, salmon, and steelhead). There have been discussions about reintroducing anadromous salmonid fish into the upper Klamath Basin. If this happens and ODEQ modifies its in-stream water quality standards to protect salmonid fish in this part of the river, the criteria will change and the monthly average effluent limits for ammonia in the summer could be as low as 1.0 mg/l.

Treatment to meet the concentrations established by the reasonable potential analysis spread sheet would be through biological treatment that induces a high level of nitrification that converts ammonia to the relatively non-toxic nitrate form of nitrogen.

Temperature. ODEQ has two temperature criteria that apply to the Klamath River between Klamath Falls and Keno. From June 1 to September 30, no NPDES point source that discharges to the portion of the Klamath River designated for cool water species may cause the temperature of the water body to increase more than 0.3°C above the natural background after mixing with 25% of the stream flow. Natural background for the Klamath River means the temperature of the Klamath River at the outflow from Upper Klamath Lake plus any natural warming or cooling that occurs downstream. During the rest of the year, no increase in temperature is allowed that would reasonably be expected to impair cool water species. ODEQ indicates in its guidance for implementing the temperature standard, that cool water species should be protected if the 7 day average of the daily maximum temperatures is 20°C or less. The 20°C criterion is that deemed by rule to protect redband trout. The implied assumption is that, if 20°C is protective of redband trout, it should also be protective of cool water species.

Below Keno, the Klamath River is considered a cold water stream and is protected for salmonid fish.

ODEQ apparently has proposed waste load allocations for heat that are intended to ensure that there is no violation of the applicable in-stream temperature criteria below Keno. As proposed, the waste load allocations would apply during the summer months of June, July, August and September.

Insufficient data exists to accurately determine the near field impact of the City's thermal discharge relative to the ODEQ temperature standard. Using temperature and flow data recorded by the Bureau of Reclamation at Link River, it appears that the treatment plant may be able to comply with the temperature criteria during the summer if:

1. ODEQ allows the impact to be determined using, as background, the 7 day average of the maximum daily river temperature measured at Link River;
2. Consistent with its temperature guidance for the Klamath River, that a violation only occurs if the discharge causes the river temperature to exceed 20°C by more than 0.3°C during the period between June 1 through September 30.
3. Effluent temperature never exceeds 22°C during the June 1 through September 30 time period.

Based upon review of river temperature data for the period October 1 through May 31, there should be no problem meeting the temperature criterion for this period of the year.

In summary, the City should be able to comply with the temperature standard with the use of a diffuser and a reasonable interpretation of the standard by DEQ.

Carbonaceous Biological Oxygen Demand (CBOD-5). DEQ is proposing an effluent concentration for CBOD-5 of about 24 mg/l and a mass load limitation of 586 #/day. This limit apparently will be applied as a monthly average year around. At the 2030 average dry weather and wet weather design flows of 5.2 and 7.8 MGD, the resulting CBOD-5 concentration limitations will be 13.5 and 9.0 mg/l. This limitation should be relatively easy to meet considering the level of treatment to meet other pollutant limitations.

Total Phosphorus. ODEQ's proposed waste load allocation for total phosphorus is an effluent discharge concentration of 0.41 mg/l and a mass load limit of 11 #/day. The mass load limit is based upon a treatment plant discharge flow of 2.9 million gallons per day (MGD). The limits are apparently monthly averages and apply year around. At the 2030 average dry weather and wet weather design flows of 5.2 and 7.8 MGD, the resulting total phosphorus concentration limitations will be 0.25 and 0.17 mg/l. This concentration can be achieved with metal salt coagulation and precipitation followed by filtration.

As previously stated, the waste load allocations for dissolved oxygen, ammonia-nitrogen, total phosphorus, and carbonaceous biological oxygen demand (CBOD-5) were determined to be necessary to meet in-stream dissolved oxygen standards in the Klamath River. ODEQ has indicated a willingness to consider a single oxygen demand allocation that would allow, for example, a permitted source to potentially have a lower minimum effluent dissolved oxygen concentration limitation by reducing its CBOD-5 concentration.

Aquatic Toxicity. ODEQ's reasonable potential analysis spreadsheet indicates that both lead and mercury in the effluent could contribute to violation of ODEQ's aquatic toxicity requirements**.** This analysis is considered near field. The following table provides the projected effluent permit limits that ODEQ would insert in the permit for both lead and mercury. The final column in the table indicates the maximum effluent concentration from the City's effluent testing. As can be observed, even with a diffuser, the City could have difficulty meeting potential effluent limits for mercury without specific treatment.

Parameter	Projected NPDES Permit Monthly Average Limitations, ug/l	Projected NPDES Permit Daily Maximum Limitations, ug/l	Curent Maximum Effluent Concentration, ug/l
Lead	8.21	11.98	2.27
Mercury	0.056	0.082	0.064

The projected limitations are based upon a diffuser providing 100% complete mix in 25% of the river's low flow.

The elevated levels of mercury in the City's current effluent have been traced to the cogeneration facility and its use of mercury-contaminated sulfuric acid. A switch to mercury-free acid may reduce mercury levels in the blowdown water. If this does not work, the blowdown water may need to be treated to reduce mercury.

Human Health Toxicity. A similar reasonable potential analysis was conducted for human health toxicity as was done for aquatic toxicity. Again, the available data is very limited. Only arsenic was found to be a problem. This problem is not surprising as the applicable human health criterion for inorganic arsenic is 0.0022 ug/l. According to the data from the City, the river's inorganic arsenic concentration ranged between 2.54 and 6.38 ug/l, slightly below the state and federal drinking water standard of 10 ug/l. The City's testing shows that its effluent contains between 31.1 and 45.7 ug/l. The reasonable potential analysis spread sheet (using projected dry and weather average design flows as previously stated) would project a monthly average limitation equal to the criterion: 0.0022 ug/l.

Infiltration and inflow may be contributing arsenic from geothermal sources within the City. This could explain why the City's influent is relatively high (about 0.02 ug/l) compared to the arsenic concentration in the City's drinking water (below detection).

Oregon Administrative Rule (OAR) 340-041-0007(2) states: "Where a less stringent natural condition of a water of the State exceeds the numeric criteria set out in this Division (OAR 340-041), the natural condition supersedes the numeric criteria and becomes the standard for that water body." The City may be able to make a case that the background concentration of inorganic arsenic is natural background. This would, perhaps, allow ODEQ to impose an arsenic effluent limit concentration equivalent to the background concentration. Potentially, the most difficult part of making the case is convincing ODEQ that background concentrations are actually natural and not due to anthropogenic activities upstream. An

immediate monitoring effort should be implemented to get sufficient data to support the background river concentrations for arsenic as the applicable in-stream standard. (This is taking place now.)

Achieving an effluent concentration of total arsenic of 0.0022 ug/l is likely not possible. If the City is required to meet river background, it could possibly be accomplished by treating the effluent (or perhaps just the blowdown return water) by chemical precipitation or reverse osmosis. The advantage of treating the blowdown water may be that it involves a smaller flow. More data is needed to better understand the concentration of arsenic in the blowdown and in the treated effluent that is produced at the treatment plant.

Bacteria. The City's current NPDES permit requires that the reclaimed water provided to the cogeneration facility have no more than a 7 day median total coliform concentration of 23 cells per 100 milliliters (mls). In addition, no two consecutive samples shall exceed 240 cells per 100 mls. ODEQ's rules for reclaimed water reuse have been recently modified. The requirements for reuse as cooling water, however, are unchanged.

The City's current NPDES permit bacteria limitations for discharge to the river are based on fecal coliform. ODEQ's rules for bacteria effluent limitations for river discharge have changed since the permit was issued. They are now based on E. coli and require a 30 day average of 126 E. coli per 100 mls and a maximum of 406 per 100 mls.

Regardless of the applicable bacteria limit, the treatment plant designed to meet the TMDL and other water quality standards should have little difficulty meeting them. In fact, effluent quality should comply with ODEQ's Class recycled water criteria, in which case the effluent could be provided for irrigation and other unrestricted uses allowed by ODEQ's rules for recycled water.

Chlorine. If chlorine is used to disinfect the final effluent to meet applicable bacteria limits, ODEQ will impose a limit on total chlorine residual in the permit to prevent aquatic toxicity. This limit will require dechlorination as is currently practiced at the existing sewage treatment plant.

pH. Federal secondary treatment standards require that the effluent pH not be outside the range of 6.0 – 9.0. This should be readily achievable with the upgraded sewage treatment plant.

Total Dissolved Solids. Pursuant to an agreement between the States of California and Oregon (called the Klamath River Compact), the conductivity in the Klamath River at the border between the states shall not exceed 400 micro-mhos. Although there is limited data relative to the conductivity of the City's effluent, a cursory analysis indicates that the City's discharge should not significantly affect the criterion.

The capital costs related to compliance with the TMDL fall into two areas:

1. Liquid stream process improvements at the Spring Street WWTP – These costs include aeration basins, filters and modifications to the disinfection system and amount to approximately $21 million. This cost is based on the fact that two of the three new aeration basins and 80% of filter capacity are needed to meet TMDLs (the remainder of the aeration capacity and filter capacity are needed for growth and reliability). A breakdown of the plant cost attributed to TMDLs is as follows:

Basis for the TMDL Plant Cost:

1 New Aeration Basin needed for growth and reliability
2 New Aeration Basin needed for full, year round nitrification
3

2/3 x $17.7 million = $11.8 million project cost

Assumed filters needed to meet the P limit and 20% of that filtration would be needed for reuse opportunities
0.8 x $12 million = $9.6 million

TOTAL = $21.4 million rounded to $21 million

2. Development of a new outfall at a location downstream of Lake Ewauna – A new outfall into Lake Ewauna was considered as an alternative but discarded. Finding enough velocity in the lake cross section to achieve the needed dilution may not be possible. Therefore, a new outfall downstream of the Highway 97 Bridge is used for planning purposes. The existing 24-inch and 12-inch diameter lines to the cogeneration facility would convey the entire plant flow to a new 36-inch outfall in the Klamath River. A conceptual schematic of the proposed disposal system is shown in Attachment C.[1] These costs could be reduced or offset if treated water can be diverted from discharge to the river and, instead, reused for beneficial purposes. A planning level cost estimate for implementing this $19 million as shown in the table below.

[1] This concept of using the cogeneration pipelines and assuming the new outfall would be somewhere near the cogeneration plant represents a worse case and deserves further study. Pumping represents most of the costs of this alternative and if an outfall could be located up close to the Highway 140 bridge, the project cost could be reduced. The alternative of using the cogeneration pipeline should also be compared to a new pipeline running south from the plant on the east side of the Klamath River before a final project is selected. Further, should South Suburban also need a new outfall, a joint new pipeline could go down the east bank. (A new joint pipeline would be needed because the existing cogen pipeline would not have sufficient capacity to handle the additional South Suburban flow.)

Item	Project Costs, $ million
Effluent Pump Station Upgrades	5
Intermediate Booster Station and Storage Tank	7
Modifications at Cogeneration Site and River Outfall	7
Total	19

Thus, the total cost of this alternative is $21M +$19M = $40M.

B. Summer Agricultural Land Application with Winter Storage

This alternative would eliminate discharge of any effluent to surface waters. Effluent would be stored during the non-irrigation season and would be irrigated at agronomic rates during the irrigation season.

Based upon current projected design flows, the storage basins would require 380 acres assuming a depth of 10 feet. Agronomic irrigation at 3 feet per year would require an irrigation area of 2000 acres.

Wastewater quality requirements set forth in ODEQ's rules for using recycled water depend upon the actual use. Irrigation of non-food crops such as forage would require a 7-day median total coliform limit of 23 CFU/100 mls with no two consecutive samples exceeding 240 CFU/100mls. Virtually any mechanical, biological sewage treatment process with disinfection should be able to achieve these levels. If food crops destined for human consumption were to be irrigated with recycled water, higher levels of treatment and disinfection would be required to achieve a Class A recycled water.

Total dissolved solids in the effluent could be the only other wastewater constituent that might impair its use for agricultural application. As previously stated, there is very limited data on effluent total dissolved solids concentrations. However, a cursory analysis with limited data appears to indicate that concentrations will be less than 500 mg/l and should not impair agricultural application.

If the storage pond were lined to restrict wastewater seepage into ground water and if effluent were irrigated at agronomic rates, ODEQ would likely not impose groundwater quality protection requirements pursuant to its groundwater quality protection rules in OAR 340-040. If the storage pond were not lined, ODEQ would likely impose a groundwater quality protection program. The program would likely require extensive groundwater characterization, monitoring wells, down-gradient compliance points and limits, and/or limitations on the quality of water stored in the storage pond.

One parameter of concern by DEQ would be total nitrogen. Total nitrogen concentrations less than 5 mg/l might alleviate DEQ's groundwater concerns relative to nitrogen. Other potential concerns might be heavy metals.

A first order planning level cost estimate for implementing this alternative is $122 million with the storage basins representing 75% of this estimate cost. This cost estimate assumes that the storage basins and irrigation would be located no more than 7 miles from the treatment plant. There are no land costs in the estimate. The cost of this alternative may be reduced if ODEQ reevaluates its TMDLs and only applies them seasonally. This could reduce the needed size of the storage basins which are a major component of the cost.

Component	Project Cost, $ million
Pump Station	6
Force main	20
Storage Basin	93
Irrigation Facilities	4
Total	122

A conceptual schematic of the proposed land application and storage system is provided in Appendix D.

Attachments

A. ODEQ Presentation (May 8th, 2008)
B. Slides 4 to 15 from the CDM Presentation (June 26th, 2008)
C. Simplified Flow Schematic for Outfall Near Highway 97 Bridge
D. Simplified Flow Schematic for Zero Discharge

Appendix A - ODEQ Presentation (May 8, 2008)

Klamath River TMDL Development

City of Klamath Falls WWTP and South Suburban Sanitary District

Oregon DEQ, U.S. EPA Region 10, U.S. EPA Region 9, and North Coast RWQCB

with support from Tetra Tech, Inc.

May 22, 2008

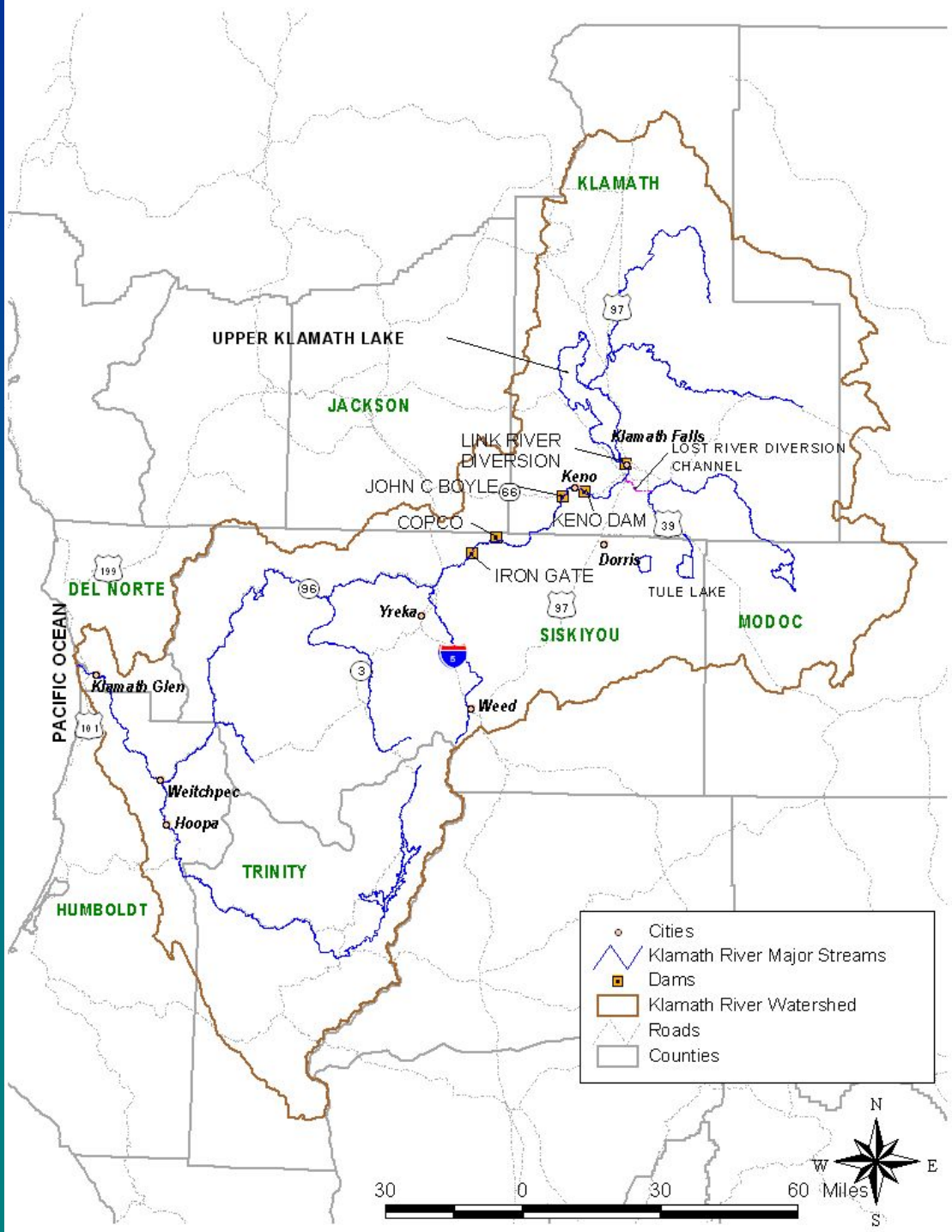
Meeting Agenda

- Introductions
- Background
- TMDL Schedules
- Modeling Approach and Scenarios
- Interpretation of Standards and Approaches for Allocation
- Draft wasteload allocations
- Uncertainty Challenges
- Next Steps

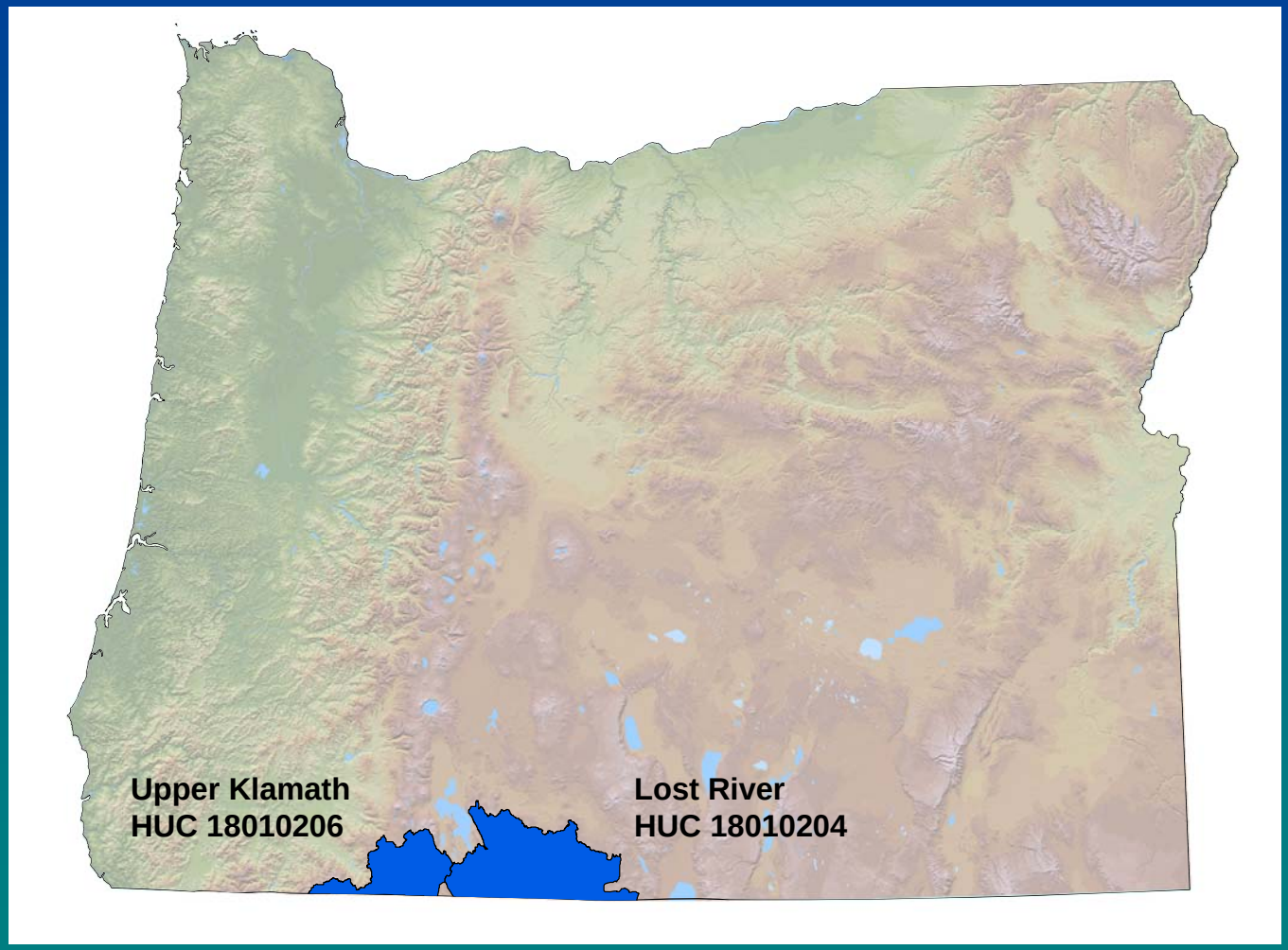
Overview

- Natural lake, river, reservoirs, and estuary segments
- High biomass load from upstream segment (UKL)
- Four point sources with NPDES permits
- Agricultural nonpoint sources
- Impairments
  - OR: pH and chlorophyll a (rm 231-251); ammonia toxicity and DO (rm 231-250)
  - CA: nutrients, organic enrichment/low DO, temperature (all)

Lower Klamath River Basin



Upper Klamath and Lost River Subbasins

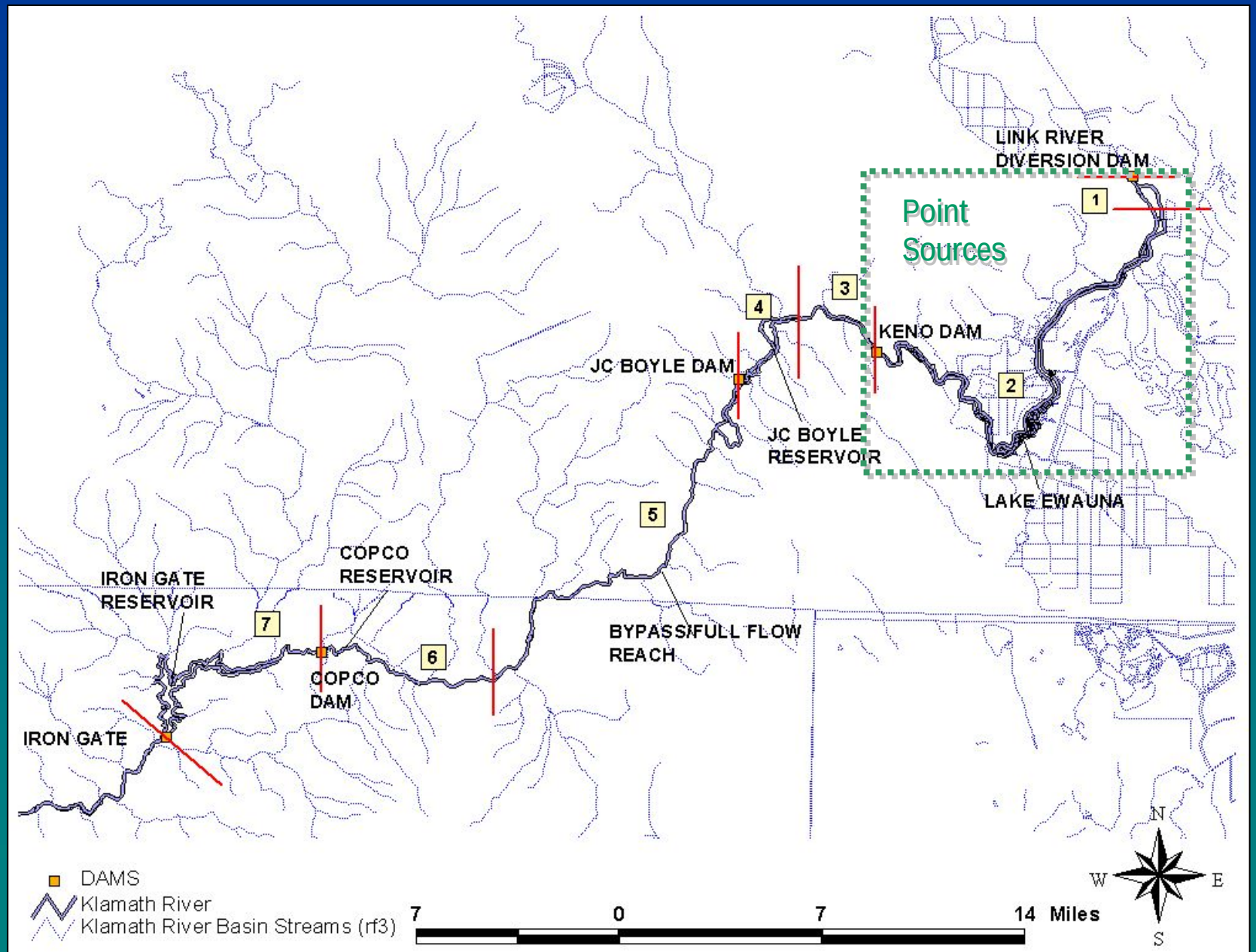


Model Overview

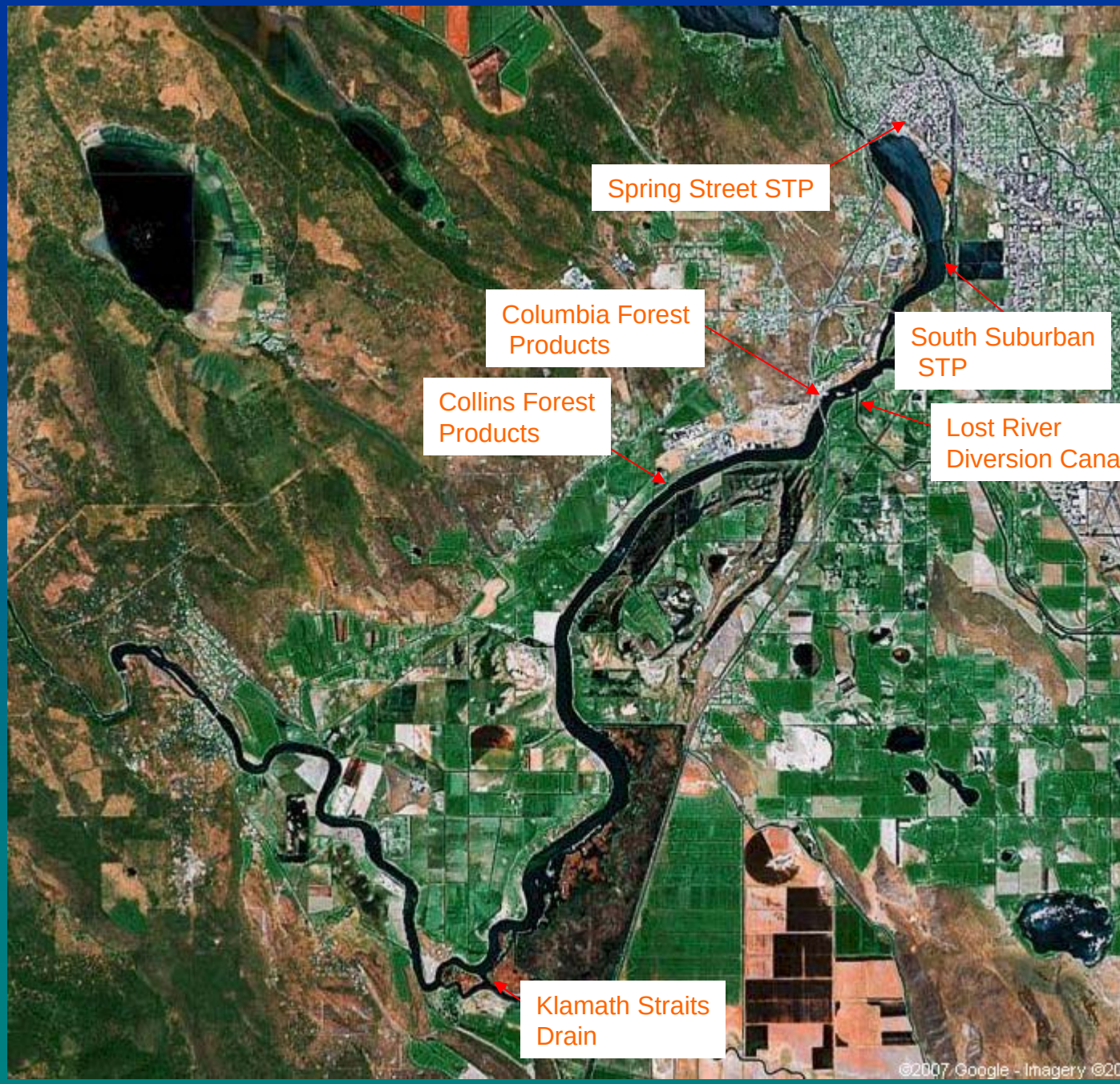
Modeling Segment	Segment Type	Model(s)	Complexity
Link River	River	RMA-2/RMA-11	1-D
Lake Ewauna-Keno Dam	Reservoir	CE-QUAL-W2	2-D
Keno Dam to J.C. Boyle Reservoir	River	RMA-2/RMA-11	1-D
J.C. Boyle Reservoir	Reservoir	CE-QUAL-W2	2-D
Bypass/Full Flow Reach	River	RMA-2/RMA-11	1-D
Copco Reservoir	Reservoir	CE-QUAL-W2	2-D
Iron Gate Reservoir	Reservoir	CE-QUAL-W2	2-D
Iron Gate Dam to Turwar	River	RMA-2/RMA-11	1-D
Turwar to Pacific Ocean	Estuary	EFDC	3-D

- RMA/W2 models are based on original Pacificorp Model
- Many enhancements to Pacificorp Model
- EFDC model is entirely new for the system

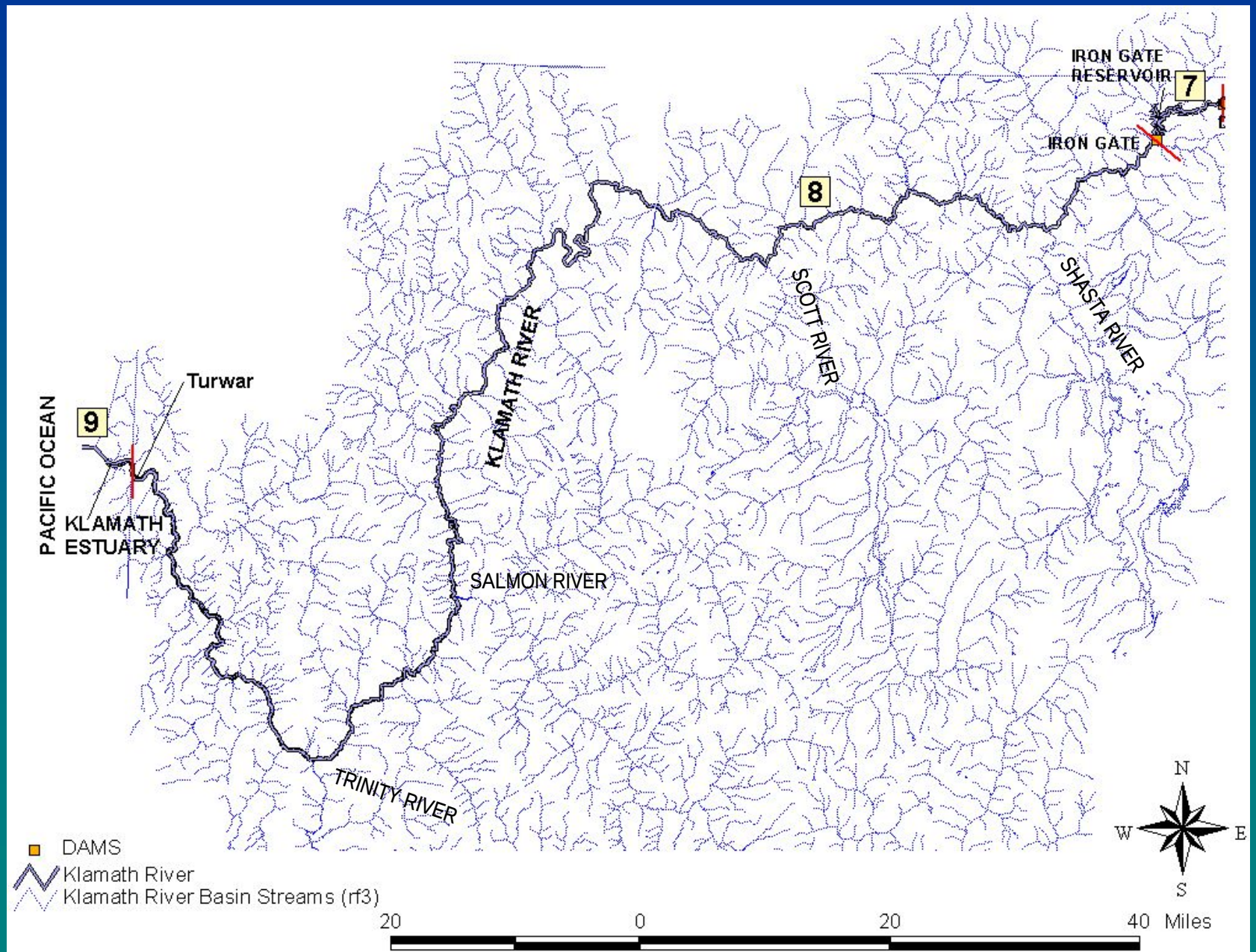
Upper Klamath Lake to Iron Gate Dam



Point Sources



Iron Gate Dam to the Pacific Ocean



TMDL Schedules

TMDL Schedule

October 2008 – ODEQ 60–day public notice Upper Klamath, Lost River Subbasins TMDL

December 2008 – EPA Region 9 establishes Lower Lost TMDL in CA

February 2009 - DEQ adopts Upper Klamath, Lost River Subbasins TMDL

March 2009 – EPA Region 10 approves Klamath, Lost River Subbasins TMDL

April 2009 – CA Regional Board 90-day public notice Klamath River TMDL

September 2010- EPA Region 9 approves Klamath River, CA TMDLs

Lost River Subbasin TMDL in Oregon

DEQ will include Lost River Subbasin TMDL with the Upper Klamath Subbasin in TMDL document

Lower Lost River TMDL in CA

- **EPA will complete the Lower Lost TMDL in 2008.**
- **CA Regional Board does not have resources to develop Lost River TMDL Implementation Plan within the next few years**

Modeling Approach and Scenarios

Modeling Approach and Scenarios

- Activities Since Last Meeting
  - Model corroboration for 2002
  - Scenario runs
  - Updated modeling report
- Expected Additional Scenario Runs

Model Corroboration for 2002: Objectives

- Improve confidence in model by testing it for an additional year (calibration was performed for 2000)
- Focus on Upper Klamath Lake to J.C. Boyle Reservoir (entirely within Oregon)
- Large amount of data available along this stretch for 2002

Model Corroboration for 2002: Results

- Required some retuning of model parameters for 2000
- Yielded results consistent with 2000
- Agreement that the model can now be used for allocation analysis

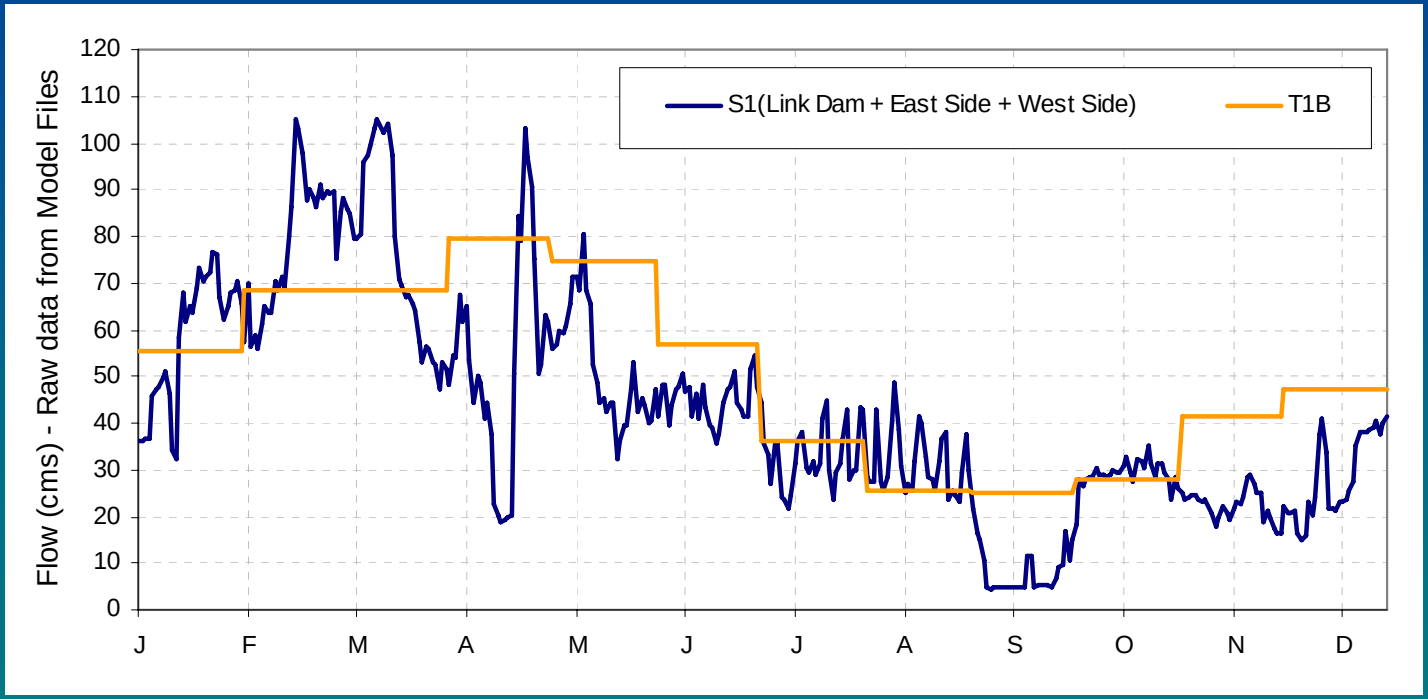
Modeling Scenarios Run Prior to Last Meeting

- **Natural Condition Baseline**
  - **T1A maximum TMDL loading condition from UKL TMDL**
  - **T1B: represents the median loading (year 1995) at natural flows (USBR)**
  - **T1BS: same as T1B but using existing flows**
- **WQ Standards Compliance Runs**
  - **TOT1: temperature compliance for point sources**
  - **TOT2: temperature compliance for non-point sources**
  - **TOD1: DO compliance for point sources**

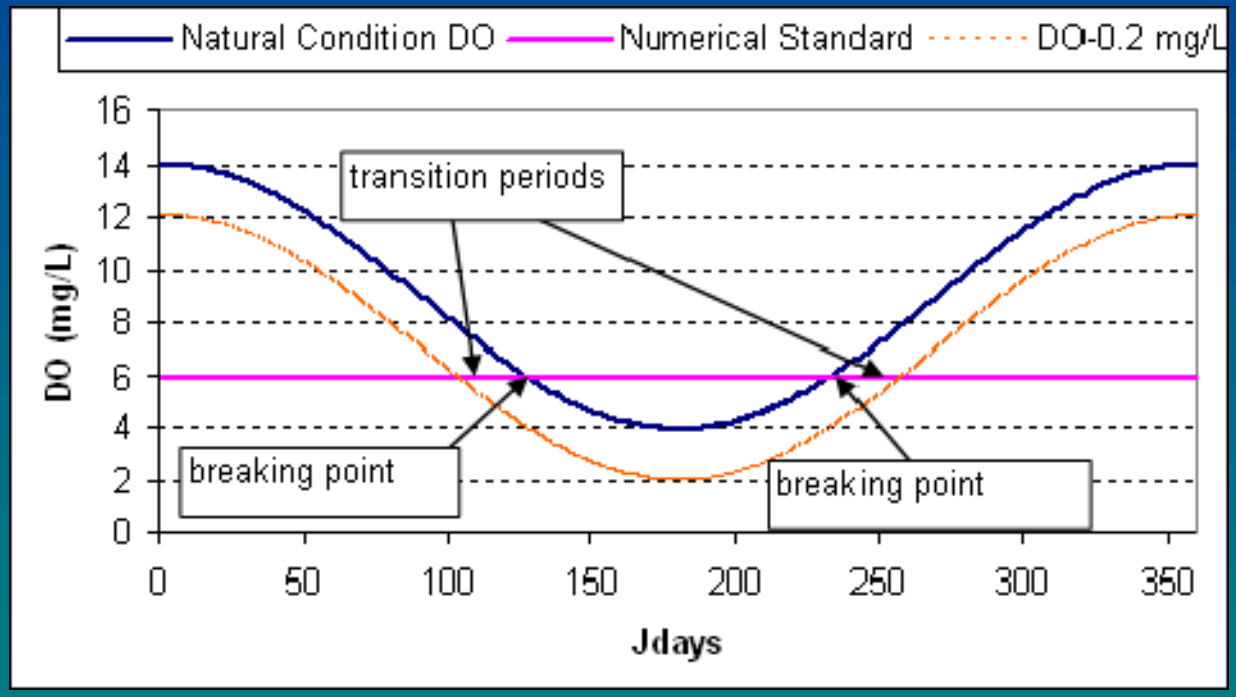
Upper Klamath Lake At Link River Natural Condition Using TMDL Condition From UKL

- Calculate average ratios for TN:TP, SRP:TP, NO_3/NO_2:TN based on WQ data UKL
- Calculate non-algal TN from non algal P and TN:TP
- Calculate PO_4 and Organic P using non-algal P and SRP:TP ratio
- Calculate organic matter using ratio OM:OP=180
- Derive NO_2/NO_3 based NO_3/NO_2-N:TN ratio
- Calculate NH_4 based on NH_4:TN ratio
- Calculate algal biomass from UKL chlorophyll-a results and an algae to chlorophyll-a ratio of 67 from model calibration
- Calculate saturated DO concentration based on temperature

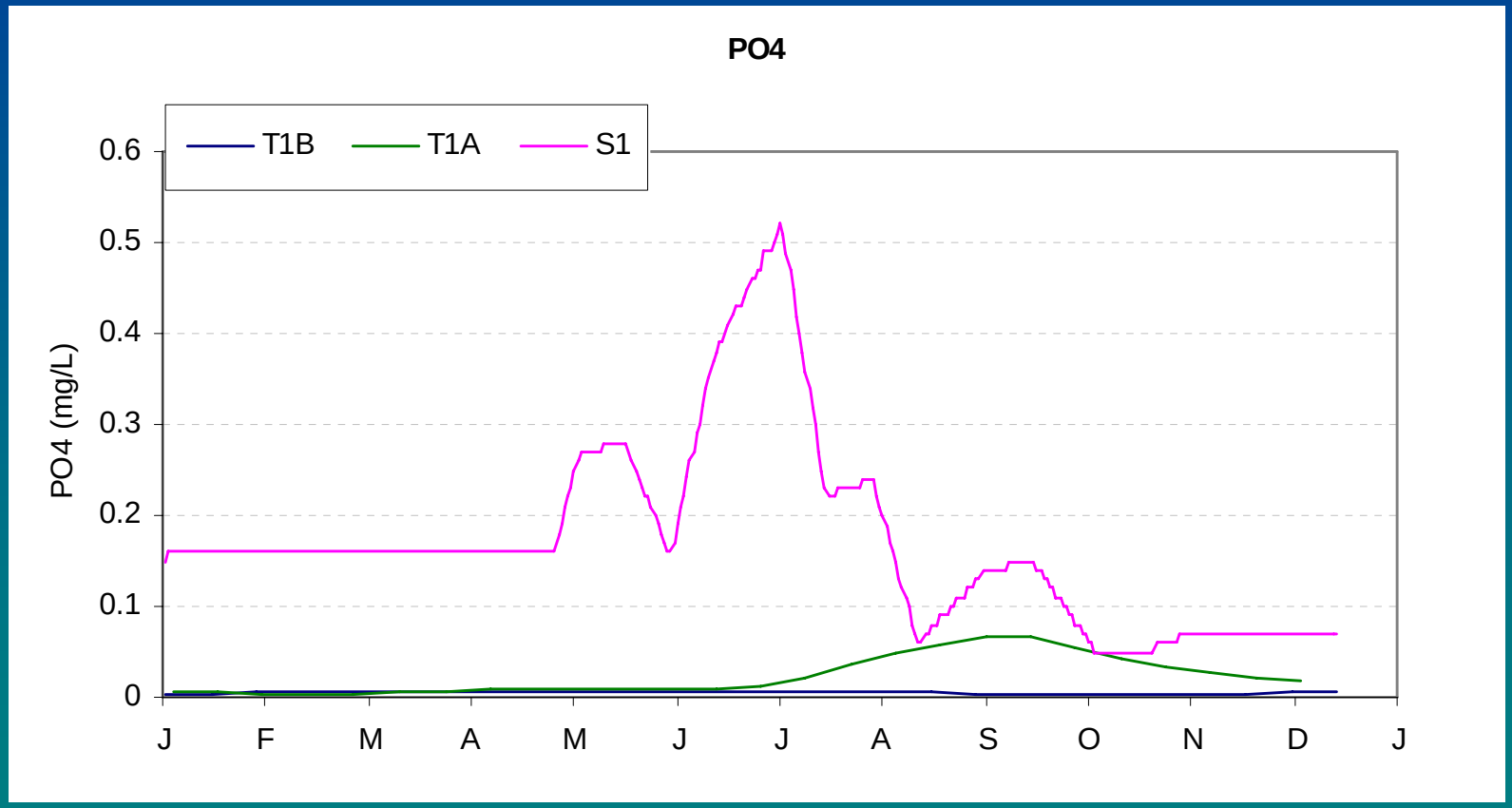
Link River Flow Existing Condition (S1) and Natural Flow T1B (USBR 2006)



Natural Condition Criteria

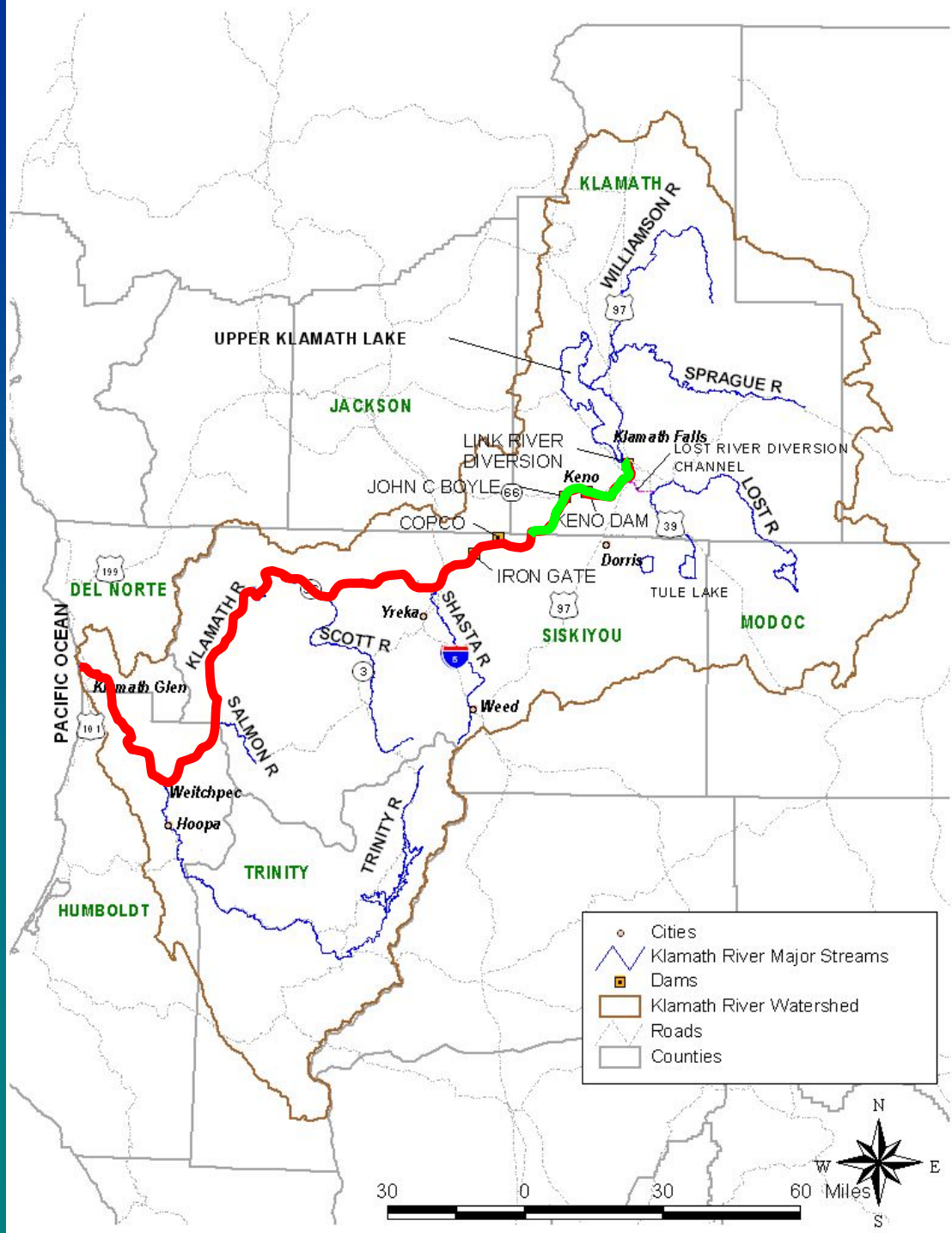


Phosphorus Loads from UKL under Natural (T1A, T1B) and Existing (S1) Conditions



Klamath River Scenarios

- Natural Condition Baseline (T1BS)
- OR temperature compliance (TOT)
- OR DO compliance (TOD)



Expected Additional Scenarios

- DO Compliance run nonpoint sources TOD2

- Dam Allocation (T4)
  - Dams in
  - Current (2000) flows: UKL, Lost River, KSD, OR and CA tributaries
  - Lost River, KSD, and Point Source water quality per T2
  - Single run (not iterative)

Interpretation of Standards and Approaches for Allocation

Compliance – General

- Numeric targets
- Except when natural condition does not achieve numeric target
- Then, compliance is determined using the difference between predicted natural concentrations and predicted concentrations with allocations.

Temperature Allocation Strategy

- Human Use Allowance (HUA) = 0.3° C or 0.075° for each point source and ¼ flow for each point source
- Point sources WLAs: current operations (design flow with current temps)
- LRD / KSD: 1/3 of (HUA – WLAs)
- Dams: 1/3 of (HUA – WLAs)
- Reserve Capacity: 1/3 of (HUA – WLAs)
- WQ Standards compliance in cool water segment (Keno reservoir) insuers compliance in cold water segment (D/S Keno Dam)
- Check if current (year 2000) operations (design flow with current temps) results in WQ standards compliance

DO Allocation Strategy

- Capacity = 0.2 mg/L DO deficit from natural
- Combined PS WLAs = 0.1 mg/L DO deficit
- NPS = 0.05 mg/L DO deficit
- Dams = 0.05 mg/L DO deficit
- Reserve capacity = 0

DO Allocation Strategy

Nutrient allocations should be determined using the following guidelines:

- Same concentration for WWTPs
- Current concentrations for industrial PS (assuming less than above)
- Equal % reductions to LRD and KSD loads.
- DO augmentation assigned to dams

DO Compliance Statistics
30-day DO Criteria

Table 1 TOD1 results upstream of Keno Dam—30-day criteria

Location	Min 30-day DO (mg/L)		Criteria (mg/L)	% time T1A is < 30-day DO criteria	Date range when T1A < 30-day criteria		% time T1BS is < 30-day DO criteria	Date range when T1BS < 30-day criteria		max DO deficit between TOD1 & T1BS (TOD1-T1BS)	% time this deficit is < 0.1 mg/L
	TOD1	T1A			From	To		From	To		
MILLER ISLAND	6.13	1.50	6.50	38.81%	2-Jul	9-Nov	15.22%	10-Jul	30-Aug	-0.045	0.00%
KFALLWWTP	7.20	6.81	6.50	0.00%			0.00%			0.000	0.00%
KSD	6.02	1.04	6.50	42.39%	26-Jun	15-Nov	17.31%	6-Jul	2-Sep	-0.055	0.00%
LRDC	6.41	2.57	6.50	35.52%	7-Jul	3-Nov	5.97%	1-Aug	21-Aug	-0.036	0.00%
SOUTH SUBURBAN SANITARY	6.77	5.15	6.50	26.27%	25-Jul	21-Oct	0.00%	1-Jan	1-Jan	-0.050	0.00%
KENODAM ND241	5.97	1.41	6.50	43.88%	24-Jun	18-Nov	18.51%	3-Jul	3-Sep	-0.059	0.00%

Draft DO Waste Load Allocations

Source	Flow rate (cms)	Minimum DO concentration (mg/L)	CBOD (mg/L)	Total Phosphorus (mg/L)	Ammonia (mg/L)
Klamath Falls WWTP	0.127	5.7	24.22	0.41	**3.34**
South Suburban WWTP	0.071	5.7	24.22	0.41	**3.34**
Columbia Plywood	0.0004	**7**	**10.17**	**0.25**	**0.20**
Collins Forest Product	0.042	**3.5**	**38.45**	**0.45**	**0.27**
			Kilograms per day		
Klamath Falls WWTP			266	5	**37**
South Suburban WWTP			149	3	**21**
Columbia Plywood			**0.35**	**0.01**	**0.01**
Collins Forest Product			**140**	**2**	**1**

RED = current modeled condition

Flow & concentration is the average June - September, 2000

Flow rate for Collins Forest based on total flow and concentration is flow weighted based

Upper Klamath Lake Boundary Condition

Source	Approach	Flow rate (cms)	Minimum DO (mg/L)	C-BOD (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
Upper Klamath Lake	UKL TMDL	29.32	saturation	3.9	0.034	0.442

Concentrations were estimated based on the average load and flow for that month

Temperature Wasteload Allocations

South Suburban Sanitary District				
NTP (Max 7-dadm)	23.96	24.32	25.53	18.92
River Flow	48.96	36.31	35.15	9.23
Effluent Temperature (deg C)	32.00	32.00	32.00	23.34
Source Flow (cms)	0.062	0.080	0.067	0.075
Allocation (kilocalories/day)	172,652,544	222,120,465	186,026,446	147,053,094

Klamath Falls WWTP				
NTP (Max 7-dadm)	23.26	23.38	24.54	21.31
River Flow	48.96	36.31	35.15	9.23
Effluent Temperature (deg C)	32.00	32.00	32.00	21.34
Source Flow (cms)	0.133	0.131	0.125	0.120
Allocation (kilocalories/day)	367,147,008	362,857,703	344,761,641	220,889,641

Categories of Model Uncertainty

- Boundary conditions
  - Flows and pollutant loadings entering mainstem
- WQ Condition of the mainstem
  - Measurement uncertainty and data gaps for current DO, pH, temperature, etc.
- Rates, constants, and kinetics
  - Decay rates for organic matter, growth rate of algae, etc.

Is the model good enough?

- Common Question
  - "Is the model accurate in predicting current water quality to the range of impact allowed (e.g., dissolved oxygen is 0.2 mg/l)?"
  - Corollary:

"If not, how can you use this model to evaluate such small water quality differences?"

Response

- No…and we do not believe that this degree of accuracy is necessary for a TMDL
  - Uncertainty is a recognized element of TMDLs
  - The overall model error is minimized to the extent feasible given the available information for this system
  - Because sources are isolated in the allocation process, the uncertainty in the allocations is different (and smaller) than overall model uncertainty
  - The model is the best available tool for implementing the water quality standards

Next Steps

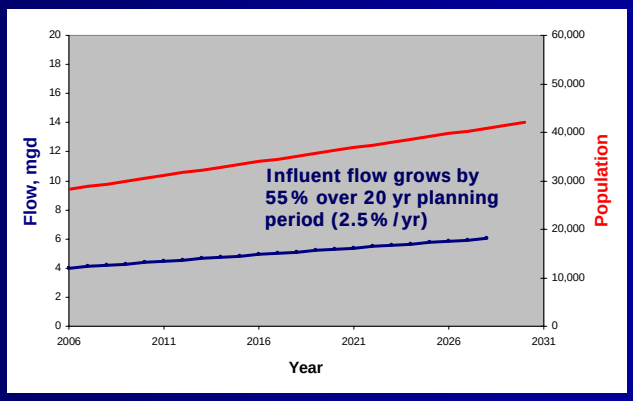
- Complete nonpoint source allocation scenarios
- Schedule next meeting with point sources to present draft allocations for all sources
- Prepare draft TMDL document for internal review

Appendix B - Slides 4 to 15 from CDM Presentation (June 26th, 2008)

TMDL's & Water Quality Issues

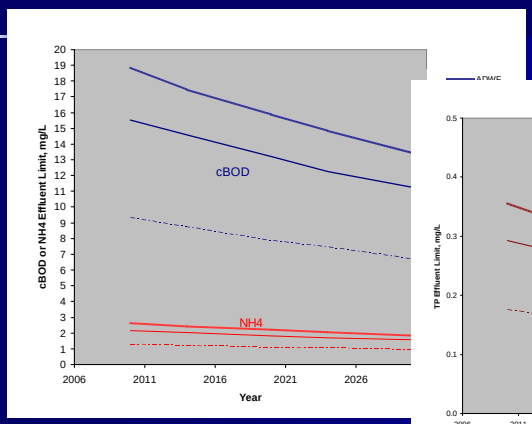
- cBOD = 275 kg/day
- Total phosphorus = 5 kg/day
- Ammonia = 37 kilograms/day ➔No total nitrogen limit
- Arsenic = 0.0022 ug/l
- Effluent Dissolved Oxygen = 5.7 mg/l
- Temp = 15C

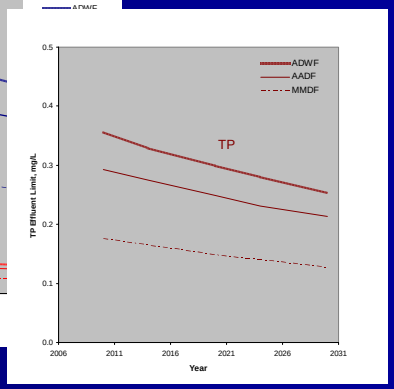
Planning Criteria – Influent Loads



Flow assumptions used in the analysis.....

Effluent Limits vs. Planning Year





Increasingly stringent concentration limits over time….

Total Phosphorus – Allocation based on 3 MGD

Source	Flow rate (cms)	Minimum DO concentration (mg/L)	CBOD (mg/L)	Total Phosphorus (mg/L)	Ammonia (mg/L)
Klamath Falls WWTP	0.127	5.7	24.22	0.41	3.34
South Suburban WWTP	0.071	5.7	24.22	0.41	3.34
Columbia Plywood	0.0004	7	10.17	0.25	0.20
Collins Forest Product	0.042	3.5	38.45	0.45	0.27
			Kilograms per day		
Klamath Falls WWTP			266	5	37
South Suburban WWTP			149	[illegible]	21
Columbia Plywood			0.35	0.01	0.01
Collins Forest Product			140	2	1

RED = current modeled condition
Flow & concentration is the average June - September, 2000
Flow rate for Collins Forest based on total flow and concentra

At planned flows, target limits are:

2006: 4.5 MGD = 0.3 mg/l

2030: 6.2 MGD = 0.2 mg/l

* *Table from DEQ May 22, 2008 presentation*

Human Health Toxicity = Arsenic

- Limited data
- Human health criteria = 0.0022 ug/l
- River background = 2.5 to 6.4 ug/l
- Drinking water standard < 10 ug/l
- Plant effluent = 31 to 46 ug/l
- Actions:
  - Ask for at least natural background
  - Source control investigations
  - Treatment as a last resort

Ammonia – Allocation based on 3 MGD

Source	Flow rate (cms)	Minimum DO concentration (mg/L)	CBOD (mg/L)	Total Phosphorus (mg/L)	Ammonia (mg/L)
Klamath Falls WWTP	0.127	5.7	24.22	0.41	3.34
South Suburban WWTP	0.071	5.7	24.22	0.41	3.34
Columbia Plywood	0.0004	7	10.17	0.25	0.20
Collins Forest Product	0.042	3.5	38.45	0.45	0.27
			Kilograms per day		
Klamath Falls WWTP			266	5	37
South Suburban WWTP			149	3	
Columbia Plywood			0.35	0.01	0.01
Collins Forest Product			140	2	1

Limit could be < 1 mg/l if Salmonid criteria apply

RED = current modeled condition
Flow & concentration is the average June - Septemb
Flow rate for Collins Forest based on total flow and

At planned flows, target limits are:

2006: 4.5 MGD = 2.1 mg/l

2030: 6.2 MGD = 1.6 mg/l

* *Table from DEQ May 22, 2008 presentation*

Dissolved Oxygen

- DEQ Std. Is 6.5 mg/l in River absolute minimum
- DEQ may allow DO deficit of 0.1 mg/l
- At 25% dilution = 5.0 mg/l STP effluent of 5.2 MGD
- DEQ TMDL requires minimum5.7 mg/l effluent DO
- Possible outfall and diffuser approaches
  - Lake Ewauna
  - Below HWY 97 Bridge

Temperature

- Insufficient data
- Mixing zone issue as well as TMDL
- No problem most of the year
- Temperature std. is more stringent in June and Sept Period
- May need to cool for both D.O. and Temperature

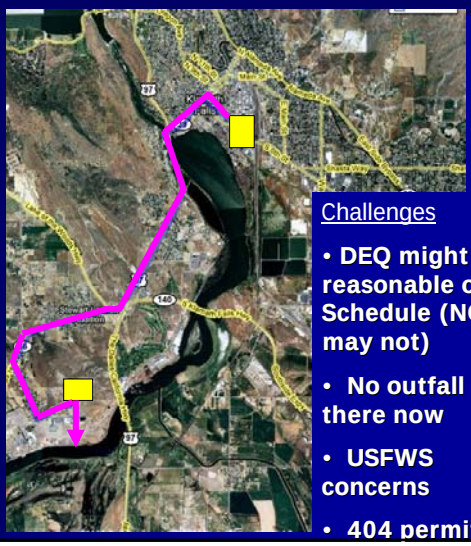
Possible outfall and diffuser approach - Lake Ewauna

- Preliminary modeling based on even flow across lake – may not be true
- Requires 600 ft long diffuser with ports every few yards

Possible outfall and diffuser approach - Below HWY 97 Bridge

<u>Could Use existing 12 and 24 inch forcemains</u>

- Capacity approx. 20 MGD if pumping upgraded
- May require booster to stay within pressure rating of pipe
- Advantages over Discharge to Lake
  - Re-aeration easier (in line or cooling towers)
  - Cogen plant towers could be used for effluent cooling and re-aeration
  - Take advantage of other reuse opportunities along the way



<u>Challenges</u>

- DEQ might be reasonable on Schedule (NGOs may not)
- No outfall there now
- USFWS concerns
- 404 permit

Reuse

Selling/diverting Class A recycled water could be an opportunity for the City

Category	Level I	Level II	Level III	Class A
Biological treatment	X	X	X	X
Disinfection	N/R	X	X	X
Clarification	N/R	N/R	N/R	X
Coagulation			N/R	X
Filtration			N/R	X
Total coliform (organisms/100 mL):				
two consecutive samples				N/L
7-Day median				2.2
Maximum				23
Sampling frequency				1 per day
Turbidity (NTU):				
24-Hour mean				2
5% of time during a 24-hour period			L	5
Sampling frequency			N/R	Hourly
Public access	Pre (fen locks)	nonpublic lands)	trolled (signs, rural or nonpublic lands)	No direct public contact during irrigation cycle
Buffers for irrigation:	Surface: 10 ft. Spray: site specific	Surface: 10 ft. Spray: 70 ft.	10 ft.	None required

Treatment technologies required to meet TMDL's for river discharge produce effluent that meets Class A Effluent Criteria

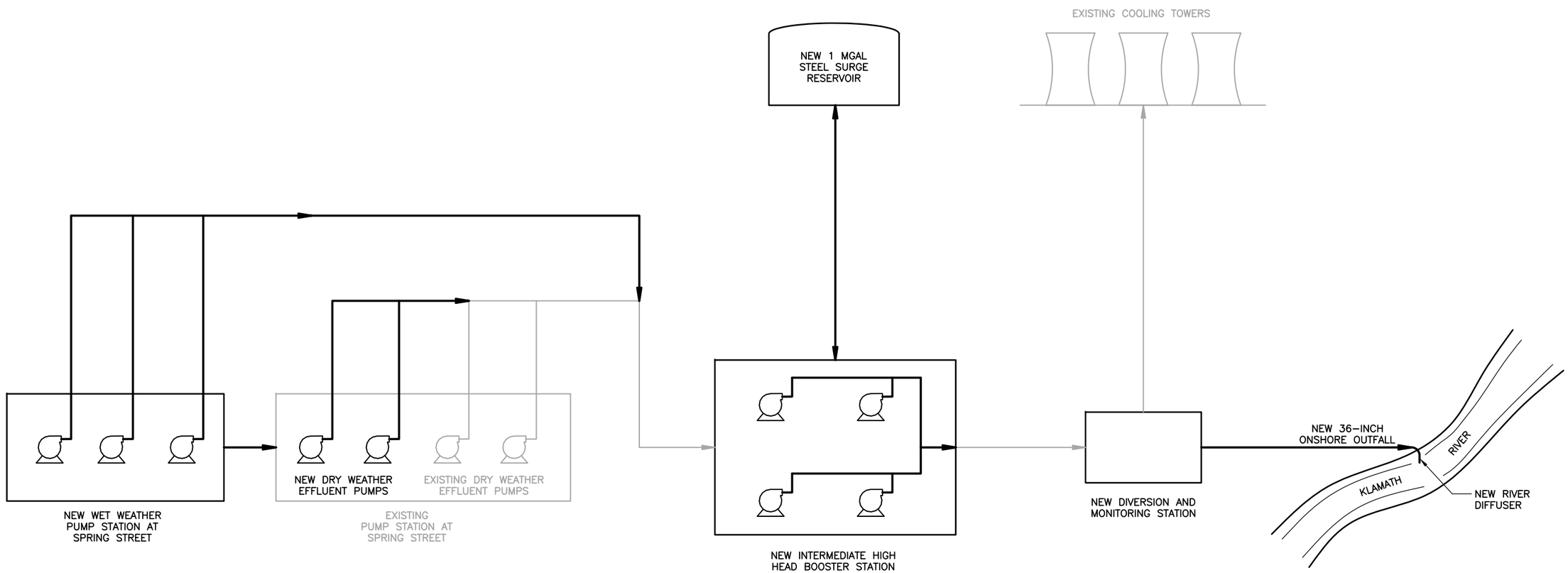
Winter Storage/Summer Irrigation (No River Discharge)

- **7 mile forcemain**
- **3,200 AF of storage**
- **Development of irrigation**
- **Same level of treatment as existing**

Component	Project Cost, $million	Annual O&M Cost, $	Present Worth Cost, $million
Pump Station	6	380,000	10
Force main	20	70,000	21
Storage Basin	93	140,000	95
Irrigation Facilities	4	110,000	5
Total	122	700,000	131

Appendix C - Simplified Flow Schematic for Outfall near Highway 97 Bridge

SIMPLIFIED PROCESS FLOW SCHEMATIC FOR A REMOTE OUTFALL NEAR HWY 97 BRIDGE



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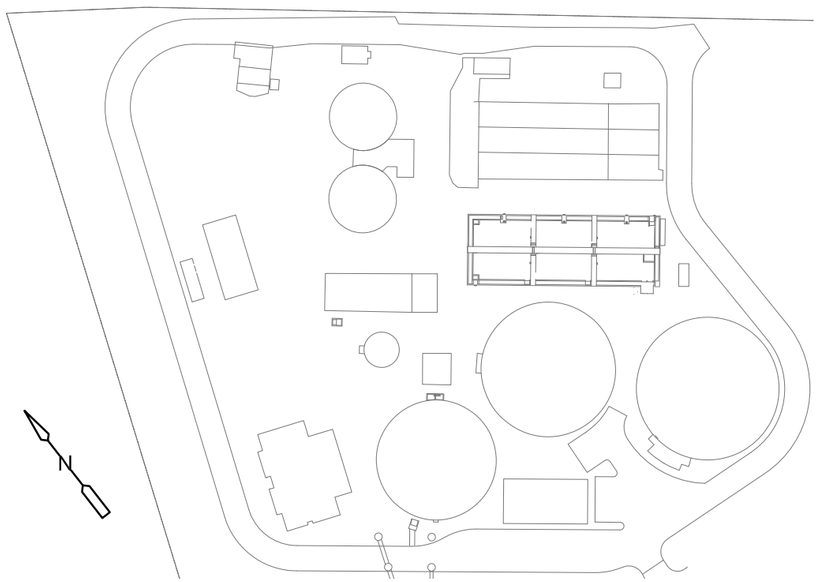
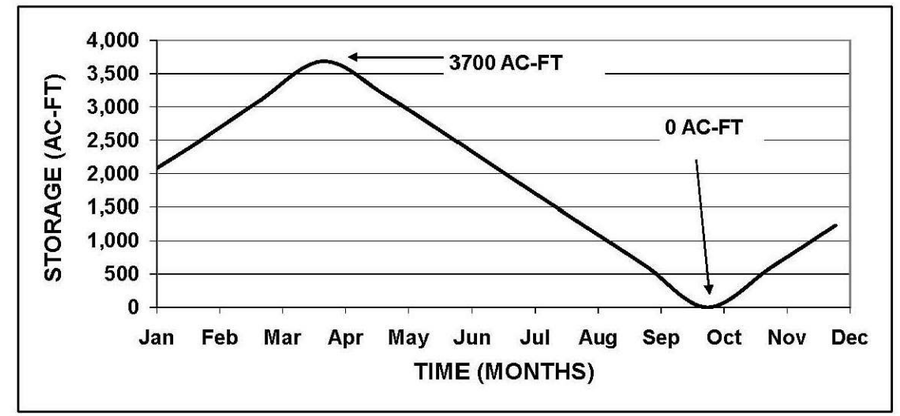
CDM

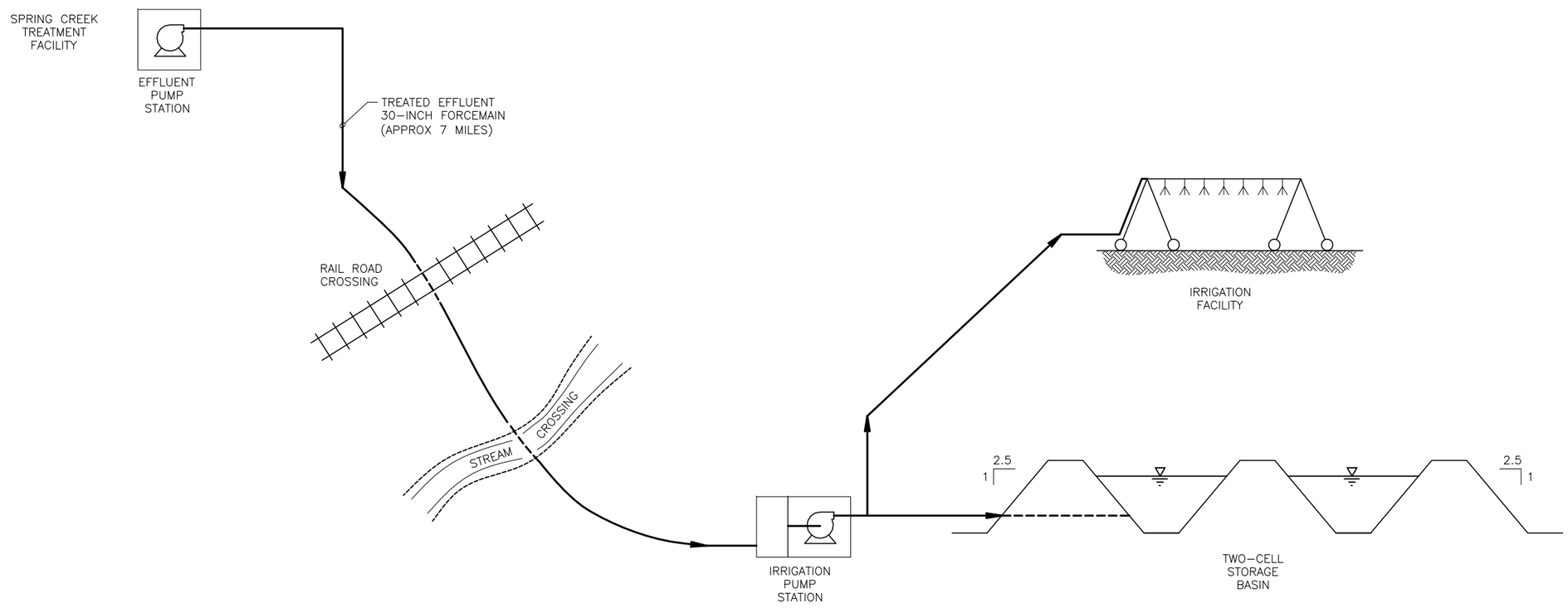
Appendix D - Simplified Flow Schematic for Zero Discharge

SIMPLIFIED PROCESS FLOW SCHEMATIC FOR ZERO DISCHARGE OPTION





DEPICTS YEARLY STORAGE REQUIREMENTS FOR IRRIGATION. CUMULATIVE MAX STORAGE OF 3,177 AC–FT OCCURS IN APRIL, WITH YEARLY DEPLETION OF STORAGE OCCURRING IN OCTOBER.



P:\20776\57850\Rept\ Flow Schematic_1 08/27/08 14:55 muglerrm XREFS: KF–SITE, KF–BASE

CDM

Table B-1 lists process configurations that can be adapted for biological nitrogen removal or combined biological phosphorus/nitrogen removal. The options listed contain variations to internal piping, pumping, aeration, and compartmentalization of the basins. Regardless of which configuration is chosen or which of the four treatment goals is implemented, the overall basin volume and footprint remain essentially the same. It is premature to select a specific internal process configuration until the effluent limitations are established. However, cost estimates allow for baffles and various mechanical equipment so that the City will have sufficient funds for developing any of the internal process configurations presented in Table B-1.

Table B-1 Internal Process Configurations for Biological Nitrogen and Combined Nitrogen and Phosphorus Removal (source: WEF, MOP 1

Nitrogen Removal Processes

Process	Advantages	Limitations or Comment
LE	Saves energy; BOD is removed before aerobic zone	Currently Operated at the Spring Street STP
	Alkalinity is produced before nitrification	
	Design includes an SVI selector	
MLE	Very adaptable to existing activated-sludge processes	Nitrogen-removal capability is a function of internal recycle
	5 to 8 mg/L TN is achievable	Potential *Nocardia* growth problem.
		DO control is required before recycle
Bardenpho (4-stage)	Capable of achieving effluent nitrogen levels less than 3 mg/L	Large reactor volumes required
		Second anoxic tank has low efficiency
Postanoxic with Carbon Addition	Capable of achieving effluent nitrogen levels less than 3 mg/L	Higher operating cost due to purchase of methanol
	May be combined with effluent filtration	Methanol feed control required
Simultaneous Nitrification/Denitrification	Low effluent nitrogen level possible (3 mg/L lower limit)	Large reactor volume; skilled operation is required, i.e. higher risk of violation
	Significant energy savings possible	Process control system required
	Process may be incorporated into existing facilities without new construction	
	SVI control enhanced	
	Produces alkalinity	

Phosphorus and/or Nitrogen Removal

Process	Advantages	Limitations or Comment
A/O	Operation is relatively simple when compared to other processes	Phosphorus removal declines if nitrification occurs
	Low BOD/P ratio possible	Limited process control flexibility is available
	Relatively short hydraulic retention time	
	Produces good settling sludge	
	Good phosphorus removal	
A^2/O	Removes both nitrogen and phosphorus	RAS containing nitrate is recycled to anaerobic zone, thus affecting phosphorus-removal capability
	Provides alkalinity for nitrification	
	Produces good settling sludge	
	Operation is relatively simple	Nitrogen removal is limited by internal recycle ratio
	Saves energy	Needs higher BOD/P ratio than the A/O process
UCT	Nitrate loading on anaerobic zone is reduced, thus increasing phosphorus-removal capability	More complex operation
		Requires additional recycle system
	For weaker wastewater, process can achieve improved phosphorus removal	
	Produces good settling sludge	
	Good nitrogen removal	
VIP	Nitrate loading on anaerobic zone is reduced, thus increasing phosphorus-removal capability	More complex operation
		Requires additional recycle system
	Produces good settling sludge	More equipment required for staged operation
	Requires lower BOD/P ratio than UCT	
Bardenpho (5-stage)	Can achieve 3 to 5 mg/L TN in unfiltered effluent	Less efficient phosphorus removal
	Produces good settling sludge	Requires larger tank volumes

CDM

Memorandum

To: *Janelle Rogers (CDM)*

From: *Mark Gould (CDM)*

Date: *October 17, 2008*

Subject: *Report on Klamath Falls Biosolids Composting Facility*

1. Existing Conditions

The wastewater treatment plant generates primary and waste activated sludge. Records indicate that primary sludge was thickened in a gravity thickener, but not since February 2006. Waste activated sludge is thickened on a dissolved air flotation thickener (DAFT). Thickened combined sludge is digested in primary and secondary digesters. Digested sludge is conditioned with a polymer and is dewatered on a belt filter press. At this time, the gas is flared. The dewatered sludge is composted at a facility located immediately to the south of the wastewater treatment plant.

Table 1 Summarizes Year 2007 monthly averages for biosolids entering the composting facility.

CDM

Table 1 - Quantities and Characteristics of Biosolids Entering Composting Process Monthly Averages for 2007

Month	Dry tons/mo (1) Before dewatering	Dewatered Sludge CY/month (2)	Percent Volatile solids (3)	Percent Nitrogen (4)	Compost CY/month (5)
January	53.4	462	67.2	1.30	
February	47.4	410	61.2		
March	57.4	497	59.1		53
April	50.3	436	62.5	1.30	254
May	50.4	436	63.3		122
June	45.2	391	66.7		426
July	48.0	416	67.9	1.58	267
August	42.7	370	60.7		314
September	46.8	405	61.7		142
October	46.5	403	69.4	0.87	0
November	45.6	395			86
December	38.9	337	70.6		
Totals	572.6	4,958			1,664
Averages	47.4	413	64.5	1.26	139

(1) (4) From 2007 Annual Biosolids Report
(2) Calculated from dry tons assuming 14 % solids and density of 1650/CY
(3) Sent to CDM March 24, 2008 Jan and Feb data are from 2008
(5) From Performance Data provided by City

The Performance Data Summary indicates that the annual volume of amendment received is 7,400 CY or an average of 617 CY per month.

Sludge is dewatered on an Alrick 1.5-meter belt filter press. The press is operated on a single shift 5 days/week. The average solids content of the dewatered biosolids is 14 percent. Normally, it is possible to dewater anaerobically digested sludge on a belt filter press to 18 to 20 percent solids. Under present conditions, with windrow composting and a sufficient amount of amendment, there is no economic incentive to improve dewatering.

The average monthly digester gas production is summarized in Table 2.

Table 2 - Monthly Gas Production

For 2007-2008	Cubic feet/ Month X1000	Million btu/month
Average	1,287	680
Maximum	1,440	760
Minimum	1,052	555

Table 2 shows that the gas production does not vary over a wide range. Analyses of the gas in May 2005 indicate that the gas is approximately 50 percent methane and has an average fuel value of 528 BTU per cubic foot. This becomes significant in evaluating the sludge drying option.

The facility consists of a 100 ft x 200 ft. open-front building that currently houses a screen and a stockpile of finished compost. There is a paved area in front of the building and an extensive area of unimproved land. The unimproved land is wet during times of precipitation and snowmelt and is not useable at those times. The building was originally intended for aerated static pile composting and included an aeration system. The aeration system had disposable aeration pipes on the concrete surface and was difficult to operate.

The current composting operation consists of forming windrows and turning them periodically using a front end loader. Since the paved area is limited, most of the windrow composting takes place on the unimproved land. During the winter, some of the dewatered sludge is stacked on the paved surface using dikes of woodchips until space is available for windrowing. This constraint is due to the lack of availability of useable land during wet conditions. The sludge is well digested and does not generate significant odor in the winter. One other disadvantage of composting on an unpaved surface is that rocks are picked up with the windrows.

The 2007 Annual Biosolids Report submitted to the Oregon Department of Environmental Quality indicates that the windrow process meets US EPA 40 CFR Part 503 requirements for Class A pathogen reduction using the turned windrow criteria.

As with most operations in which dewatered biosolids are composted, it is necessary to mix the biosolids with an amendment consisting of ground or chipped wood. The amendment is needed to increase the solids content, provide porosity and structure for aeration, and provide supplemental carbon. The amendment used at Klamath Falls is chipped wood and brush from the clearing of electrical utility rights of way. The material is abundant, and the City receives some revenue for taking it. It is an entirely suitable amendment material, except that it can contain some large chunks of wood. After composting in windrows, the compost is screened. The screen is an old and unreliable unit with conveyors salvaged from other

facilities. It is not capable of handling the rocks that are picked up from the unpaved surface or the large chunks of wood that come in with the amendment.

The compost has an attractive appearance and little residual odor. The Year 2007 Biosolids Summary Report has quarterly analyses of biosolids (prior to composting) for metals regulated under 40 CFR 503. An EQ (Exceptional Quality) product can be distributed without regulation of its use.

Table 3 - Pollutant Metal Concentrations and Limits for EQ Biosolids Products

Regulated Pollutant	Pollutant Concentration Limit for EQ product mg/kg	Highest Year 2007 Reported Quarterly Average Concentration mg/kg
Arsenic	41	11.7
Cadmium	39	2.0
Copper	1,500	149
Lead	300	50.2
Mercury	17	1.0
Nickel	420	34.4
Selenium	36	1.9
Zinc	2,800	309

Table 3 shows that the biosolids produced at Klamath Falls are well below the EQ limits for all regulated pollutants. The composting process further dilutes the metal pollutants, since some of the amendment remains in the compost.

The demand for the compost exceeds the supply over a full year, although storage is required during the winter months. The 2007 annual report indicated that nearly 250 customers picked up a total of 1,992 cubic yards. Note that this annual production rate is slightly higher than the rate shown in Table 1. The monthly compost distribution in 2007 was as follows:

Table 4 - Monthly Distribution of Compost

January – March	69 CY/month
April – May	104 CY/month
June	441 CY/month
July	267 CY/month
August	314 CY/month
September-November	140 CY/month
Annual Total	1,992 CY/year

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2. Design Flows and Projected Loading Rates

Composting facilities are designed so that the material handling systems can handle high peak loadings, so that they do not have to be operated full time. The detention time in the active composting stage is 3-4 weeks. For this reason, monthly rather than daily loading rates are used to size the composting and curing stages. Table 1 shows a current average month loading of 47.4 dry tons/month and a peak month of 57.4 dry tons/month. These should be multiplied by 0.95 to account for the solids capture rate in the belt filter press: Average month 45.1 dry tons; peak month 54.5 dry tons.

The facilities planning calculations show future digested solids production rates as follows:

2010	65.0 dry tons/month
2014	69.6
2020	76.8
2024	82.0
2030	90.4

The projected tonnage for 2010 is (65.0/45.1) or 44 percent higher than the reported 2007 average tonnage, and (65.0/54.5) or 19 percent higher than the reported 2007 peak tonnage. This is because the facilities plan is intended to provide a design for peak conditions with a margin of safety.

3. Deficiencies

In general, the City of Klamath Falls is believes that the current biosolids management operation is cost-effective and sustainable. There is a sufficient supply of amendment for composting at the current sludge production rate, the compost demand is robust, and the operation is simple and has a low operating cost.

Deficiencies identified by the Wastewater Division Staff are summarized as follows:

a) The screen is old and unreliable and should be replaced
b) The front-end loader is old
c) There is not enough paved surface to allow all-weather windrow composting throughout the year
d) Mixing biosolids and amendment is time-consuming
e) Composting operation is a full-time job in the summer when they are catching up with the winter backlog

The low solids content of the dewatered sludge (14-15%) is not viewed as a deficiency at this time. There is an adequate supply of amendment, and compost dries out quickly in the semi-arid climate of Klamath Falls. The operators believe that the composting process works better with the high moisture content in the biosolids.

It is reported that there are no odor complaints. At the time of the site visit there was little odor. There is an adjacent lagoon-type treatment facility operated by the South Suburban Sanitary District.

The composting building is in good condition and is an underused asset. It was designed for aerated static pile composting and includes the remains of an aeration system. The aeration system did not work effectively, and the building was the used for windrow composting in which the piles were flipped from one location to the next location using the front-end loader. Currently, the building is used only for screening and storage of finished product.

4. Alternatives to be Evaluated

The following alternatives have been identified for further evaluation:

4.1 Alternative 1 - Upgraded Windrow Composting

Because the City is generally satisfied with the windrow composting operation the baseline alternative consists of providing the equipment and site improvements needed to optimize the process. Improvements are summarized as follows:

a) New Screen
b) Windrow turner
c) Site improvements to provide sufficient all-weather surface to meet biosolids processing demand throughout the year

4.2 Alternative 2 - Aerated Static Pile Composting in the Building

The building was constructed originally for aerated static pile composting. Aerated static pile composting requires less loader time and less space and can be contained within the building. However it is a more complex process, since building of piles requires a number of steps, and blowers are operated by a control system that requires some operator attention.

The building includes the remains of a reversible forced aeration system for active composting, aeration for curing, and odor collection from negative aeration. The aeration system appears to be poorly designed compared with current practices. The aeration pipe was laid on the concrete surface. The pipe was crushed and disposed of after one use. This type of pipe does not provide good air distribution. The aerated static pile process was discontinued, due to poor air distribution and non-uniform temperatures.

Resumption of aerated static pile composting will require the construction of a state-of-the art aeration system with either pull-out aeration pipe or a new floor with aeration trenches. Pull-out pipe is fabricated from heavy wall high density polyethylene (HDPE) and is pulled out from under the pile before the pile is taken down. It costs less than aeration trenches but requires space to pull out and handle the pipe. Both sub-options are evaluated in this facilities plan.

Improvements are summarized as follows:

a) New Screen
b) New batch mixer
c) New aeration and control system
d) Either a new concrete floor overlay with aeration trenches or a pull-out pipe system
e) Site improvements to provide additional sufficient all-weather surface, but not as much area as for windrow composting

4.3 Alternative 3 - Biosolids Drying using Digester Gas as Fuel

Dried biosolids is an entirely different product than compost. Most of the water is removed and there is no amendment, so the resulting product volume is much less than with composting. It is more effective than composting in preserving the nitrogen value in the biosolids and is used as a low-strength organic fertilizer. It does not provide as much soil organic matter as compost. Because the biosolids is digested, the dried product would not have a strong odor if kept dry until application.

Dryers are relatively complex and have high capital cost. For this reason most treatment plants with dryers are either larger than Klamath Falls or have other constraints limiting their biosolids management alternatives. Dryers can be cost effective if digester or landfill gas is used to provide the heat, as could be the case with Klamath Falls.

The following types of dryers are provided in the appropriate range of sizes and capacities for Klamath Falls.

Indirect Dryer:

Dewatered sludge comes into contact with hot metal surfaces in a jacked mixer with hollow flights. The surfaces are heated by hot fluid on the other side. The fluid is typically oil that can be heated to a high temperature without boiling. The fluid is heated by a boiler that is fired with digester gas. The advantage of the indirect dryer that no air comes in contact with the sludge, so the exhaust gas consists only of the water vapor and volatile contaminants. The condensable organics are removed in a water-wash condenser.

Budget pricing was obtained from Fenton Environmental Technologies for the Fenix Dehydration Process and from Siemens Water Technologies for the Dragon Dryer. CDM specified a Fenton dryer for the Hobbs, NM wastewater treatment facility. It being installed and is not yet operational. The Siemens Dragon Dryer operates continuously until it runs out of sludge. The Fenix dryer operates in individual batches.

Direct Belt Dryers:

In direct dryers, the dewatered biosolids passes through a tunnel on a chain link conveyer belt. Hot air passes downward through the drying biosolids and the belt. The air is partly recycled and the waste air is treated in a condenser and biofilter. Belt dryers are relatively new in the U.S. Andritz lists nine operational facilities in Europe. Budget pricing was obtained from Andritz Separation Inc.

The air for the dryer could be heated by burning digester gas. The combustion gas could be used directly in the dryer or used to heat ambient air through a heat exchanger. The temperature range of the drying air is 250-300 deg. F. This temperature is low enough to use waste heat from a cogeneration process rather than directly firing digester gas. The volume of exhaust air is relatively high, as compared with indirect dryers.

Gas is produced by the digesters continuously. The digester system must include gas storage capacity for times when the dryer is not operating. The theoretical amount of energy needed to evaporate water is 975 BTU/lb water evaporated. Additional heat is required to heat the solids and water from ambient temperature to the boiling point. Heat is also lost due to radiation, conduction, and heat in the dried product. The actual energy requirement is around 1,450 BTU/lb water evaporated. The final product is assumed to have a solids content of 92 percent.

The digester gas has a reported fuel value of 528 BTU/cubic foot. Table 5 shows the theoretical amount of gas required for years 2010, 2020, and 2030 for biosolids dewatered to 18 percent solids. New dewatering equipment would be needed to get from the current belt filter press performance to a inlet TSS concentration that is typical for most viable dryer operations. All quantities are on a 7day/week basis in this table.

Table 5 - Gas Balance Biosolids Dewatered to 18 percent Solids

	Year 2010	Year 2020	Year 2030
Dewatered sludge at 18% solids Lbs/day	23,755	28,072	33,033
Gas generated Cubic feet/day	58,600	69,300	81,200
Gas generated mmBTU/day	30.9	36.6	42.9
Gas used at 18 % solids Mmbtu/day	27.7	32.7	38.5
Gas used at 20 % solids Mmbtu/day	24.3	28.7	33.7

The table shows that there will be sufficient gas to operate the dryer at 18 percent solids, but with a margin of safety of only 11 to 12 percent. Dewatering to 20 percent will increase the margin of safety to 28 percent. There is not sufficient gas to operate a dryer on the 14 percent cake .

Dryers require water for operation of the condenser. The water flow requirement will be in the range of 120 - 240 gpm, depending on the size and type of dryer. This water can be plant effluent. The direct belt dryer requires about 10 gpm of potable water in addition, for belt washing.

Operating electrical power for mechanical equipment and air handling is in the range of 70 to 180 kW, depending on the size and type of dryer.

Indirect dryers will generate an air exhaust flow consisting of non-condensable compounds, in the range of 230 – 480 cfm, depending on the size and type of dryer. This exhaust may be treated in the activated sludge process using a dedicated coarse bubble diffuser. The direct belt dryer generates a much larger volume of exhaust, in the range of 4,000 – 8,000 cfm, depending on the size of the dryer.

5. Analysis of Composting Alternatives

5.1 Materials Balance

The average month loading rate from Table 1 is 47.4 dry tons/month and the peak month is 57.4 dry tons/month. The facilities plan projection for the year 2007 would be 61.4 dry tons/month, or 2 dry tons/day. This is the basis for the following calculation.

The volume of material to be processed in the composting operation is sensitive to the volume of amendment that is required. For relatively low cake solids content as in Klamath Falls, the ratio of amendment to dewatered biosolids is determined by the solids content of each material. The following assumptions were used to estimate materials balances:

Dewatered biosolids in dry tons/day 7 day/week basis	2.0
Solids content of amendment:	70 %
Density of amendment:	600 lbs/cy
Recovery of amendment on screen	70%
Reported nitrogen content of biosolids	1.3 %
Target solids content of feedstock mix	38%

The typical target solids content is 40 percent. It has been adjusted to increase starting moisture since the humidity in Klamath Falls is relatively low and the operators report that the compost tends to dry out too quickly. Table 6 shows the estimated materials balances at the current dewatered solids content of 14%.

CDM

Table 6 - Composting Materials Volumes for Biosolids at 14 % Solids

	Year 2010	Year 2002	Year 2030	Reported for 2007
Quantities per day on 7 day per week basis	2.14 dry tons/day	2.52 dry tons/day	2.98 dry tons/day	1.48 dry tons/day
Volume of dewatered cake (CY)	18.5	21.9	25.8	
Volume of amendment (CY)	27.6	33.0	38.7	20.3
Volume of Mix (CY)	58.8	69.9	82.0	
Volume to screen (CY)	41.9	49.8	58.5	
Volume of screened compost(CY)	27.4	32.7	38.3	4.6
Mix C/N ratio	127	127	127	

The theoretical volume balance is compared with the reported volume balance as follows:

CY of amendment used per dry ton of biosolids:
Reported: (20.3/1.48)= 13.7 CY/dry ton
Theoretical: (27.6/2.14)= 12.9

CY of product per dry ton of biosolids:
Reported: (4.6/1.48)=3.1
Theoretical (27.4/2.14)=12.8

The reported and theoretical amendment use ratios are close. There is a significant difference with respect to product volume. The difference may be partially due to blinding of the screen. This would cause more product to go back into the composting process and undergo further decomposition. Screen blinding would not explain the entire difference.

Table 7 shows the estimated materials balances if the sludge cake solids content is increased to 20% through more efficient dewatering. The table shows that the volume of material that is handled at each stage of the process is significantly lower at 20%.

Table 7 - Composting Materials Volumes for Biosolids at 20 % Solids

	Year 2010	Year 2020	Year 2030
Quantities per day on 7 day per week basis	2.14 dry tons/day	2.52 dry tons/day	2.98 dry tons/day
Volume of dewatered cake (CY)	13.0	15.3	18.1
Volume of amendment (CY)	19.3	23.0	27.0
Volume of Mix CY)	41.1	48.8	57.3
Volume to screen CY)	29.3	34.8	40.8
Volume of screened compost CY)	19.2	22.8	26.8
Mix C/N ratio	97	97	97

Table shows that the volume of material decreases significantly if the cake solids content is increased to 20 percent. The table also indicates the carbon to nitrogen ratio (C/N). The ideal C/N is around 30. These mass balances show an excess of carbon in relation to the amount of nitrogen, due to the large amount of amendment that is required to achieve a target mix solids content of 38 percent. The high C/N will tend to slow down the composting process. This is typical of anaerobically digested sludge, where much of the nitrogen become soluble and is and returned in the filtrate and where the cake solids content is low.

In 2007 the facility received an average of 617 CY of amendment per month or 20.3 CY per day, which appears to be sufficient at 20 percent solids but not at 14 percent. The table does not make a distinction between windrow and aerated static pile composting. However, there will be some differences. Windrow composting uses up more amendment, because the periodic turning reduces the particle size of the amendment. As a result, more amendment passes through the screen into the product, and more new amendment is needed.

It is clear that the composting process will require less material handling and work more effectively if the cake solids are increased to 20 percent. Because there is less water to be evaporated for the amount of energy generated by the destruction of volatile solids, the higher solids content will also generate more consistently high temperatures.

5.2 Upgraded Windrow Composting

The upgraded windrow composting would operation is sized for continued dewatering to 14 percent solids. Instead of mixing and turning the windrows with the front-end loader, the material would be mixed with a windrow turning machine. For this analysis a 14-foot wide turning machine has been selected. This mid-size turner is nearly optimal for Klamath Falls and is widely available. It turns windrows with a volume of 5.8 cubic yards per lineal foot of windrow and can process 900 tons per hour.

Initially, a bed of woodchips is laid down by the loader, dewatered biosolids and the remaining amount of woodchips is placed on top, forming a windrow. The turner then mixes and shapes the windrow. For subsequent turnings, the loader is not required. The turner passes along the windrow mixing and re-establishing porosity.

Figure 1 shows a layout for 2 dry tons/day of biosolids dewatered to 14 percent solids or the 2030 loading of 3.2 dry tons per day dewatered to 20 percent solids. There are four windrows each representing one week's production and providing a detention time of 30 days before screening. After the compost meets temperature requirements and is screened it is windrowed again for an additional 30 days' curing.

Windrows are accessed from one side by truck and front end loader. Windrows are grouped into pairs with a narrow space between the windrows in the pair for the turner wheels.

The layout shows 310 lineal feet of windrow for composting divided into four sections, and 150 lineal feet for curing of screened compost, again, divided into four sections. A single 75 foot windrow section representing one week of active composting can be turned in less than 30 minutes.

This particular windrow layout would require filling and paving an additional 12,000 square feet of surface.

5.3 Aerated Static Pile Composting in the Existing Building

The aerated static composting process would take place in the existing building. The biosolids and amendment would be mixed in a stationary batch mixer. The materials are dumped into the mixer in correct proportions using the front end loader. The mixer is equipped with load cells and a large digital readout, so the operator can add materials in the correct proportions. One or more augers or paddles mix the material and discharge it through an out-feed conveyor. The mixing and discharge cycle typically takes about 15 minutes. This process requires less labor and loader time than mixing with the loader and produces a more uniform mix. Uniformity is critical for the aerated static pile process, as there is no way to correct air channeling once the pile is built.

The most operator-friendly approach would be to pour a new concrete floor approximately 12 inches thick over the existing floor with aeration trenches. The base cost estimate is for aeration trenches. A layer of amendment is placed on the floor over the trenches, and the mix is stacked to a depth of 8.0 feet. The mix is covered with a 12-inch layer of unscreened compost to provide insulation and ensure that the top surface of the pile meets temperature requirements. The pile remains in place for a minimum of 21 days. The layout is designed for 30 days to provide a margin of safety. Following this active composting period, the pile is removed and screened. Then, it is re-stacked for an additional 30 days' curing.

The aeration system would be designed to provide both positive aeration (blowing up through the piles) and negative aeration (drawing down through the piles). This provides optimal distribution of air. Air extracted during negative aeration would be treated in a biofilter. A system of this type was originally installed in the building, but was inadequate in a number of respects.

With aeration trenches, it would not be necessary to increase the paved area on site. With the alternative of pull-out pipe, it would be necessary to extend the paving, so the loader could pull out an 80 foot length of pipe and pull it around for storage until it is needed for the next cycle.

Table 8 shows the length of building needed for aerated static pile composting and the total length of windrows for enhanced windrow composting.

Table 8 - Length of Composting Areas

	Year 2010	Year 2030
Aerated Static Pile Length inside Building		
14 % solids	181 ft	225 ft.
20% solids	148 ft.	178 ft.
Enhanced Windrow Total length of windrows		
14 % solids	450 ft.	630 ft.
20 % solids	320 ft.	440 ft.

The existing building is 200 feet long. Table 8 shows that, with biosolids dewatered to 14 percent solids aerated static pile composting would take up nearly the entire building length initially and exceed the building length at year 2030 tonnages. Dewatered to 20%, the process would fit into the existing building.

Windrow length is less critical, since the windrows would be located outdoors.

5.4 Cost Comparison for Composting Alternatives

Table 9 shows the capital and operating costs for the three composting alternatives. Operations and Maintenance (O&M) costs are based on the following unit costs. For aerated static pile composting, it is assumed that biosolids is dewatered to 20 percent and that the aeration system would cover the entire floor. The O&M costs associated with material handling operations would apply for year 2010 at 14 percent solids or for year 2030 at 20 percent solids. O&M costs are based on the unit costs summarized in Section 4 or the facilities plan.

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Table 9 - Preliminary Cost Comparisons for Composting Alternatives

	Alternatives		
	Enhanced Windrow	Aerated Static Pile Aeration Trenches	Aerated Static pile Pull-out pipe
Capital Costs			
Site Improvements	$69,000		$32,000
Concrete		$470,000	
Air Handling		$177,000	$331,000
Subtotal	$69,000	$647,000	$363,000
Contingency 30%	$21,000	$194,000	$109,000
Subtotal	$90,000	$841,000	$472,000
Cont. O&P 12%	$11,000	$101,000	$57,000
Const. Total	$101,000	$942,000	$529,000
Mobile Equipment	$210,000	$172,000	$172,000
Total Capital Cost	**$311,000**	**$1,114,000**	**$701,000**
O&M Costs			
Fuel	$16,400	$23,300	$24,000
Electricity	$1,200	$7,700	$7,700
Equipment O&M	$22,500	$34,200	$35,400
Labor	$54,000	$59,600	$62,300
Total O&M Cost	**$94,100**	**$124,800**	**$129,400**

The labor cost is based on the estimated number of hours required at a fully loaded cost of $74,000 per year or $35.60 per hour. In practice, all of the alternatives will employ one full-time person.

5.5 Recommended Composting Alternative

Aerated Static Pile Composting is recommended where there are space limitations or if the location is particularly sensitive to odor. The City of Klamath Falls has been using the windrow process for several years without odor complaints. The available space can be increased by filling and paving some of the land currently outside the paved area. Aerated static pile composting offers no cost advantages or significant environmental advantages at this location. For these reasons, the enhanced windrow composting process is recommended.

6. Summary of Dewatering Issues

For aerated static pile composting, it would be possible to operate for a few early years at 14 percent solids, but would be necessary to increase the solids to 20 percent as the tonnage increases. For windrow composting the solids content of the biosolids is not as critical in terms of space. For both aerated static pile and windrow composting, biosolids at 20 percent solids will generate higher temperatures and be a more robust process, because of the lower amount of water to evaporate and the more favorable C/N ratio. The facility plan

recommends addition of a new, 2.5 meter belt filter press in addition to moving the existing unit. The BFP costs are not included with either the composting or dryer alternatives.

For drying it will be necessary to dewater to 20 percent solids. At 14 percent solids, the available gas volume is likely to be marginal or insufficient and the equipment will have to be larger and more expensive.

In the facility plan relocation of the dewatering operation to the vicinity of the current composting facility is recommended along with installation of a new 2.5 meter belt filter press.. This will bring the dewatered sludge closer to the final processing location. A dryer could be co-located with the new dewatering facility.

7. Analysis of Dryer Alternatives

7.1 Location of Equipment

The dewatering equipment would be located within a portion of the existing composting building. Additional walls would be constructed to create an enclosed space, and all surfaces would be insulated. Locating the dewatering process adjacent to the dryer would eliminate the need to transport dewaters sludge in a truck. However, the following utilities would have to be constructed between the wastewater treatment plant and the new solids processing facility.

a) Pipeline for digested sludge
b) Return line for filtrate and dryer condenser water.
c) Digester gas supply
d) Plant effluent for condenser
e) Potable water for belt wash (direct belt dryer only)
f) Return exhaust air, if treated in activated sludge tanks (indirect dryer only)
g) Electrical power
h) Instrumentation and controls

The pipelines for digested sludge and potable water are included in the cost estimate for relocation of the dewatering operation. If gas is used for co-generation and waste heat is used for a direct belt dryer, it is assumed that the generator would also be located in the existing composting building.

The two indirect dryer alternatives, Siemens and Fenton, are similar in operational principle and the cost estimate would apply to both vendors. The budget pricing provided by dryer vendors are in the range of $1,300,000 to $2,000,000 depending on the selected capacity. There is a trade-off between labor cost associated with extended shifts for dewatering and drying and the higher capital cost of a system that can operate on a single shift. In this evaluation, the project cost is based on a mid-range budget pricing of $1,600,000, and the assumption that the facility will operate on a 10-hour shift in the initial years, increasing to a 12-hour shift at initial loading and an 14- hour shift at design capacity.

The indirect dryer does not use air to remove the water vapor, so the volume of exhaust gas is small. The gas first passes through a condenser to remove most of the pollutants and reduce the temperature. The condenser brings the hot exhaust in contact with plant effluent, which is then returned to the head of the wastewater treatment plant. The small volume of non-condensable gas would be returned to the wastewater treatment plant and injected into the aeration tank using a dedicated blower and coarse bubble diffuser. Figure ----- is a schematic diagram for a typical indirect direct dryer system.

The direct belt dryer is uses a flow of heated air to dry the sludge. Air is recirculated through the dryer, and make-up air is introduced replaced at a rate to ensure that the exhaust air is nearly saturated with water vapor. The air is heated using digester gas. The air heater may inject combustion gas directly into the dryer or heat outside air through an air-to-air heat exchanger.

The advantage of the direct dryer that waste heat from a co-generation process is may be used to supplement and reduce the amount of digester gas required to heat the air. There are practical problems associated with using co-generation waste heat. The generator will probably operate continuously, while the dewatering drying operation is on 1-2 shifts five days per week. Table 5 shows that there is a sufficient amount of gas available for operating a dryer. If that gas were used in a generator, the remaining waste heat would not be sufficient to operate the dryer, so supplemental gas would be required. Figure --- is a schematic diagram for an Andritz belt dryer, showing the use of waste heat from co-generation. However, without further development of the co-generation concept, it is assumed that the dryer would operate directly on digester gas.

The volume of exhaust air exceeds the amount that could be treated in the aeration tanks. Some direct dryers release exhaust air following the condenser without further treatment. If odor control is critical, the exhaust may be treated in a regenerative thermal oxidizer (RTO). This treatment stage would require additional fuel gas. In the cost estimate, the RTO stage is shown as an add-on item.

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Table 10 - Cost Comparison for Dryer Alternatives

	Indirect dryer	**Direct Dryer without RTO**
	Based on Siemens 4008	Based on Andritz BDS1.0
Connected HP	113	
Water consumption	120 gpm	140 gpm
Initial Hours/week operation	10	14
CAPITAL COST		
Utilities	$ 425,000	$ 353,000
Dryer, feed hopper, condenser, gas cleanup, and combustion equipment	$ 1,600,000	$ 2,135,000
Air Pollution Control Activated sludge treatment RTO	$ 11,000 0	
Enclosure within existing composting building	$ 209,000	$ 209,000
Installation, electrical, instrumentation	$ 840,000	$ 1,103,000
Subtotal	$ 3,085,000	$ 3,800,000
Contingency 30%	$ 926,000	$ 1,140,000
Subtotal	$ 4,011,000	$ 4,940,000
Contractor costs 25 %	$ 1,002,000	$ 1,235,000
Subtotal	$ 5,013,000	$ 6,175,000
Escalation to mid point of construction 6%	$ 301,000	$ 370,000
Capital Cost Total	**$ 5,314,000**	**$ 6,545,000**
ANNUAL O&M COSTS		
Value of gas @ $1.35/therm		
Dryer	$ 132,000	$ 132,000
RTO	0	$ 15,000
Total	$ 132,000	$ 132,000
Electricity @ $0.055/KWH	$ 12,000	$ 25,000
Labor @ $37.42/hr	$ 97,000	$ 136,000
Maintenance @ 2% of equipment cost	$ 62,000	$ 76,000
Total	$ 303,000	$ 369,000

Table 10 shows that the indirect dryer has a lower capital and operating cost than the direct belt dryer. The cost of the direct belt dryer as shown in the table includes no odor control beyond the condenser. This may not be sufficient to prevent off-site odor at this location. Addition of a regenerative thermal oxidizer will increase the capital cost to $7,403,000 and increase the operating cost to $ 398,000 per year. The operating cost estimate for the direct belt dryer does not include fuel savings due to use of waste heat from co-generation.

Generation of electricity from digester gas has proven not cost-effective at Klamath Falls. Therefore, waste heat from co-generation will not be available. Without waste heat, there is no advantage to the direct dryer.

APPENDIX A

NPDES Permit

APPENDIX B

Spring Street Facilities Condition Assessment Report

APPENDIX C

Effluent Disposal Options Technical Memorandum
(Part A, Part B)

APPENDIX D

Biological Nutrient Removal Configurations

APPENDIX E

Composting Technical Memorandum

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Section 1
Executive Summary

The purpose of the Spring Street Sewage Treatment Plant Facilities Plan is to present a framework and improvement plan to ensure current and expected future discharge requirements are met. This Executive Summary is divided into two parts.

- Part I – Summary of the Planning Effort
- Part II – Updates and implementation

At the start of the planning effort almost 26 months ago, the discharge limits that would be imposed on Klamath Falls were still in development, but due out in the spring of 2008. However, there is still considerable uncertainty in what these limits might be. Therefore, Part I of this Executive Summary provides a broad plan for improvements to the plant, which considered a certain degree of effluent limit variations. Part II summarizes the current status of the total maximum daily limit (TMDL) development and presents a short term course of action for the City.

Part I – Summary of Facilities Plan

Background

The City of Klamath Falls owns and operates the Spring Street Sewage Treatment Plant (Spring Street STP), which discharges its treated effluent into Lake Ewauna, a natural reservoir on the Klamath River. The City's current National Pollutant Discharge Permit (NPDES) was last issued in 1990, with its renewal pending on clarifying water quality issues emerging in the Klamath River and the associated effluent quality criteria required to be met. The process of issuing TMDLs for the river and the associated waste load allocations (WLAs) for dischargers took DEQ longer than expected, causing the City to postpone major plant upgrades until it knew to what level it would be required to treat its wastewater. Currently, the City faces upgrades required to meet the upcoming TMDLs and also significant upgrades due to aging facilities.

Study Area Characteristics

The urban area around Klamath Falls includes the City of Klamath Falls and the South Suburban area, with a combined urban population of approximately 42,000.[1] Two treatment facilities currently serve the population of Klamath County: the Spring Street Sewage Treatment Plant (Spring Street STP) owned by the City, and a separate wastewater treatment facility owned and operated by the South Suburban Sanitary District (SSSD).

[1] City of Klamath Falls planning department, May 2007 meeting.

Population within the city limits is projected by the city planning department to reach 26,000 by the design year of 2028. In 2007, the City planning department estimated future overall growth at a rate of about 1.2 percent.[2] The total year 2030 city sewered population projection is approximately 42,000.

Water Quality

The Spring Street STP currently discharges to Lake Ewauna downstream of the Upper Klamath Lake and feeds into the Klamath River to the south, which eventually runs through California and discharges to the Pacific Ocean. The water quality of Lake Ewauna is usually poor during the summer months with large algal blooms, high temperatures, high pH, high coliform bacteria counts, and low dissolved oxygen levels. Lake Ewauna's water quality is largely dependent on the water quality of the entire watershed upstream of the Klamath River. The Klamath River is considered a water quality limited stream.

Existing Wastewater Facilities

Nearly two-thirds of the existing sewer system was installed prior to 1932. Assuming that the sewers are not surcharged, the Collection System Master Plan (December 2006) concluded that the maximum flow that can be conveyed to the plant via the existing trunk sewers and wastewater pumping stations is 18.5 MGD. The City is currently reviewing its wet weather modeling to help in identifying critical areas for collection system rehabilitation.

The existing plant layout, which excludes the solids composting area, is shown in **Figure 1-1**. The plant is considered a conventional activated plant with primary, secondary, and disinfection processes. A pumping station and pipeline were constructed in 2001 to deliver the majority of treated effluent to a local cogeneration plant where the majority of the effluent is evaporated. The remaining warmed effluent is returned to the end of the Spring Street STP and discharged to Lake Ewauna via one of the two adjacent outfalls.

[2] Communication with Erik Nobel, Klamath Falls Planning Dept, May 20, 2007.

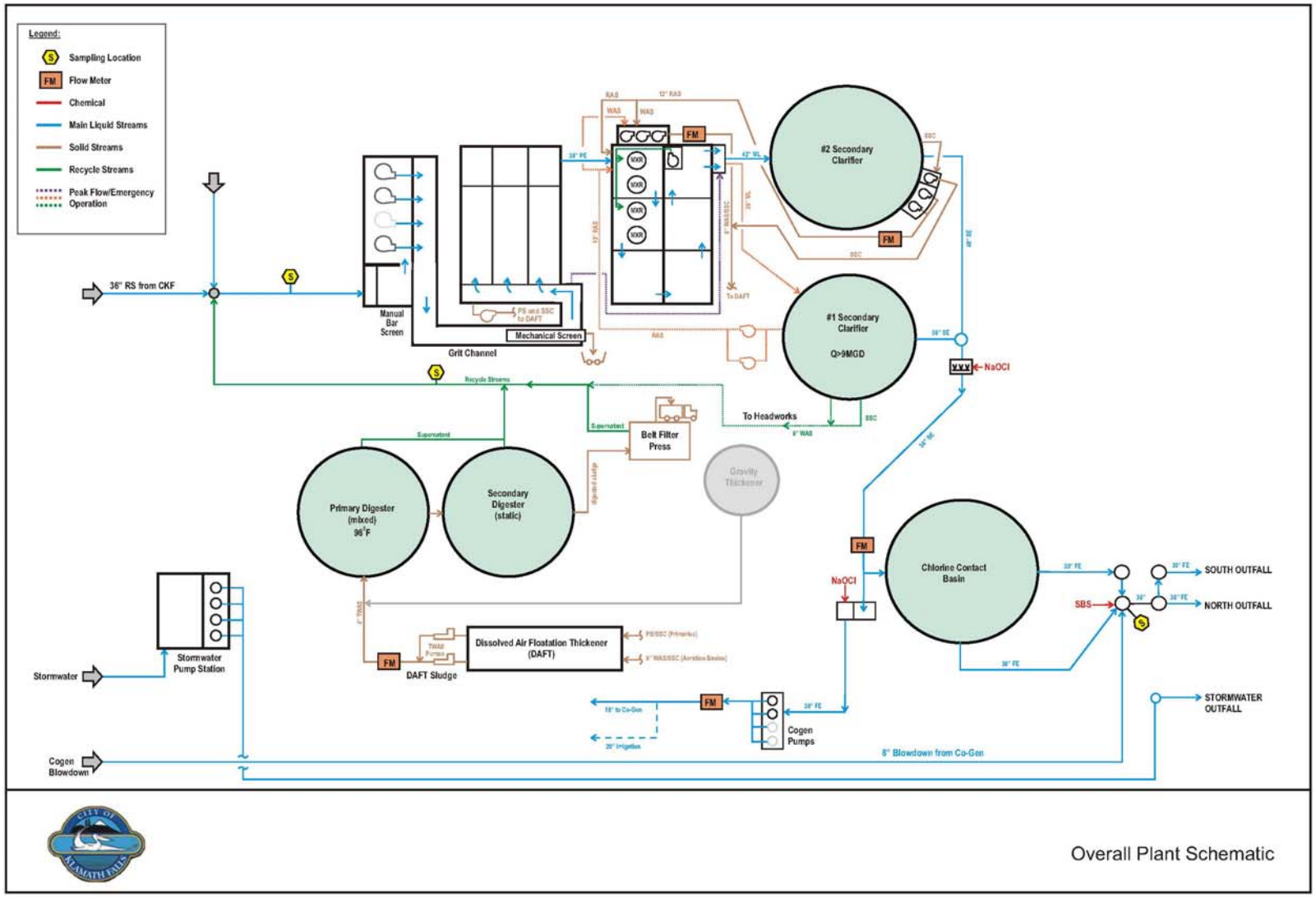


Figure 1.1 Spring Street STP Existing Layout

Wastewater Characteristics

At 124 gallons per capita per day (gpcd), dry weather flows in the Klamath Falls area are on the high end of the typical range of 100 to 120 gallons per capita per day (gpcd). An average of 5 years of recent plant influent loadings along with projections for build out are summarized in Table 1.1. Average pounds per capita per day (pcpd) contribution over the 2002-2006 years are lower than typical, at 0.14 pcpd and 0.13 pcpd BOD and TSS, respectively, which translates into a relatively dilute influent and is consistent with the higher flows per capita observation. This may be of concern should stringent total nitrogen limits be imposed and the City is required to add a carbon source to operate the nitrogen removal process.

Table 1.1 Spring Street STP Projected Design Influent Characteristics (1)

Parameter	Units	2002-2006 average	2030
Flows			
Annual Average Daily Flow (AADF)	mgd	3.8	6.2
Average Dry Weather Flow (ADWF)	mgd	3.5	5.2
Maximum Month Average Daily Flow (MMADF)	mgd	5.4	10.4
Peak Instantaneous Flow (PIF)	mgd	N/A(2)	22.0
BOD			
Annual Average (AA_{BOD})	ppd	4,900	8,100
Peak Month BOD	ppd	5,700	10,700
Peak Day BOD	ppd	10,800	21,500
TSS			
Annual Average (AA_{TSS})	ppd	4,500	7,600
Peak Month TSS	ppd	5,300	10,000
Peak Day TSS	ppd	12,000	21,700
TKN(3)			
Concentration during Average Dry Weather Flow ($ADWF_{TKN}$)	ppd	N/A	1,220
Concentration during Max Month Flow ($MMADF_{TKN}$)	ppd	N/A	1,830
Total Phosphorus(3)			
Concentration during Average Dry Weather Flow ($ADWF_{TP}$)	ppd	N/A	268
Concentration during Max Month Flow ($MMADF_{TP}$)	ppd	N/A	403

Notes:

(1) Values rounded for clarity.

(2) Peak instantaneous flow is currently limited by the influent pump capacity; influent flow meter pegs out at about 14 mgd, which is consistent with the pumps' capacity.

(3) The City is sampling for nutrients twice a year since 2004. Records show the following influent averages: NH3-N=15 mg/L, TKN=22mg/L, TP=7.3 mg/L.

Treatment Plant Deficiencies

From a capacity standpoint, a number of the plant's processes do not meet commonly accepted reliability criteria or EPA's Class I reliability requirement and are undersized to meet the projected flows: influent pumping station, headworks, primary sedimentation basins, aeration basins, and final disinfection. Those deficiencies are highlighted in **Figure 1.2.** Total capacity (that is, when all units are operating) and firm capacity (when the largest unit is out of service) are shown with the projected design flows (maximum month). Those processes with firm capacities not meeting the 2030 MMADF are deficient and do not meet the EPA reliability requirement.

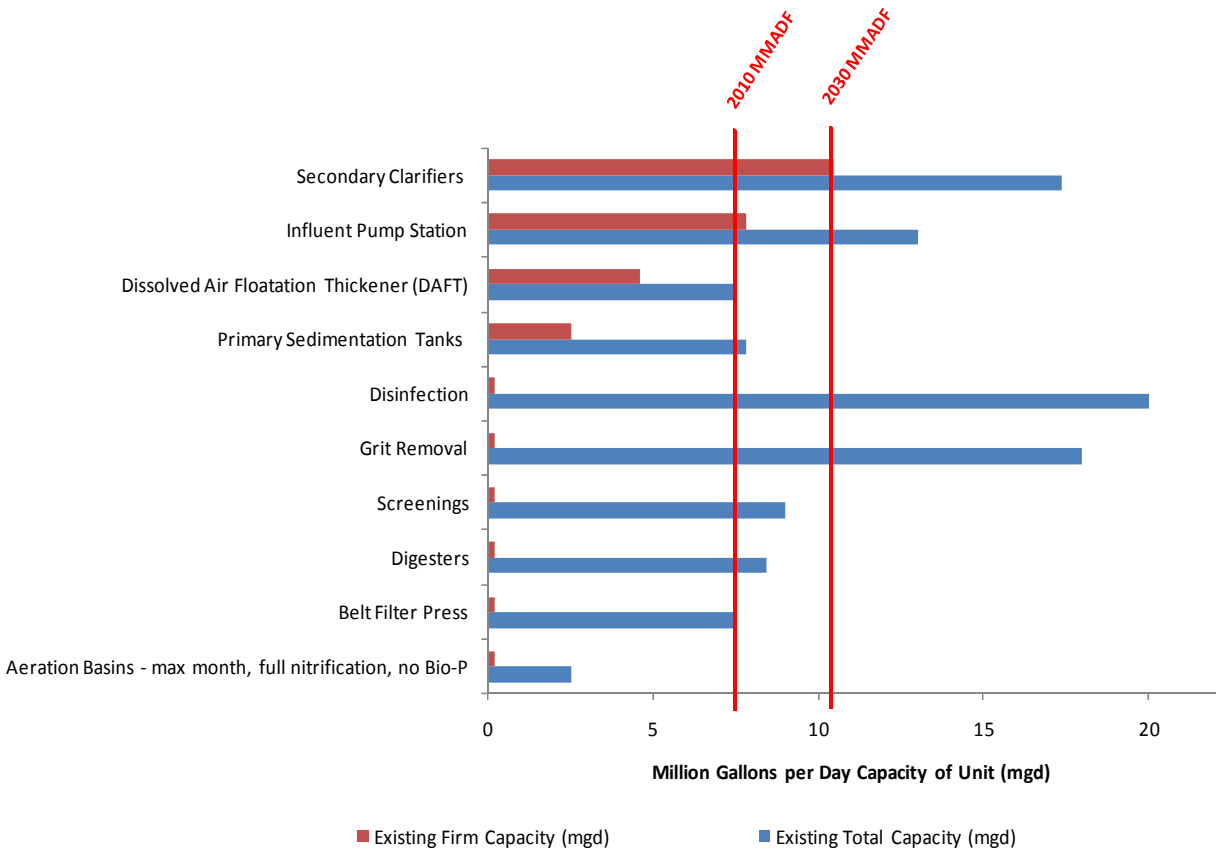


Figure 1.2 Comparison of Existing Unit Process Total and Firm Capacities with Flow Projections (MMADF = projected Maximum Month Average Daily Flow)

In addition to the capacity limitations, a condition assessment of existing facilities done at the outset of the Facility Plan process showed many structural, operational, and mechanical deficiencies. **Figure 1.3** highlights the source of significant deficiencies faced by each existing unit process at the plant, independent of future discharge requirements.

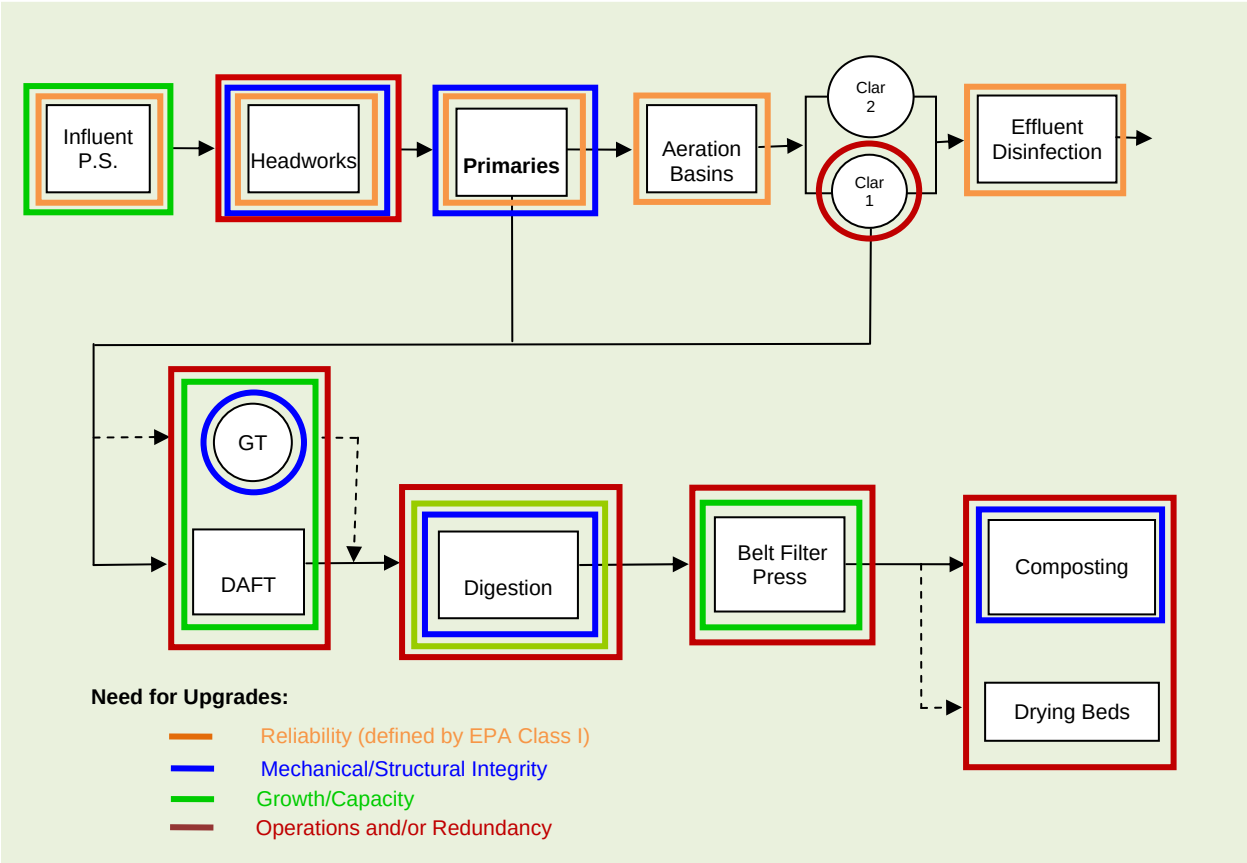


Figure 1.3 Spring Street STP Existing Unit Process Deficiencies that are Independent of the TMDL Outcome (P.S.= Pump Station; Clar= Clarifier; GT=Gravity Thickener; DAFT=Dissolved Air Flotation)

Basis for Planning to Meet TMDLs and Water Quality Standards

A number of effluent quality scenarios were initially developed, from the base case where effluent quality abides by DEQ's Anti-degradation Policy, to the most stringent case that would drive the City to take the effluent out of the river. In May, 2008, DEQ proposed draft limits for ammonia and phosphorus that allowed a more focused development of facility needs. The proposed plant layout is shown in **Figure 1.4.** Since then those limits have been withdrawn and DEQ continues to work on TMDL development.

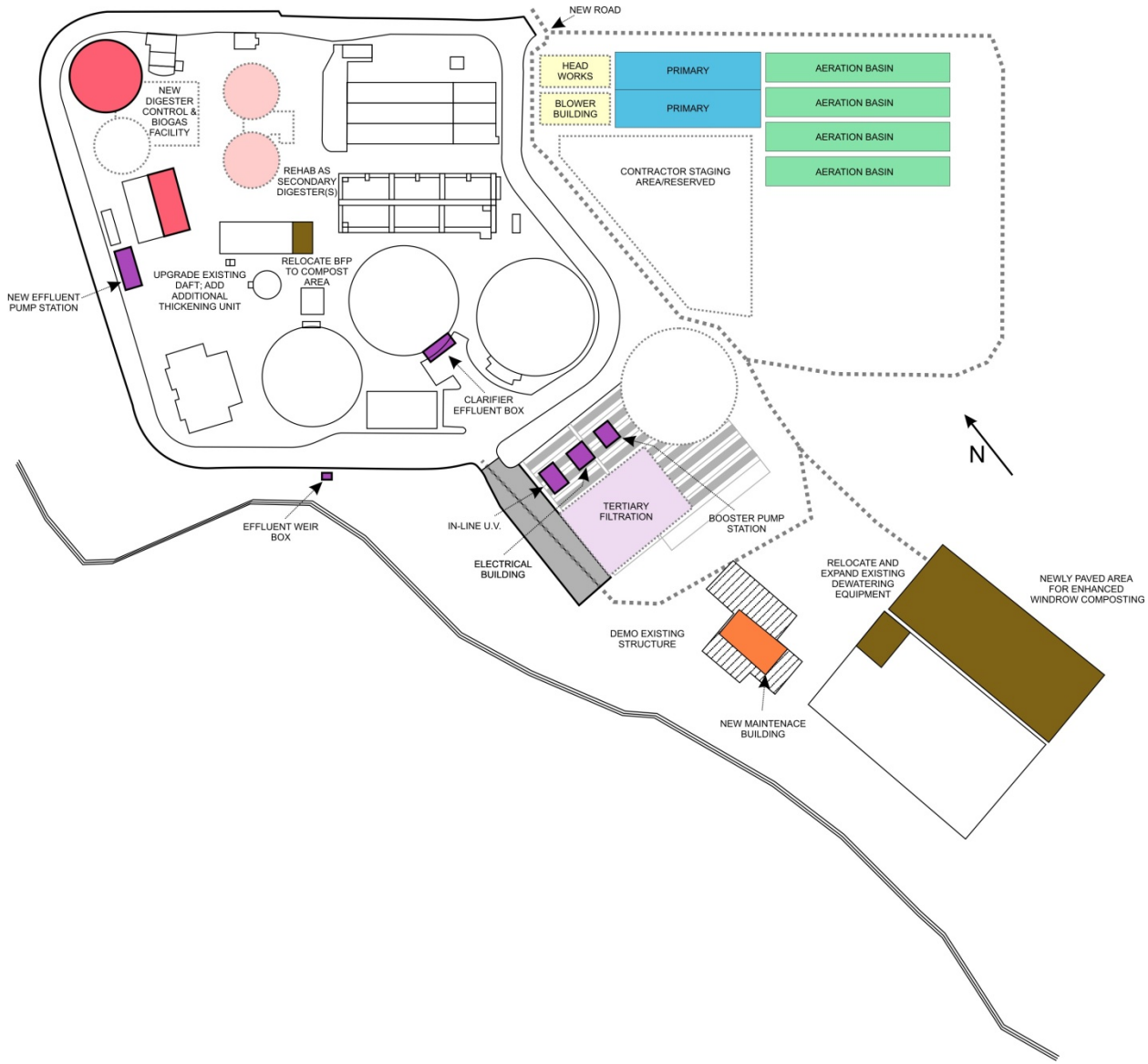


Figure 1.4 Recommended Treatment Plant Upgrades

Effluent Management Options

The planning effort included consideration of nine effluent management options to explore disposal avenues other than direct river discharge. Based on investigation of the nine options, workshops with City staff, and meetings with DEQ, it became clear that the City faces two major choices: either provide year-round nutrient removal with advanced treatment and an outfall directly into the Klamath River (not Lake Ewauna), or, get out of the river altogether, by implementing summer irrigation and winter effluent storage.

The two complete alternatives were compared side by side to clarify the cost and non-cost impacts of each.

1. Alternative 1: Year-Round Effluent Discharge into the River, but with New Diffuser and Advanced Treatment to meet TMDL Waste Load Allocations and In-stream Water Quality Standards

2. Alternative 2: Summer Agricultural Reuse with Winter Storage (No River Discharge)

Since the final outcome of TMDLs, water quality, permitting, and other non-engineering aspects are still unknown, the inputs for the alternatives comparisons are detailed to the greatest extent possible while still allowing room for modifications as regulatory conditions are clarified. Schematics of the discharge portions of the alternatives are presented in **Figure 1.5** and **Figure 1.6**.

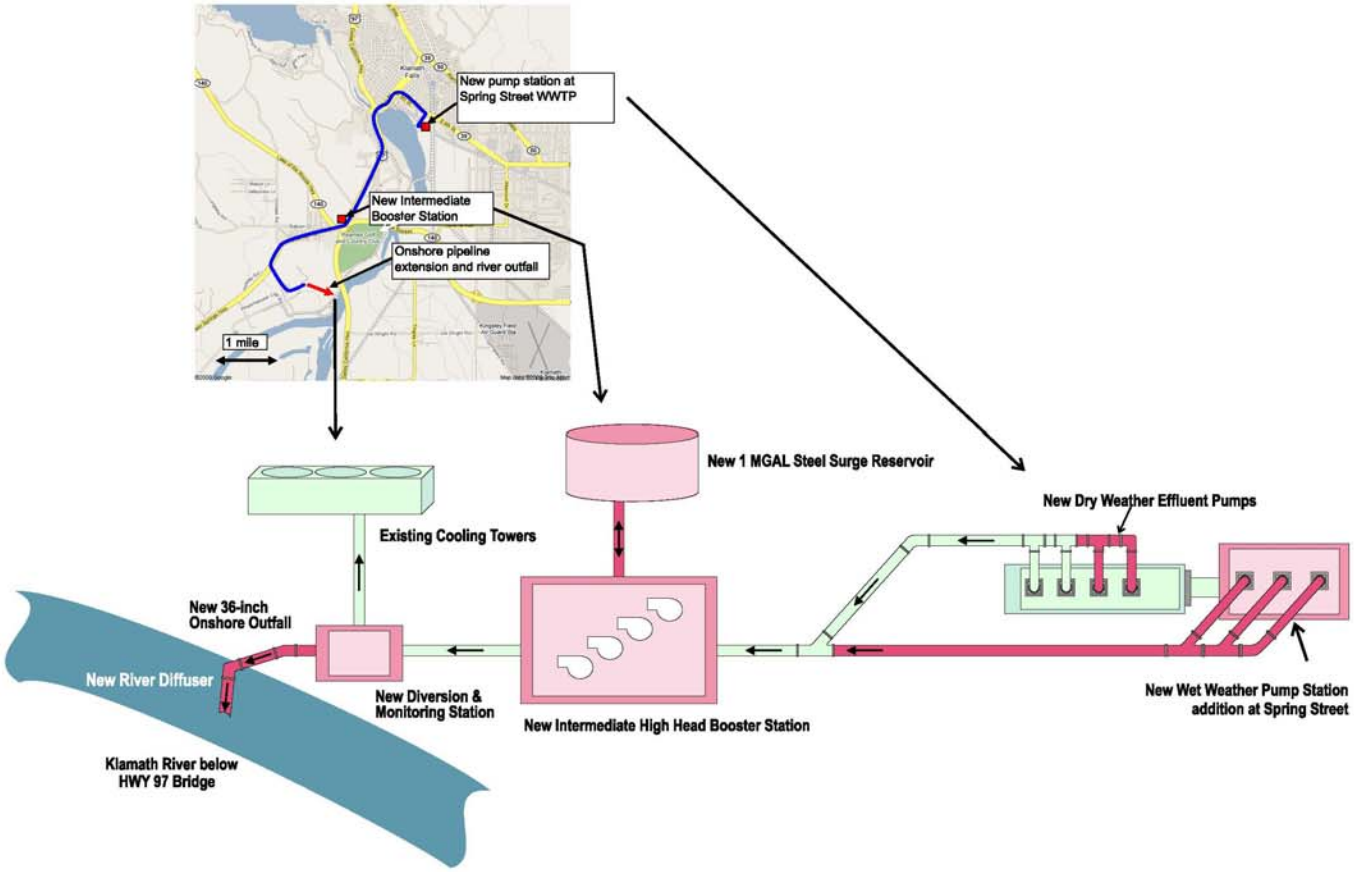


Figure 1.5 Year-Round River Discharge (Alternative 1)

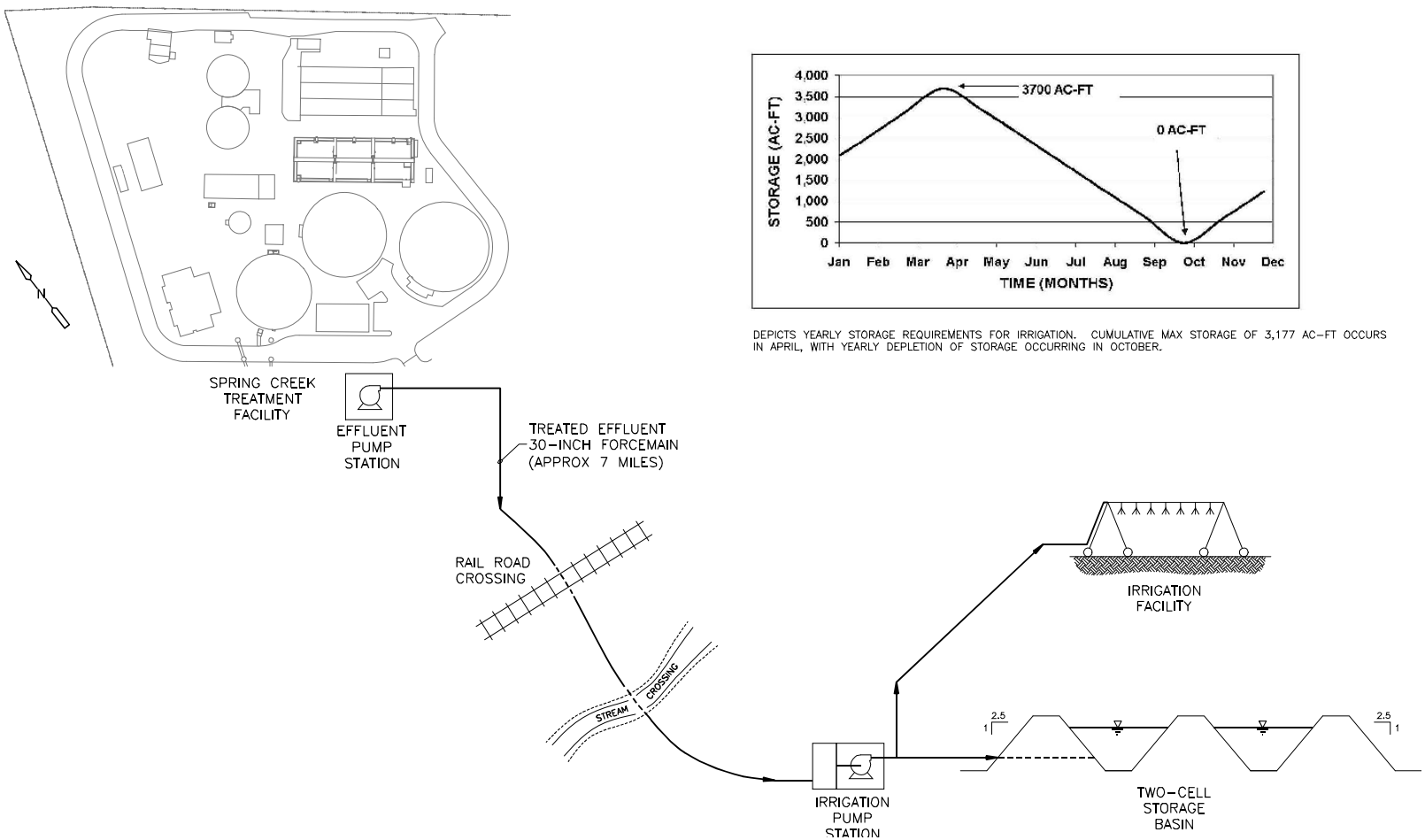


Figure 1.6 Summer Irrigation/Winter Storage Alternative - Effluent Pumping and Discharge Elements ("No River Discharge" Alternative)

Projected Costs

Total project costs for the two ultimate effluent management alternatives are listed in **Table 1.2**. Regardless of the TMDL outcome, the City is in need of upgrades that exceed $65,000,000, of which $18,000,000 are associated with relocating the outfall to meet water quality standards in Lake Ewauna and the Klamath River. The total project costs listed in **Table 1.2** include engineering, construction, and administration costs.

Table 1.2 Cost of Implementation – Complete Alternatives(1)

	Improvement	Total Capital Cost(2), Million US$	
		Alt 1: River Discharge	Alt 2: No River Discharge
Growth, Reliability, Operations	1. New influent IPS and headworks	7.3	7.3
	2. New conventional primaries (2) in new location	11.3	11.3
	3. New Aeration Basins (1)	5.6	5.6
	4. Add one DAFT	3.3	3.3
	5. Modify to thermophilic digestion and add (1) 500,000 digester	6.3	6.3
	6. Relocate existing belt filterpress and add (1) by composting area	2.0	2.0
	7. Enhancements to windrow composting	0.6	0.6
	8. Site piping modifications around clarifiers, including tertiary/disinfection booster pumping station	7.0	7.0
	9. New RAS pumps for Clarifier No 1	1.4	1.4
	10. Ultraviolet Disinfection	3.3	-
	11. Hypochlorite Disinfection	-	3.4
	12. New plant water pumps (at existing BFP location)	0.6	0.6
	13. New maintenance building	1.3	1.3
TMDL	14. New Aeration Basins	10.0	-
	15. New Continuously Backwashed Sand Filters, single stage	8.7	-
	16. Storage Pond, Low Head Pumping Station and Irrigation Facilities	-	123
Water Quality	17. Expand Co-Gen Pump Station for effluent pumping	5.1	5.1
	18. Effluent Re-aeration, final chemical injection and New Outfall	5.0	-
	19. New intermediate off-site pump station	8.1	8.1
	TOTAL	$ 87 M	$ 186 M

Notes:

(1) Estimates reflect September 2008 economic indexes and conditions.

(2) Total Capital Cost includes site construction, concrete, metals, equipment, instrumentation and controls, electrical, mechanical, installation, field office overhead (10%), home office overhead (6%) estimator's

contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%).

With either alternative, many improvements are required for increased capacity, reliability, or improved operations purposes. However, as shown in **Figure 1.7**, the cost impact of the TMDLs would be significant if the City is required to remove its effluent from the river.

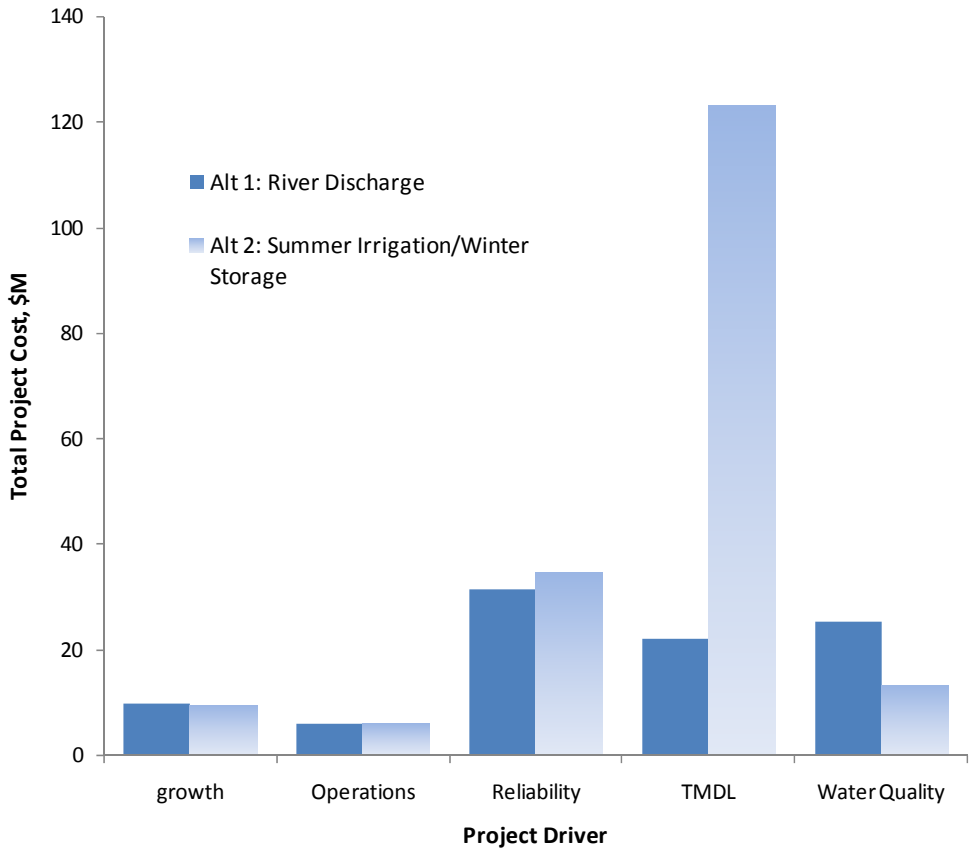


Figure 1.7 Drivers for Each Complete Alternative

Rate Impacts

Based on the projected capital and O&M costs and assumed debt financing, the impact to the monthly bill for a single family residential customer using 6 hcf/month is shown in **Table 1.3**.

Table 1.3 Rate Impacts

	Monthly Single Family Rate, $		
	FY2008	FY2013	FY2018
Alternative 1	30.39	87.25	91.61
Alternative 2	30.39	113.79	163.31

Part II – Updates and Recommendations for Implementation

Pieces of the planning basis continue to change. Because the TMDLs and TMDL water load allocations have not yet been issued at time of writing this facilities plan, the evaluations and recommendations have been developed broadly to meet potential scenarios including increasingly stringent effluent quality scenarios, and the possibility of not allowing discharge to surface waters. Oregon Department of Environmental Quality (OR DEQ) has shared draft TMDLs with CDM and these draft conditions have been incorporated into this document to the extent possible. As shown in **Figure 1.7,** five components comprise the very significant needs at the Spring Street STP. Part II of this executive summary includes a discussion of each of those areas, the factors that influence their implementation, and next steps. The discussion of TMDL related needs includes what is known and what is changing, likely outcomes, schedule and specific next steps with DEQ.

Operations and Reliability

In Alternative 1 (river discharge option), a majority of the costs are tied to the need to increase reliability and operational flexibility of the STP. These needs are dominated by the replacement requirements for the aging facilities and hydraulics (wet weather flows that reach the STP) while growth is mostly impacting solids handling upgrades.

Capacity

Dry weather flow at Spring Street STP has leveled off since this facility plan was developed. ADWF has stayed constant since 2007 at approximately 3 mgd. This lower than projected loading has the biggest impact on the solids handling needs. It may be possible to divide this component of the plan into smaller projects. Improvements that can be staged depending on short term need include DAFT additions, addition of a new digester, improvements to the belt filter press and composting.

Water Quality

Water quality issues are generally near field issues. Near field is a term that refers to water quality impacts near the outfall diffuser, which is currently in Lake Ewauna. These impacts and requirements generally involve ammonia toxicity, depletion of dissolved oxygen and raising the river temperature. In general, these issues for Klamath Falls can be addressed by finding a location on the river where the effluent receives good dilution. For facility planning, it was assumed that the cogeneration pipelines could be used to get to a point on the river downstream of Lake Ewauna where dilution needs can be met. This assumption needs to be developed and refined. Next steps are:

- Specific to dissolved oxygen - Klamath Falls needs DEQ to confirm that it can use 25% of the river flow for dilution. The City also needs DEQ to recognize that the City should not be responsible for background dissolved oxygen concentrations in setting limits at the edge of the allowable mixing zone.

- Investigation of pipeline capacity and optimization of new pipeline and wet weather effluent storage versus pumping the entire wet weather flow.

- Optimization of outfall location considering dilution, environmental impacts, right-of-way considerations, conflicts with the railroad, etc.

- Development of specific permitting requirements with agencies involved such as the Corps of Engineers

- Potential to include South Suburban in selection of a new outfall location.

These items would be part of a detailed Predesign of a new outfall.

TMDLs

In February 2009, there were significant developments in the TMDL determination process. DEQ determined that the baseline model assumptions used for developing waste load allocations were incorrect.

- The Bureau of Reclamation recently asked the DEQ modeling contractor, how, under natural conditions, the model handled the reef at Keno. Prior to construction of the dam at Keno, a reef existed just upstream from the dam site. This reef partially blocked flow in the Klamath River, creating a natural impoundment. When the Keno Dam was built, a notch was cut in the reef so that the water level in the Klamath River above Keno Dam could be controlled by dam operation. The initial model runs made by the DEQ contractor removed Keno Dam, but left the notch in the reef. This allowed the river above the reef to behave more like a river and less like an impoundment. In other words, with the notch in the reef, the model did not recreate the natural condition. The model was revised to remove the notch.

- The natural condition of the river is created when the model is run without the dams, point source discharges, or any other known anthropogenic discharge or activity that would alter the water quality of the river. When this scenario is run, current water quality standards for listed parameters (dissolved oxygen, pH, etc) are still not met in the river. Because of this, the TMDL will be based on reducing the impact of discharges and other activities (such as dams) so that water quality is not significantly altered from the natural condition.

These new model results, which became available in early February, show that the impact of the point sources at their year 2000 discharge loads do not significantly alter water quality from that which represents natural conditions. As a result, DEQ anticipates that waste load allocations for the point sources (including the City's sewage treatment plant, will be capped at the model input levels (2000 plant discharge). The waste load allocations could include total nitrogen which was not a parameter anticipated when DEQ informed the City of tentative waste load allocations early last summer.

Other potential issues relative to the TMDLs that could impact the City are:

- California is concerned about toxic algae (reservoir issue). Residence time behind dams is extremely long year round. CA is thinking about setting a TMDL for toxic algae. How they might do this is questionable. However, since the formation of toxic algae occurs mostly in impoundments behind the dams on the river, this is more likely a problem for the owners of the dams.

- DEQ and California North Coast Regional Water Quality Control Board are in agreement but California may want a "load allocation" at the border meaning that upstream limits may be a little more restrictive than historical loads.

The impact of these new results is unclear because the 2002 data used in the model is not representative of Spring Street 2002 effluent discharge. This situation is currently being investigated by DEQ staff. The likely result is that phosphorus removal will not be a significant issue for Klamath Falls. Instead, the City may be faced with restrictive total nitrogen limits. The treatment processes outlined in this Facilities Plan can be configured to meet low nitrogen limits. However, filtration may be needed to meet low nitrogen limits instead of phosphorus removal.

DEQ is reviewing the arsenic criterion (WQ standard) as a part of its effort to set appropriate criteria for the protection of human health (fish ingestion and drinking water). The human health criterion for arsenic for protecting human health is the 0.022 μg/l. This arsenic criterion is impacting discharges across the whole state. DEQ is stepping back and engaging in the following:

- Considering what other states are doing.
- Looking at research on bioaccumulation in fish and other impacted species – very significant issue to the Tribes.
- Revising upward the quantity of fish consumed. Note: the impact on human health is a function of the amount of a particular toxin in the fish and the amount of fish consumed over a given time. Tribal people believe that the consumption of fish tissue is much higher than that used by DEQ to determine in-stream toxic criteria. The amount of toxin in the fish depends on the concentration of the toxin in the water and factors related to bioaccumulation.
- Reviewing characterization of the speciation of arsenic (inorganic, organic, trivalent, etc.). Inorganic arsenic is the main human health concern.
- Working with a stakeholder advisory committee.
- Considering the fact that EPA has been requiring detection levels at 5 μg/l resulting in non-detects in many areas.
- Looking at intake credits and other ways of passing background conditions through the dischargers.

Some states have developed an arsenic standard in the single digit μg/l range. It will take about a year and half to sort this out. For permits issues in the interim, the self monitoring requirements for arsenic will be specified (mid 2010). Klamath Falls may not see a numerical arsenic limit until 2015-16. By the end of March 2009, DEQ should have an interim approach to the arsenic issue.

Compliance Schedule

EPA is in litigation over compliance schedules. If the decision is favorable to EPA, DEQ will have the authority to set the schedule for TMDL compliance. The TMDL will be enforced as part of the permit renewal. A possible schedule may be:

- Oregon DEQ may issue the Klamath River TMDL this summer (2009) for public notice with final issuance by the end of the year. Remaining work on the TMDL prior to public notice appears to include finalization of the source input data in the computer model, negotiations with California, and

completion of the modeling documentation. Public comment period is 60 days but may be longer and may coincide with California.

- Permit written and issued in six months following TMDL adoption, mid-2010.
- Compliance in 5 years (2015) or "as soon as practical."

The schedule for arsenic and other loads that are not part of the TMDL process will be different. The permit may contain an interim monitoring requirement for these constituents of concern.

Because of aging facilities, most upgrades are required before year 2015. **Table 1.4** lists the project costs for identified plant upgrades for each year under the current assumptions of this plan. **Table 1.4** shows the phased capital cost expenditures between FY 10 and FY 15 on an encumbrance basis, that is, the total cost of each project is shown in the year that design of the project is scheduled to commence. No capital is expected to be spent in FY 16 – FY 19 at this time. Costs shown in the table reflect the estimated total costs of the various projects during the analysis period, including engineering, construction, and administrative costs.

In conclusion, Part I of this Executive Summary provides a broad plan for improvements to the plant, which considered a certain degree of effluent limit variations. Part II summarizes the current status of TMDL development and presents a short term course of action for the City. With this facilities plan, the City of Klamath Falls now has a long-term planning document with implementation recommendations that can be incorporated in its budgeting and planning efforts.

Table 1.4 Alternative 1 Capital Cost Phasing

Line No	Upgrade	FY 09	FY 10 $	FY 11 $	FY 12 $	FY 13 $	FY 14 $	FY 15 $
		TMDL Approved	New Permit Issued					Compliance Required
1	Liquid Stream - IPS/Headworks Upgrades		1,500,000	4,400,000	1,500,000			
2	Liquid Stream - Primaries Upgrades		1,100,000	3,400,000	4,500,000	2,300,000		
3	Liquid Stream - Aeration Basins Upgrade		1,600,000	4,700,000	6,200,000	3,100,000		
4	Solids - Sludge Thickening Upgrades							3,260,000
5	Solids - Sludge Digestion Upgrades		300,000	1,300,000				4,700,000
6	Solids - Sludge Dewatering Upgrades				1,960,000			
7	Solids - Composting Area Upgrades				640,000			
8	Liquid Stream - Effluent Piping Modifications		4,200,000	2,800,000				
9	Liquid Stream - RAS Pumps Upgrades					1,370,000		
10	Liquid Stream - Effluent Disinfection Upgrade			300,000	2,000,000	1,000,000		
11	Ancillary - Plant Water Pumps Upgrade		570,000					
12	Ancillary - Maintenance Building		1,330,000					
13	Liquid Stream - Tertiary Treatment Addition - year round		900,000	2,600,000	3,500,000	1,700,000		
14	Liquid Stream - Effluent Pump Station – Onsite				1,000,000	2,000,000	2,000,000	
15	Effluent Discharge - Effluent Pump Station – Offsite				1,600,000	3,200,000	3,200,000	
16	Effluent Discharge - Outfall, Final Aeration, and Effluent Polishing				1,000,000	2,000,000	2,000,000	
	Subtotal (Uninflated)		11,500,000	19,500,000	23,900,000	16,670,000	7,200,000	7,960,000
	Subtotal (Inflated)		11,787,600	20,487,200	25,737,600	18,400,500	8,146,100	9,231,200

Section 2
Introduction, Purpose and Need

2.1 Introduction, Purpose and Need

The City of Klamath Falls (City) owns and operates the Spring Street Sewage Treatment Plant (Spring Street STP), which discharges its treated effluent into Lake Ewauna, a natural reservoir on the Klamath River. The City's current National Pollutant Discharge Permit (NPDES) was last issued in 1990, with its renewal pending on clarifying emerging water quality issues in the Klamath River. The purpose of the Spring Street STP Facilities Plan is to present a framework and improvement plan to ensure current and expected future discharge requirements are met.

Currently, the City faces significant upgrades due to aging facilities as well as upgrades required to meet the upcoming TMDLs. The City anticipates that significant facility improvements to the Spring Street STP will be necessary over the next 10-20 years. These improvements will be needed to:

- Replace existing infrastructure that is nearing the end of its service life,
- Enhance the effectiveness and efficiency of current processes,
- Provide additional treatment capacity for new wastewater flows from developing portions of the City, and
- Meet potential new permit effluent limits and other regulatory requirements related to the Klamath River Total Maximum Daily Load (TMDL) process.

The Oregon Department of Environmental Quality (DEQ), in conjunction with the EPA, the North Coast Water Control Board, and the State of California, is developing TMDLs to address nutrient-related and temperature water quality impacts in Lake Ewauna, the Klamath River from Lake Ewauna to the Keno Dam, and the Klamath River to its confluence with the Pacific Ocean. These TMDLs will require that wastewater effluent discharges to Lake Ewauna and the Klamath River meet more stringent water quality standards. In addition, DEQ has regulations concerning thermal and toxic effluents that will also affect discharges to Lake Ewauna and the Klamath River. Overall system planning, in particular a Wastewater Facilities Plan and effluent plan, is necessary to meet DEQ discharge requirements, obtain a new NPDES permit, and provide the critical documentation to secure state and federal grants or loans.

Treatment facilities at the Spring Street STP include:

- Liquid stream – coarse screening, influent pumping, grit removal, fine screening, primary sedimentation, activated sludge aeration, secondary clarification, disinfection and dechlorination
- Solids stream – grit and fine screening offsite disposal, gravity thickening, WAS floatation thickening, anaerobic digestion, sludge dewatering, sludge drying, sludge storage, and sludge composting

- Effluent reuse – treated effluent wastewater reuse pumping, storage, and return flow infrastructure

A draft preliminary design report involving modifications to the solids management process was prepared for the City of Klamath Falls in May 1999 (Brown & Caldwell). The report presents an overview of recommended plant improvements with associated hydraulic profile and design data including technical memoranda for each element of the proposed plant improvements. These improvements were implemented in 2000 to 2002.

Following the preliminary design report, a draft facilities plan was begun by Brown & Caldwell in October 2000. Recommendations outlined in the draft facilities plan include planning efforts focused on improving the efficiency and expanding the capacity of the existing system. Increased capacity in thickening and digestion were recommended by expanding or upgrading the DAF thickening and anaerobic digestion. In addition, two solids dewatering alternatives were presented and compared. As part of the facilities plan, a separate biosolids composting facility evaluation was performed.

The City is still developing their Wastewater Collection System Master Plan.

This Facilities Plan continues and updates the October 2000 draft facilities plan to reflect the current issues and plans of the City and regulators. In general, sections of the Facilities Plan follow the Table of Contents provided by the *Oregon Guidelines for the Preparation of Facilities Plans and Environmental Reports for Community Wastewater Projects* (DEQ, 1999). At the direction of the City, certain language and subsections of the draft 2000 facilities plan (such as those related to some study area characteristics) that remain the same have been incorporated, thereby saving the City money.

Section 3
Study Area Characteristics[1]

The interaction of socioeconomic factors such as economic activity, population growth, and land use with environmental characteristics such as topography, geology, soils, climate, and water resources may profoundly affect the overall Klamath Falls environment. The development of sound, long-range sewerage and treatment plans for the Klamath Falls area thus requires consideration of both environmental and socioeconomic characteristics, which are defined in this section for the Klamath Falls study area.

3.1 Study Area

The City of Klamath Falls is located in the south central region of Oregon near the border of northern California and east of the Cascades mountain range. The City sits on the southern shore of Upper Klamath Lake. Klamath County is nestled within the Klamath Basin, which lies in portions of southern Oregon and northern California. Klamath Falls is somewhat isolated from other major population centers, the closest being Medford about 80 miles to the west. Klamath Falls is bordered by Klamath Lake to the northwest, Link River and the Klamath River to the south and west, and Hogback Mountain to the east. The land southeast of Klamath Falls is primarily flat, agricultural land. The urban area around Klamath Falls includes the City of Klamath Falls and the South Suburban area, with a combined urban population of approximately 42,000.[2]

Two main treatment plants serve the population of Klamath County: the Spring Street Sewage Treatment Plant (Spring Street STP) owned by the City, and a separate wastewater treatment facility owned and operated by the South Suburban Sanitary District (SSSD). An even split between sewered populations serviced by each treatment facility existed until recently; however, new developments within the urban growth boundary are being connected to the Spring Street STP, with a service population of about 28,000 at the Spring Street STP in 2007.

The Spring Street STP sits on the eastern shore of Lake Ewauna downstream of Upper Klamath Lake and receives residential and industrial flow from within the city limits, the Kingsley Field area, the Oregon Institute of Technology, and from the Running Y Resort. Pacific Klamath Energy Cogeneration Plant also contributes 0.2 million gallons per day (MGD) of sanitary waste to the Spring Street STP. An additional 0.8 MGD of cogeneration cooling system return stream - referred to as "blowdown"- is returned directly to the Spring Street STP and combined with treated effluent for discharge into Lake Ewauna.

The South Suburban Sanitary District's treatment facility consists of aerated lagoons located to the south of the Spring Street STP, on the eastern shore of the Klamath River. The SSSD receives residential and industrial flow from the sewered Klamath County area outside of the city limits. While the SSSD facility is entirely separate from the Spring Street Plant, the capability was

[1] This Section utilizes information contained in the draft 2001 Facilities Plan and Chapter 2 of the December 2006 Wastewater Collection System Master Plan ("Sewer Master Plan") prepared by Brown and Caldwell. The information was revised and expanded as appropriate for this Facilities Plan.
[2] City of Klamath Falls planning department, May 2007 meeting.

recently added to allow one to two MGD of SSSD wastewater to be diverted into the Spring Street Plant as needed, to satisfy minimum flow requirements for cooling water provided to the cogeneration plant. SSSD currently discharges to a stormwater drainage ditch. The water in the stormwater water ditch is pumped into Lake Ewauna.

From the early 1990s to the mid-2000s, an annual average of about 2.5 MGD of effluent was treated by the South Suburban Sanitation District WWTP. This rate is about three times what it was in 1961.

Figure 3.1 shows the boundaries of the Klamath Falls Urban Growth study area and associated land use designations.

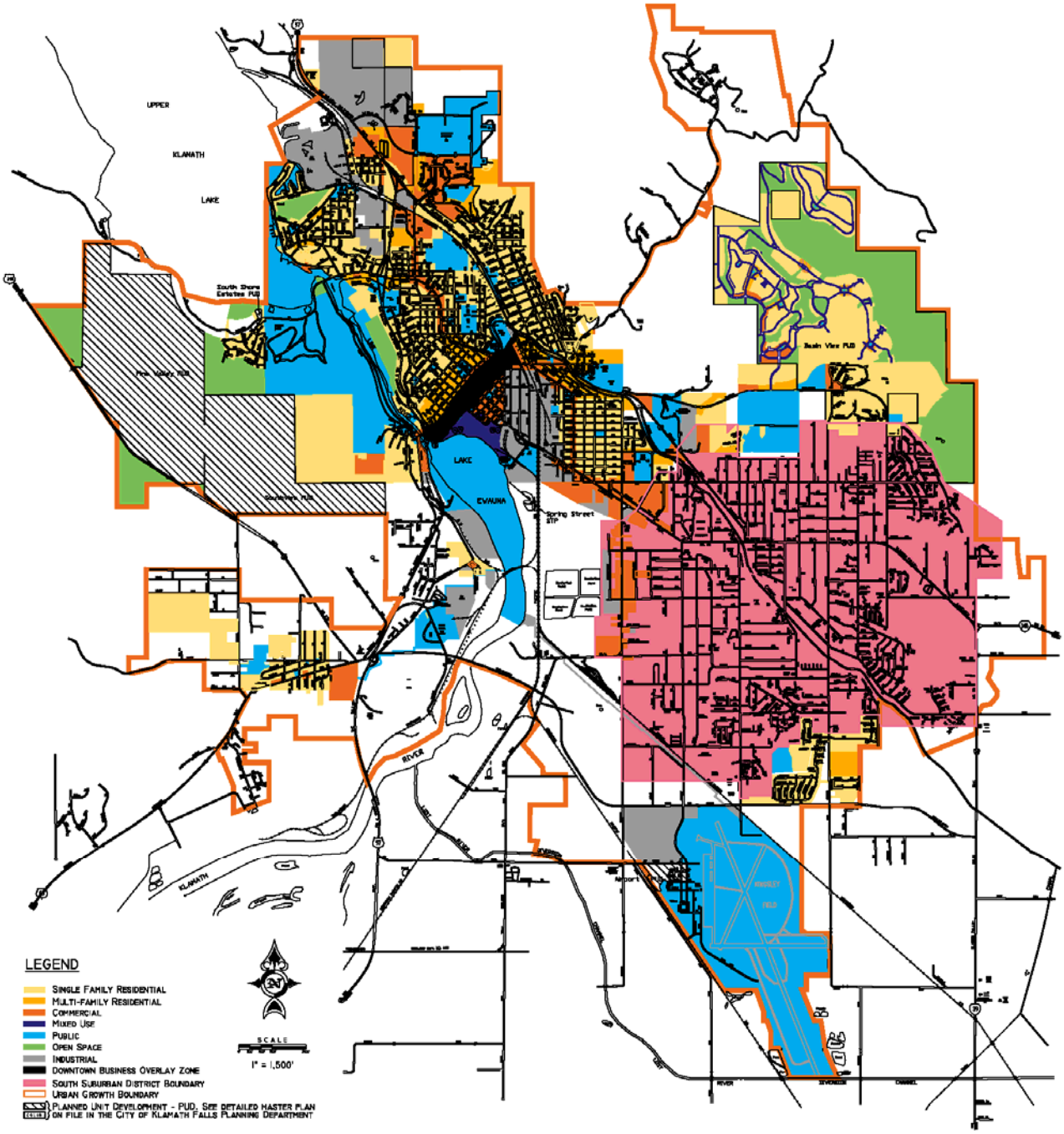


Figure 3.1 Klamath Falls Study Area and Urban Growth Boundaries

3.2 Physical Environment

Within the Klamath Falls city limits, the land varies in elevation from 4,080 feet to 4,600 feet, with the low point of the City near the shores of Lake Ewauna. The slopes of Hogback Mountain ridge to the east account for the highest elevations in the City.

The Klamath Basin is approximately 60 to 70 miles wide and about 115 miles long, consisting largely of basins and ridges running north to south. The basins are typically at elevations of 4,100 to 4,500 feet separated by steep mountain ridges rising 2,000 to 4,000 feet above them. Most of the major drainages in the Oregon portion of the basin eventually enter Upper Klamath Lake. These include the Williamson River and Klamath Marsh to the north, Sprague River and Sycan Marsh to the northeast, and Langell Valley and Lost River to the southeast (water bodies in the Klamath Basin are presented later in this Section in Figure 3-6). In addition, many small creeks flow towards Upper Klamath Lake from Crater Lake to the north and the Cascade mountains to the northwest. The total watershed draining to Upper Klamath Lake – the Upper Klamath Basin - is about 3,800 square miles (USGS). A man-made dam and spillway at the southern end of Upper Klamath Lake controls the Lake's elevation and flow into Link River and Lake Ewauna downstream. Lake Ewauna is the headwaters of the Klamath River which flows through northern California and ultimately to the Pacific Ocean. Lake Ewauna is fed by Link River from Upper Klamath Lake and controlled by the release of water from Keno Dam 18 miles downstream. The Spring Street Wastewater Treatment Plant Outfall discharges into Lake Ewauna, which stays at a relatively constant level throughout the year because of the dam.

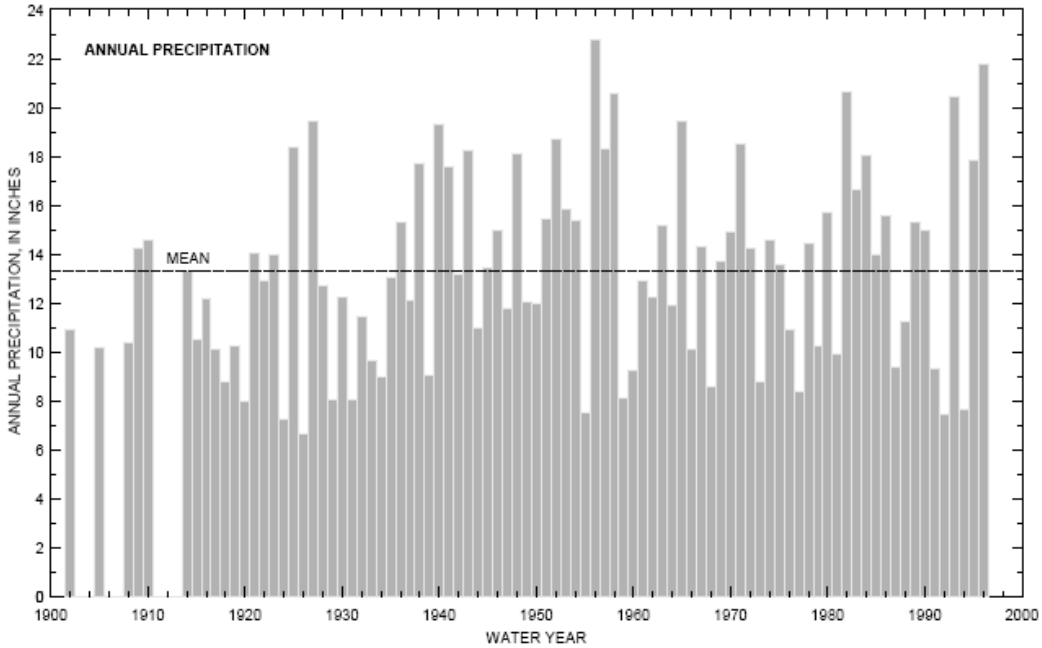
Development of the wastewater treatment alternatives in this plan includes correction factors for the high Spring Street treatment plant elevation of 4,090 feet.

3.2.1 Climate

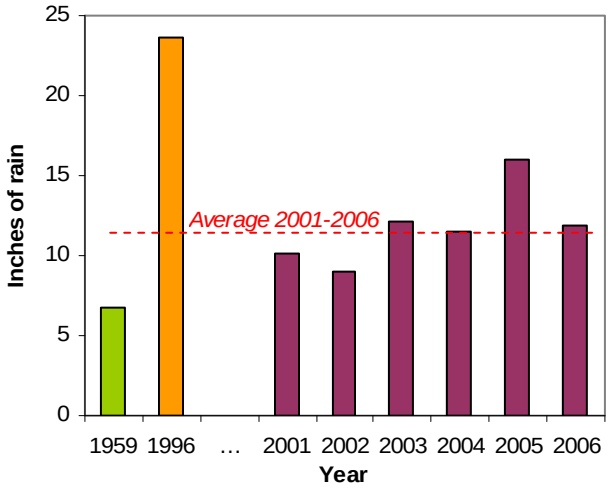
Climate can be defined by temperature, precipitations, wind, and storm patterns. Climate patterns have an important impact on the design wastewater treatment facilities. Precipitation and storm patterns may have a substantial impact on the cost and size of conveyance and treatment facilities, as well as technology choice and operational strategies that optimize costs and performance. Moreover, temperature patterns typically influence the performance and sizing of biological treatment processes. This section discusses the general climatic factors in the study area as they might affect the treatment facilities design.

Precipitation

The general climate in the Klamath Basin is characterized by warm, dry summers and cool winters with the Cascade Mountains shielding the Klamath Basin from Pacific moisture. Long-term records from the official National Oceanic and Atmospheric Administration (NOAA) weather station at the Klamath Falls International Airport shows total annual precipitation varying between as little as 6.7 inches in 1959 to as high as about 24 inches in 1996, with a long-term annual average of about 13.5 inches (**Figure 3.2 (a)**). Recent years were dryer with total annual precipitations averaging less than 12 inches from 2001 to 2006, as shown in **Figure 3.2 (b)**.



(a) Years 1900 to 1996
(source: USGS Water-Resources Investigations Report 98-4198)



(b) Years 2001-2006 (as recorded at the International Airport Station, with record low (1959) and high (1996) added)

Figure 3.2 (a) (b) Klamath Falls Annual Rainfall Data

Monthly precipitation patterns. Most precipitation occurs over the months of October through May, with the wettest months typically November through February, and the driest months including June, July, and August. **Figure 3.3** illustrates monthly rainfall data over the years

2001 to 2006, the wettest month being December with monthly precipitations exceeding 2-inches while the driest month over that period was July with less than 0.25-inches of rainfall. The extent and timing of the dry, wet, and transitional months is used to define flow and loading factors (**Section 4**) and support flow and load projections (**Section 5**).

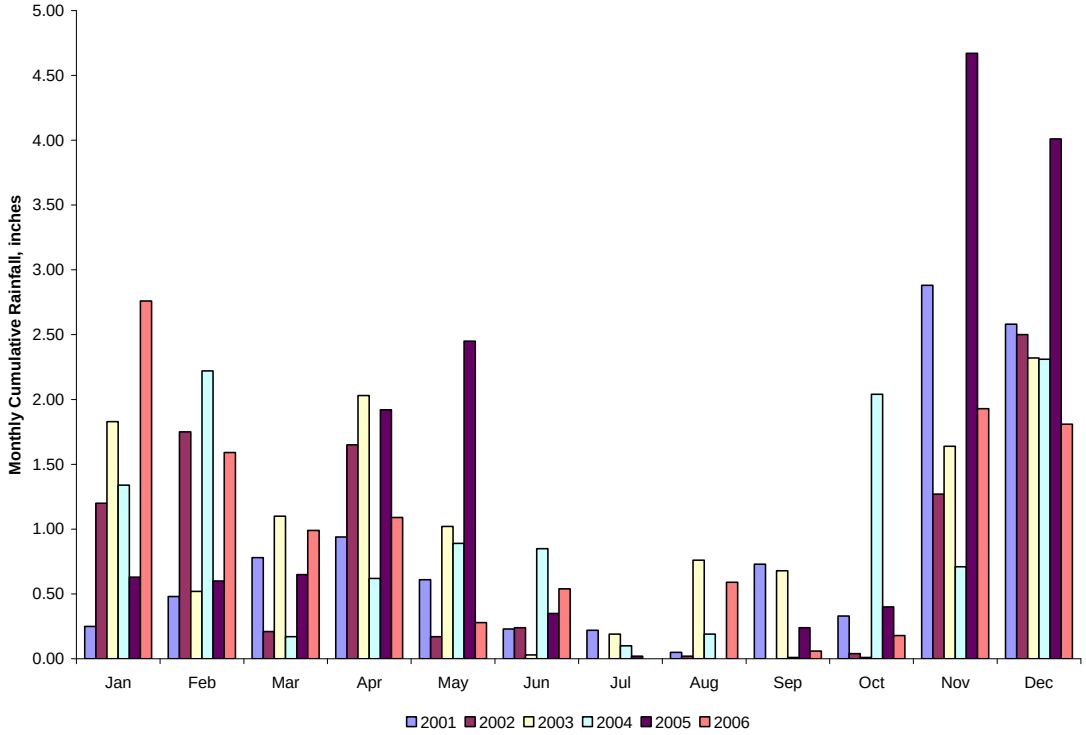


Figure 3.3 Klamath Falls Monthly Rainfall Data 2001-2006

(As recorded at the International Airport Station)

Daily precipitation patterns. Historic daily precipitations for the years 2001 through 2006 are illustrated in **Figure 3.4**. The area typically experiences the largest rainstorms during the winter through spring, receiving up to 1.5 inches of rain per event. Large (more than 1-inch of precipitation) back-to-back storms were not experienced during the period of record and are not typical of this area.

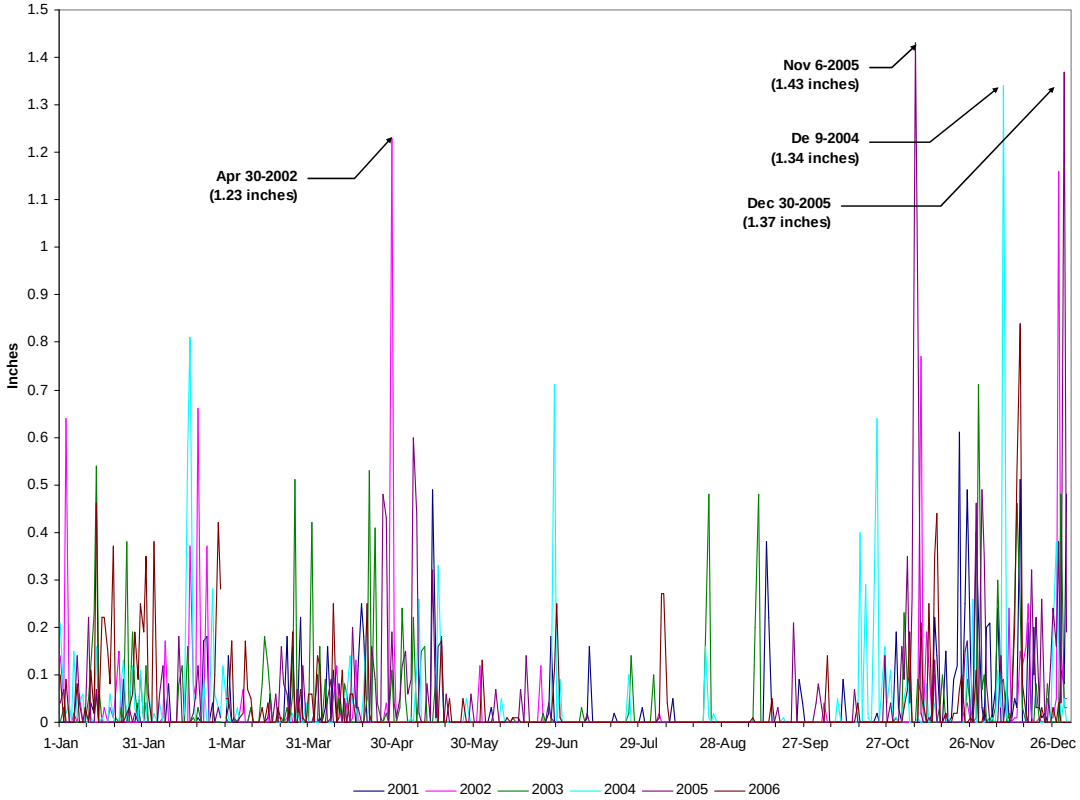


Figure 3.4 Daily Precipitation Records, 2001-2006

Temperature

Temperature variations impact treatment and facilities design, with cooler temperature usually controlling the sizing of the biological treatment system and impacting ancillary system sizing and configuration (e.g., HVAC, heat tracing, enclosures, insulation, and pipe burying depths for freeze protection, etc.).

The coolest month of the year in Klamath Falls is January, with average temperatures in the 30 degrees Fahrenheit (-1.1 degrees Celsius) range or so. Northeast air flow can bring cold Arctic air into the area, with temperatures as low as -30 Fahrenheit; but, the temperature seldom goes below 0 Fahrenheit with about 120 hours below 15 Fahrenheit in a typical year and little wind coincident with cold temperatures. July is the warmest month, with an average temperature of 68 degrees Fahrenheit (+20 degrees Celsius). Daily maximum air temperature in July and August averages 82 degrees Fahrenheit (+27.8 degrees Celsius), while daily minimum temperatures in January and February average 19 degrees Fahrenheit (-7.2 degrees Celsius). In the Klamath Falls area, the frost line is approximately 18 inches from the surface and all water systems are installed 36 inches below surface to prevent pipe freezing.

Wind

Although it generally does not impact plant performance, wind is increasingly becoming an important factor in planning wastewater facilities as it determines the impact of odors generated from the treatment plant on neighboring sites. To another extent, wind may also

impact planning factors related to energy efficiency (by requiring more insulation, covering up basins to maintain warmer temperatures and higher process efficiency, for example).

Prevailing winds in the Klamath Falls study area are generally from the northwest in the summer, with winds frequently exceeding 10 mph from the north, and from the southeast in the winter.[3] Because development is planned to the northwest of the plant, the risk of odor complaints in the summer, when odors are likely to peak, is low.

Impact of Climate Change
Although the impact of climate change is still being debated nationally and internationally, there is consensus that climate change is happening. Little information is available on specific impacts of climate change. The JISAO Climate Impacts Group (University of Washington, WA), recently published its *Impacts of climate variability and change in the Pacific Northwest* report. The effort originated from water resources concerns and focused on calibration of computer models based on past climate events in order to predict possible future long-term climate change. The conclusions are thus limited to long term average trends rather than extreme events, and of limited use for predicting peak flow events at wastewater treatment plants. Nevertheless, the report predicts long term (year 2050) precipitation increase up to 5 percent.

Given the uncertainty of the impact of climate change, especially from storm events, it would be premature to design around dramatic increases in the magnitude of the storms. That said it would be prudent to allow flexibility to accommodate higher peak events either on the conveyance side or at the treatment plant.

3.2.2 Soils and Topography

Klamath Basin lies in the Basin and Range geomorphic division. The geology of this division is largely volcanic. Inactive volcanoes that make up the Cascade Range define the western edge of the Basin. Geologic formations in the Cascades include lava flows, volcanic cinders, and basaltic rock deposits. Hills to the east of Klamath Falls were formed by block faulting and differential erosion. Upper Klamath Lake's basin, like many others in the Basin and Range area, was formed by similar tectonic processes. It lies in a graben, a depression formed by faulting. Silty clay sediments beneath the lake range from 48 to over 100 feet in depth. They overlay older alluvial deposits (Klamath Consulting Service, 1983).

Materials in the valleys and basins come from two main sources: pumice comes from wind-eroded material from volcanic eruptions while gravel, sand, silt, clay, and diatomite come from lake (lacustrine) deposition, much of it from Lake Modoc, which covered the area during the wetter climate of the last ice age, the Pleistocene.

Many area lakes are remnants of Lake Modoc, left behind in the deeper basins, when the lake receded. Upper and Lower Klamath Lakes and Tule Lake are the largest remaining examples.

[3] Data from *Upper Klamath Basin Nutrient-Loading Study*, Laenen and Letourneau, USGS report 95-414, Portland OR, 1996.

Due to its relatively recent volcanic and lacustrine origins, the Klamath Basin's drainage system is poorly developed. Many small streams either end in marshes or disappear into porous lava or pumice.

Soils found in the Klamath Falls area clearly reflect their origins as either volcanic material or lake and riverine sediments. Detailed information on soil series can be found in the Soil Survey of Klamath County, with some of the information summarized below.[4] The study area includes Lorella soils, Henley-Poe-Laki soils, and Teeters silt loam.

Lorella soils underlie those parts of the study area not immediately adjacent to the lake or river. They consist of well drained soils of slow permeability located on side slopes of mountains and hills and on convex slopes of escarpments. Lorella soils are relatively shallow, used for livestock grazing, pasture, water supply, and wildlife habitat. Vegetation is mainly western juniper, bluebunch wheatgrass, Idaho fescue, antelope bitterbrush, and mountain big sagebrush.

Henley-Poe-Laki soils are predominant south of the city where they were deposited along the Klamath River valley. These deep soils are generally high in water content and have low compressive strength.

The soil at the treatment plant site is Teeters silt loam. This poorly-drained soil is composed mainly of diatoms and pumice ash deposited by Upper Klamath Lake. Because this soil has low compressive strength, it is not desirable for use in construction. The low permeability, high shrink-swell potential, and poor strength of soils at the plant site and in the service area are factors that impact planning, construction, and operation of the sewer facilities, with infiltration and inflow (I/I) as one result.

3.2.3 Geologic Hazards

In Klamath County, recognition of geologic issues including earthquake and volcanic hazards, watershed health, and geologic controls on groundwater have resulted in an effort by the Oregon Department of Geology and Mineral Industries (DOGAMI) to prepare detailed geologic maps covering the City of Klamath Falls and other priority areas in the upper Klamath River Basin, with planned completion in 2007. As this effort is coincident with the facilities plan development, further discussions with the Department will be made to update as necessary the hazards specific to the study area and, more importantly, the Spring Street STP site. The information below discusses the latest reported information specific to the Spring Street STP area.

Earthquake Risk

The Klamath Falls area is in a zone of moderate seismic risk with known fault lines running northwest to southeast on either side of the Klamath Falls urban area (HGE, 1977). On September 20, 1993, the area experienced twin earthquakes of magnitude 6.0 and 5.9. Those earthquakes and numerous smaller tremors occurring during the following year were centered to the northwest of Klamath Falls. At this time, the known fault lines do not traverse the

[4] *The Soil Survey of Klamath County*, *Oregon*, *Southern Part*, Joe Cahoon, Soil Conservation Service, United States Department of Agriculture, in cooperation with Oregon Agricultural Experiment Station, 1985.

existing Spring Street STP or any of the proposed sites for expansion; however this should be confirmed during detailed design.

With many minor surface fractures within 30 miles of Klamath Falls and recognizing the potential for higher seismic activity, the Uniform Building Code seismic zone for Klamath County was upgraded from 2B to 3 as of January 1, 1993. Alternatives developed for this Plan are all based on UBC seismic design criteria of 3, as discussed in Section 6.

3.2.4 Public Health Hazards

No declared public health hazards exist in Klamath Falls or adjacent to the City at this time, nor is there any information to suggest that one should be declared. Declared public health hazards are established by the administrator of the Oregon Public Health Division and are associated with contaminated public water systems or failing sewage disposal systems.

The operation of wastewater facilities have inherent potential public health hazards that need to be addressed during the planning efforts. The public health hazards can be described as acute hazards and those related to potential long-term exposure created by the operation and discharge of the wastewater facilities. Floods, earthquake, and catastrophic man-made events, or catastrophic events related to the transport or handling of chemicals are sources of acute hazards potential, when the public could come in contact with chemicals or untreated wastewater either directly or via groundwater or surface water supply contamination. Examples of long-term hazards include the potential for detrimental impacts on trophic state of lakes and/or rivers, the potential to contaminate fish and shellfish that would be consumed by the public, and the potential exposure to airborne contaminants (hydrogen sulfide) related to the wastewater facilities operation.

Flood Potential
Past floods in the Klamath Falls area have resulted from heavy winter rains augmented by snow melt. The San Francisco District of the Army Corps of Engineers researched flooding potential of the Spring Street STP and the SSSD Oxidation Lagoons sites. The Corps found that both sites were in the flood plain of Lake Ewauna during the February 1965 flood, which was equal to a 40-year event and reached a maximum height of about 4,087 feet above mean sea level (fmsl) (HGE 1977). Since that flood, the Pacific Power and Light Company replaced the Keno dam so that it could hold the 100-year flood water surface in Lake Ewauna at about 4,086 fmsl. This is below the SSSD lagoons levees (4,091 to 4,094 feet elevations) and at or below the Spring Street STP site elevation of 4,086 to 4,090 feet, presenting a low risk of flooding at the Spring Street STP.

Earthquake Potential
As mentioned in **Section 3.2.3.**, the Klamath Falls area lies in an area with moderate seismic activity. In response to this, facilities will be planned per the requirements of UBC seismic zone 3 to present a low potential of earthquake-related failure.

Catastrophic Man-Made Events
In 2005, the United States Government Accountability Office (GAO) published a report to the Senate Committee on Environment and Public Works that identified prioritized wastewater security-enhancing activities. Of those, the potential for chemical release, physical access to the

treatment plant by non-authorized persons, and unauthorized access to the treatment plant's Supervisory Control and Data Acquisition System (SCADA) were ranked high. To prioritize the actions minimizing catastrophic events, the GAO report recommends that utilities complete a vulnerability assessment study, the findings of such study serving as a basis to obtain federal funding.

The alternatives developed for Klamath Falls integrate as applicable the recommendations to minimize man-made catastrophic failures or malfunctions.

Directives from Klamath Falls City Code and the Uniform Fire Code will be followed for new chemical handling and storing (if any).

Long-Term Exposure Risks

DEQ is the state's lead authority for protecting and enhancing Oregon's water and air quality. In addition to local programs, the Environmental Protection Agency (EPA) delegates authority to DEQ to operate federal environmental programs within the state such as the Federal Clean Air, Clean Water, and Resource Conservation and Recovery Acts. Coincident with DEQ's objectives, the alternatives herein all have the utmost priorities to maintain, protect and enhance the public health as it relates to the construction and operation of new or modified wastewater facilities.

3.2.5 Energy Production and Consumption

The study area has abundant energy resources available in the form of hydroelectric power and geothermally heated water. Hydroelectric power is generated from dams and reservoirs operated by Pacific Power and Light along the Klamath River. In a downstream order, they are the Link River Dam, Keno Dam, John C. Boyle Dam, Copco Reservoir, and Irongate Reservoir. The City of Klamath Falls lies within a Known Geothermal Resource Area and benefits from an abundant supply of warm water produced from wells scattered throughout most of the area. Waters with temperatures exceeding 60 degrees C (140 degrees F) are confined to three areas: the northeast part of the city, the Olene Gap, and hills to the southwest. The hot water areas appear related to major fault and fracture zones of the Basin and Range geomorphology (Oregon Department of Geology and Mineral Resources, 1982).

Several methods are used to tap into the geothermal resource. Some wells utilize closed loop systems with below-ground heat exchangers. In other systems, the hot water is pumped into an above-ground heat exchanger and then re-injected into the ground. A third method is to pump the heated water directly into the heating system and then waste the water to a storm sewer. The City of Klamath Falls is attempting to eliminate this last type of geothermal use to help conserve the resource. The geothermal water is used for heating residences, commercial buildings, governmental buildings, and swimming pools.

The Spring Street STP currently uses geothermal water in an open-loop system to heat buildings at the treatment plant as well as primary anaerobic digester sludge. Electricity is provided by Pacific Power & Light while natural gas is provided by Avista Utilities.

The Spring Street STP supports the operation of the City's 500 megawatt cogeneration plant by providing it with cooling water.

3.2.6 Water Resources

Water resources in and around the study area are important in wastewater planning influencing both water supply and wastewater treatment and discharge requirements. They supply water to domestic, agricultural, and industrial users, and also provide recreational opportunities. Prominent water bodies of the Klamath Falls area include Upper Klamath Lake, Link River, Lake Ewauna, Klamath River, and groundwater. See **Figure 3.5** for an illustration of the Klamath Falls area water bodies. The Spring Street STP currently discharges to Lake Ewauna downstream of the Upper Klamath Lake and feeds into the Klamath River to the south. Lake Ewauna's water quality is thus largely dependent on the water quality of the entire watershed upstream of the Klamath River.

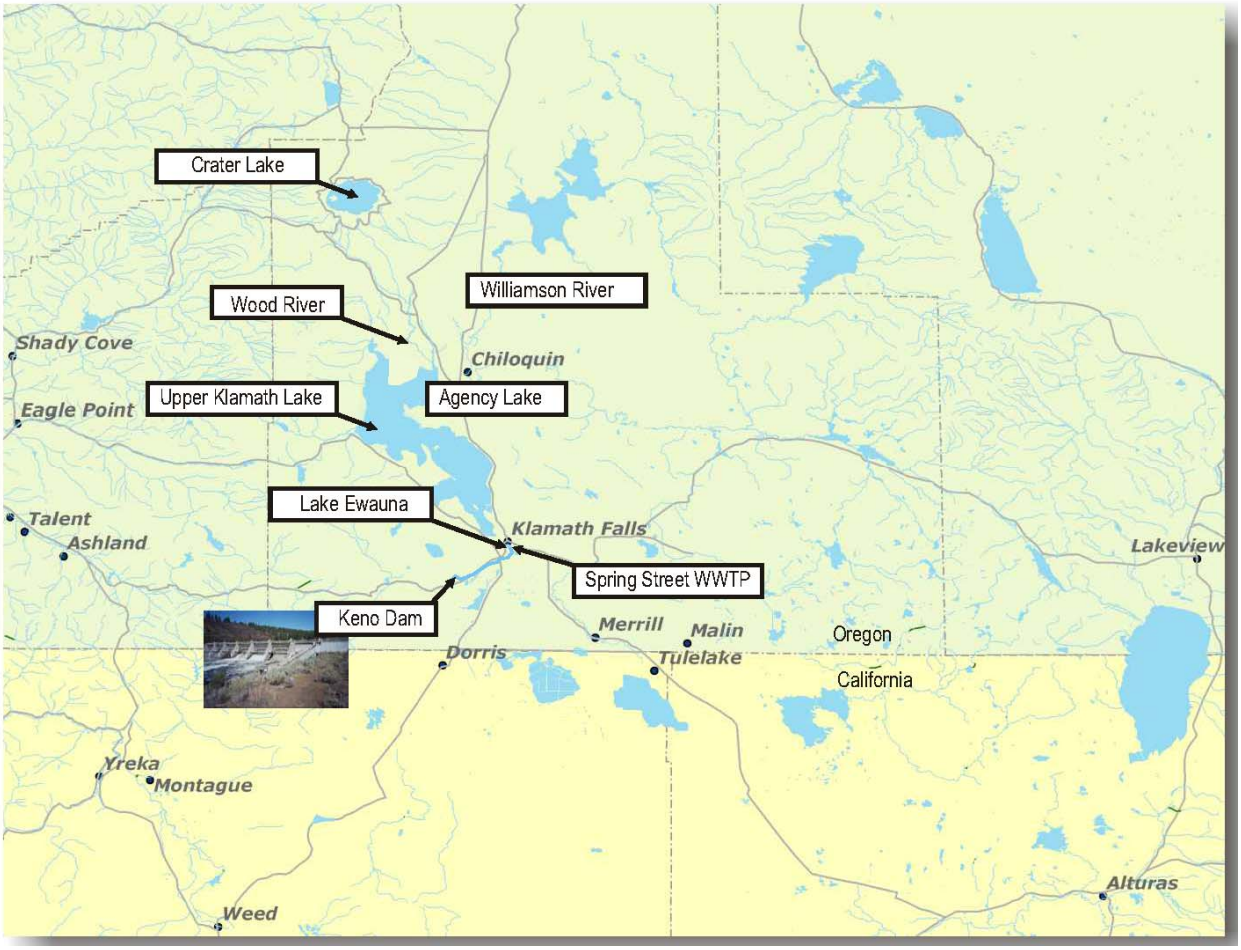


Figure 3.5 Water Bodies

Upper Klamath Lake

Upper Klamath Lake, the largest lake in Oregon at approximately 80 square miles (USGS report 95-414), receives waters from an area of almost 3,800 square miles. The lake forms the northwestern border of the City of Klamath Falls. Because the lake is highly eutrophic, recreational use is limited. Waters of Upper Klamath Lake have also been utilized for agriculture since the mid 1800s. With the development of the Klamath Project by the Bureau of Reclamation in 1905, and the construction of the Link River Dam in the 1920s, this use increased dramatically for both irrigation and hydropower. As a result of the dam and diversion of irrigation water into "A" canal, the lake functions less as a natural state and more as a reservoir. The Lake's elevation is maintained between 4,137 and 4,143 feet, with the lower elevation corresponding to a mean lake depth of five feet.

Regulation of lake elevations changes the flushing patterns and retention time of nutrients in the lake and affects resuspension of lake-bed sediments, especially in the summer during draw-downs.[5] With its low depth, the lake is now classified as hypereutrophic, with nutrients entering the lake by stream inflow from mobile volcanic soils in the watershed, irrigation return flows, ground water, and resuspension of the sediments by wind and wave action. This nutrient loading has contributed to summer algae blooms events.

Historically surrounded by marshes, about 35,000 acres are being restored to wetlands. Much of the land adjacent to the lake is in State and Federal Wildlife refuges and State and National Forests. County and private land account for the rest of the property.

Water Budget

A study from 1964-1967 (Hubbard, 1970) developed a water budget for Upper Klamath Lake. Sources of inflow to Upper Klamath Lake are listed in **Table 3.1**. The study showed water entering the lake came from surface inflows, infiltration, and precipitation. Water left the lake via surface outflows, irrigation, and evaporation. Surface inflow provided the largest inflow to Klamath Lake with 79 percent of the total. The Williamson River was the largest single contributor with 49 percent of the inflow. Wood River, also entering from the north, added 16 percent. Other permanent streams from the Cascade Range enter irrigation canals before flowing into the lake. These streams contributed 8 percent of the inflow. A number of intermittent streams added a further 2 percent of inflow to the lake. The remaining 4 percent of surface inflow came from agricultural drainage. Infiltration of water into rocks in the Cascade Range provides the source for the springs and seeps that provided 14 percent of the total inflow to the lake. Springs are also the major sources of flows in the Wood and Williamson Rivers. Finally, Klamath Lake received 7 percent of its inflow from precipitation falling directly on the lake.

Surface outflow constitutes 84 percent of the outflow from Upper Klamath Lake. Flow through the Link River at the southern tip of the lake accounts for most of this 82 percent. The other 2 percent is water diverted for irrigation. Evaporation from the lake's surface and evapotranspiration from plants in the marshy areas made up the remaining 16 percent of outflows.

[5] *Upper Klamath Basin Nutrient-Loading Study*, Laenen and Letourneau, USGS report 95-414, Portland OR, 1996.

Table 3.1 Upper Klamath Lake Water Budget (Hubbard, 1970)

Inflow	**Proportion**
Surface Inflow	79%
Williamson River	49%
Wood River	16%
Cascades Range Streams	8%
Intermittent Streams	2%
Agricultural Drainage	4%
Infiltration	14%
Precipitation	7%
Total Inflow	*100%*
Outflow	**Proportion**
Surface Outflow	84%
Flow Through Link River	82%
Irrigation	2%
Evaporation	16%
Total Outflow	*100%*

Link River
The mile-long Link River joins Klamath Lake to Lake Ewauna. A dam at the southern tip of Klamath Lake controls the flow in Link River and the water level in the lake. The dam also diverts flow for the generation of hydroelectric energy.

The average flow over the 79-year period of record was 1,593 cubic feet per second (cfs), but due to drought, recent flows have been lower. During the 1990 calendar year for instance, 590,400 acre-feet flowed from Klamath Lake into the Link River at an average rate of 815 cfs (United States Geological Survey, 1991). **Figure 3.6** illustrates the impact of the seasonal operation of the dams on the river flow rate, where river flow is the highest during the early summer months and lowest at the end of the dry season. This information will be used for the water quality analysis as it relates to the Spring Street STP operation.

Table 3.2 gives the latest toxics data available for the river.

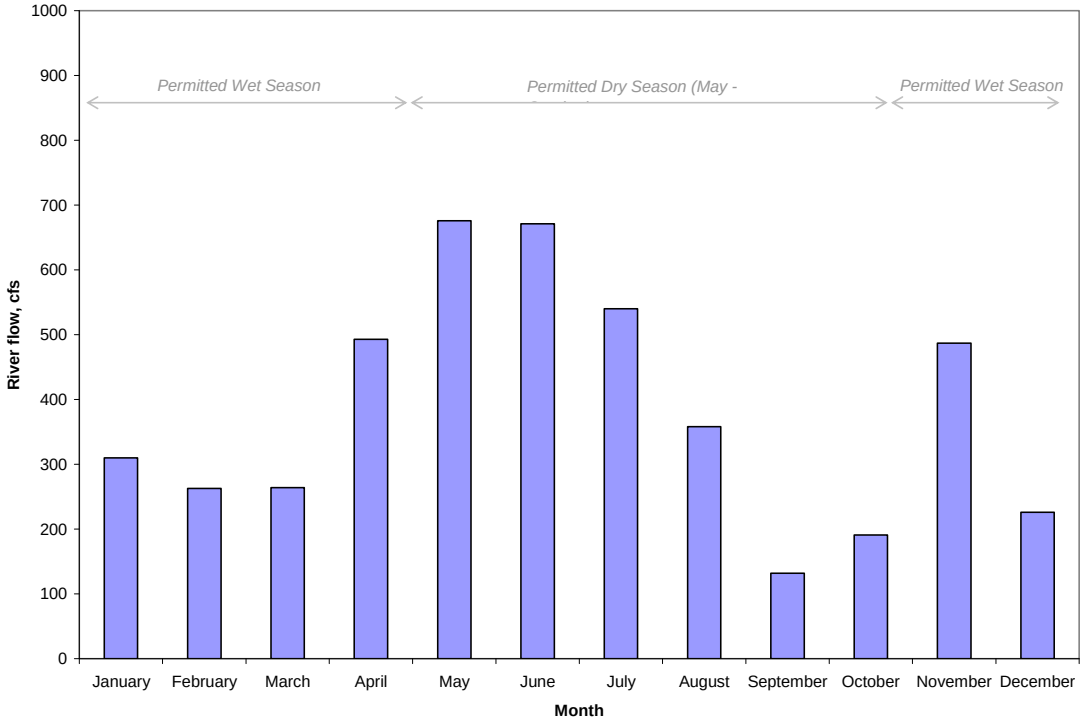


Figure 3.6 Link River Monthly Flow, 1997-2006

Table 3.2 Link River Toxics Data (Oregon DEQ online database)[(a)]

Compound	Units	Date						
		11/29/1979	12/17/1979	1/21/1980	3/24/1980	5/19/1980	7/22/1980	8/25/1980
Alkalinity as $CaCO_3$	mg/L	53	53	48	44	45	45	47
As	mg/L	0.005				0.005		0.006
Ba	mg/L	<0.1				0.14		<0.1
B	mg/L	<0.2				<0.2		<0.2
Cd	mg/L	<0.001				<0.001		<0.001
Ca	mg/L	7.6				7.5		7.4
Cl^-	mg/L	4	3	3	3	2	3	3
Cr	mg/L	<0.05				<0.05		<0.002
Cu	mg/L	<0.05				<0.05		<0.002
F^-	mg/L	0.1				0.1		0.1
Fe	mg/L	0.36				0.47		0.29
Pb	mg/L	<0.01				<0.01		<0.01
Mn	mg/L	<0.02				<0.02		0.03
Hg	mg/L	<0.0005				<0.0005		<0.0005
Se	mg/L	<0.005				<0.005		<0.005
Ag	mg/L	<0.01				<0.001		<0.001
Zn	mg/L	<0.01				<0.01		<0.01

Notes:

(a) from station 10768 at Link River's mouth.

Lake Ewauna
The portion of the Klamath River immediately downstream from the Link River is referred to as Lake Ewauna. Although precise information is not available, Lake Ewauna covers 350 to 400 acres with an average depth of 6 to 8 feet (USACE, 1979). Most of the flow going through the lake passes through a deeper, narrow channel along the west side. Both the Spring Street STP and the SSSD lagoons discharge into this reach of the Klamath River. The water quality of Lake Ewauna is usually poor during the summer months with large algal blooms, high temperatures, high pH, high coliform bacteria counts, and low dissolved oxygen levels.

Lake Ewauna's levels are proportional to the Link River flows illustrated in **Figure 3.7**, with the lowest levels in late summer-early fall.

Klamath River
The Klamath River runs from Lake Ewauna into the state of California and discharges into the Pacific Ocean. The Klamath River is used for irrigation of the southern Klamath Basin. A number of canals divert flow from the river for summer irrigation and return excess water from the agricultural land back to the river during the winter months. The Klamath River is considered a water quality limited stream. This means that established in-stream water quality standards set to protect recognized beneficial uses are not met at all times. A meeting was held in May 2007 with Oregon Department of Environmental Quality (DEQ) to discuss the timetable of the upcoming Klamath basin TMDLs as they apply to the Klamath River and specifically to the Spring Street STP discharge. During the meeting, DEQ estimated that a reasonable timeframe for approval of the TMDLs may be mid to late 2008. The TMDLs will include waste load allocations that designate the amount of specific pollutants each National Pollutant Discharge Elimination System permit holder, including the Spring Street STP, may discharge into the river. This facility plan is thus being developed coincidentally with the TMDL development, and why various possible effluent quality and discharge options will be evaluated.

Other water quality issues concern aquatic life. For example, studies by Dr. Wisseman have found that significant populations of unionid mussels have been found in the Klamath basin and the Klamath River, a factor that has significance with the 2004 EPA notice of intent to re-evaluate aquatic life criteria for ammonia.[6] More discussion about ammonia toxicity criteria appears in Section 6 of this report.

Groundwater
The supply and quality of groundwater is doubly critical in the Klamath Falls area, as aquifers supply nearly all of the drinking water while wells supply irrigation water to the basin's agricultural fields.

Based on 1996 amendments to the Safe Drinking Water Act, the Oregon Department of Human Services is certifying groundwater sources of drinking water. DEQ is certifying surface water sources. Research by Sweet *et al* in 1980 produced a statewide map of aquifers sensitive to contamination. The results of this study are reported in DEQ's 2006 Groundwater Quality

[6] From Aquatic Biology Associates, Corvallis OR

Report for the Klamath Basin.[7] **Figure 3.7** shows sensitive aquifers that are vulnerable to contamination from human activities near the Spring Street STP location. The sensitive aquifers shown in the figure are based on saturated, near-surface alluvial sediments. In its 2006 report, DEQ also reports nitrate and bacteria detection from anthropogenic activities.

Water tables in the Klamath Basin range from ground level to several hundred feet deep. The shallow water tables may produce problems for the wastewater planning process in several ways. High groundwater levels cause infiltration into gravity sewers. At the basin and sewer conveyance scale, groundwater infiltration can account for a significant percentage of total plant flow, directly affecting the facilities hydraulic design. On the other hand, without proper planning, low groundwater levels might allow wastewater to leak and contaminate the aquifer. At the treatment plant site, high groundwater levels combined with sub-zero temperatures will affect construction costs for the addition of freeze protection measures.

3.2.7 Flora and Fauna

The biological environment is determined mainly by the Basin and Range geomorphology and dry climate of the Klamath Basin. In many areas, the natural biology has been heavily influenced by human activities such as dams and agriculture.

Vegetation

The dry climate that set in after the last Pleistocene ice age dried up many of the lakes that had been formed by glaciers in the Cascade Mountain Range. Large expanses of relatively saline soils were left behind derived from the Quaternary alluvium deposited by the glacial waters. Originally, the dry climate and warm temperatures gave rise to an ecological zone referred to as warm temperate montane steppe. The natural vegetation in the area consisted of zones of desert shrub, ponderosa pine, and grand fir (Loy, 1976).

The desert shrub zone occupied the spot where the City of Klamath Falls is now located as well as areas to the south and east. It contains the most drought-tolerant vegetation in Oregon. Shrubs include shadscale *(Atriplex confertifolia),* salt sage (A. *nuttallii),* greasewood *(Sarcobatus vermiculatus),* and spiny hopsage. Most of these shrubs and other vegetation native to this zone are salt-tolerant.

Areas of the basin north and west of the City of Klamath Falls belong to the Ponderosa Pine Zone. Ponderosa pine *(Pinus ponderosa)* is the most drought-tolerant of the forest types in Oregon. It has a relatively open upper story made up of its namesake pine. Its understory in central Oregon contains bitterbrush *(Purshia tridentata)* and ceanothus *(Ceanothus velutinus),* while further east, meadows dominated by Idaho fescue *(Festuca idahoensis)* and bluebunch wheatgrass *(Agropyron spicatum)* are common.

[7] Groundwater Quality Report for the Klamath Basin, David L Cole (2006), Oregon Department of Environmental Quality, Laboratory and Water Quality Divisions, Portland OR.

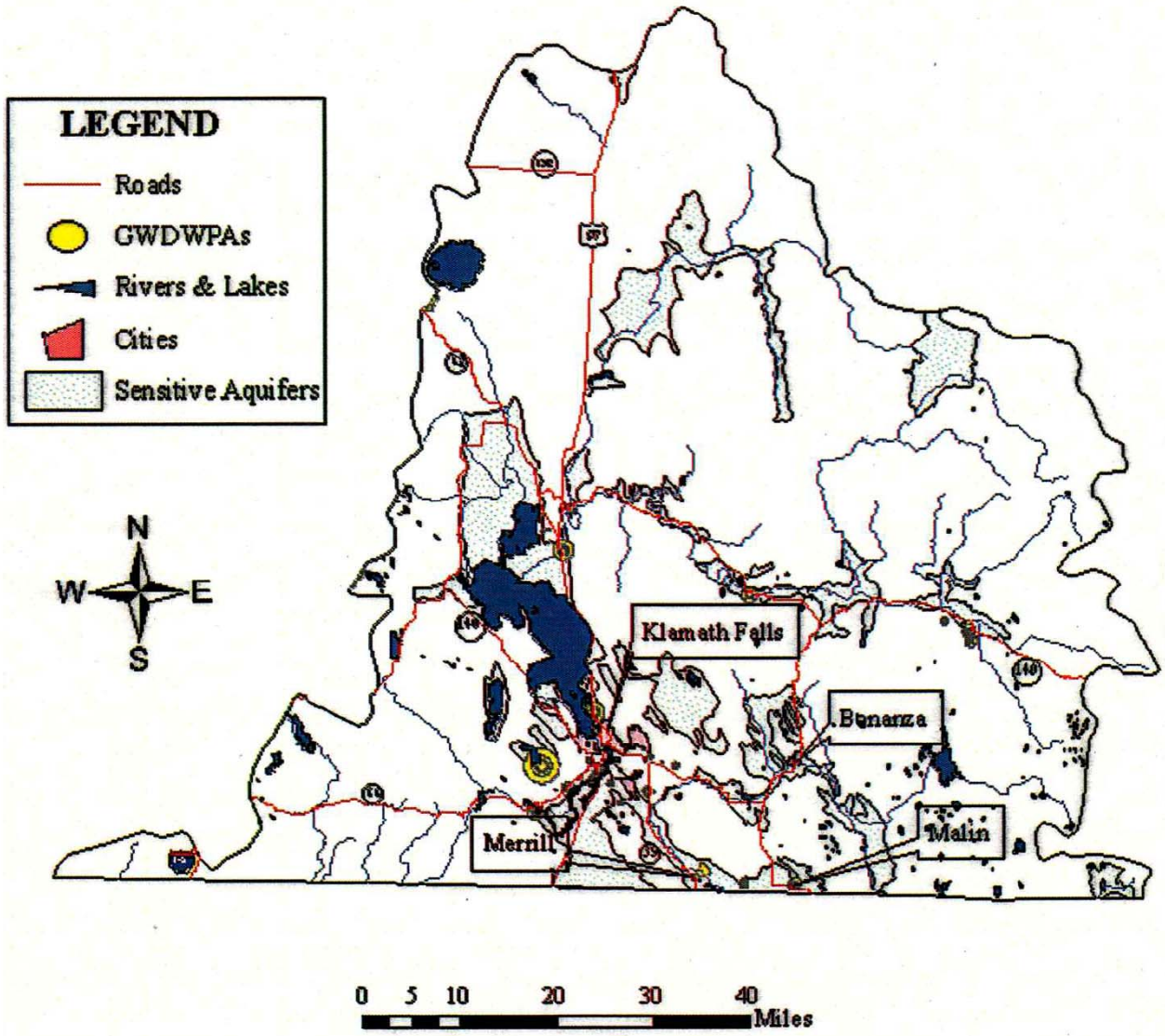


Figure 3.7 Sensitive Aquifers

The grand fir zone occurs in the western part of the Klamath Basin on the eastern slopes of the Cascades. Grand fir *(Abies grandis)* grow at lower elevations than the subalpine pacific silver fir *(Abies amabilis)* where moisture and temperature conditions are not extreme. On warmer and drier sites, Douglas fir is prominent while lodgepole pine and Western larch *(Larix occidentalis)* appear in early successional stages of this zone, for instance, after fires.

Vegetation around Upper Klamath Lake reflects the vegetational zones in the surrounding area. The eastern shores are mostly a mixture of barren land and scattered vegetation. The western shores are heavily forested with conifers and undergrowth. The northern shore is primarily marshland with a few sedges and rushes and large numbers of cattle.

Although some areas of natural vegetation still exist in the basin, much of it is has been extensively altered by irrigation and cultivation. Cattle-grazing is prevalent throughout much of the basin. Hardy crops such as alfalfa, clover, wheat, potatoes, malting barley, and onions are also produced.

Wildlife
The Klamath Basin's vegetation and water resources have played large roles in attracting a diversity of wildlife.

Mammals. The Klamath Basin is home to a wide variety of mammals. There are many small ones such as ground squirrels, marmots, and Nuttall's Cottontail *(Sylvilagus nuttallii)* that are adapted to the ponderosa and desert shrub vegetation and generally dry conditions. Small mammals also occur where there are water resources. Beaver (genus *Castor),* otter (genus *Lutra),* and muskrat *(Ondatra zibethica)* frequent the marshes, streams, and lakes. Common large mammal species include black bear *(Ursa americanus),* Mule deer *(Odocoileus hemionus),* badger *(Taxidea taxus),* raccoon *(Procyon lotor),* coyote *(Canis latrans),* and red fox *(Vulpes fulva).* Many of the mammals have commercial value.

Reptiles/Amphibians. A large number of reptiles and amphibians also make their home within the Klamath Basin. Several species of skinks, in particular, are quite numerous. Turtles occur in large numbers around the lake.

Birds. The Klamath Basin is best known for its birds. Many of the species present are concentrated in the wildlife refuges of the area. More than 275 bird species have been counted, of which at least 180 have nested in the area.

Many of the avian species are raptors. Five hundred or so bald eagles *(Haliaeetus leucocephalus)* winter in the basin. This is the largest number outside Alaska. Golden eagles *(Aquila chrysaetos)* are also numerous, as well as eight species of hawks and eight kinds of owls.

Dozens of waterfowl species nest in the refuges producing over 60,000 goslings and ducklings in a good year. While pintails and mallards *(Anas platyrhynchos)* are the most numerous, white pelicans, double-crested cormorants, great blue herons, California and ring-billed gulls, Caspian terns, eared grebes, and western grebes are also residents.

The Klamath Basin is located along the Pacific Flyway. Migrating birds in the spring and fall can literally darken the sky. Snow geese, Ross' geese, Canada geese *(Branta canadensis),* white-

fronted geese, emperor geese, whistling swans *(Olor columbianus),* and more than 20 duck species all pass through the Klamath Basin.

The migratory bird populations tend to be more concentrated at Lower Klamath refuge and Tule Lake in California. The flocks attract large numbers of bird watchers especially during the migrations.

Fisheries
The upper part of the Klamath River Basin, including Upper and Lower Klamath Lakes, has a distinctly different fish assemblage than the lower part of the river basin. Fish species native to the upper basin are primarily lacustrine (lake-dwelling) while those in the lower basin in California are riverine and anadromous (Buettner and Scoppetone, 1991). Before Copco and Iron Gate reservoir construction resulted in expanses of still waters, lacustrine fish from the upper basin were unable to colonize the lower basin.

Fishes native only to the upper basin include: shortnose sucker *(Chasmistes brevirostris),* Lost River sucker *(Deltistes luxatus),* Klamath largescale sucker *(Catostomus snyderi),* blue chub *(Gila coerulea),* tui chub *(Gila bicolor),* Klamath Lake sculpin *(Cottus princeps),* Pit-Klamath brook lamprey *(Lampetra lethophaga),* and slender sculpin *(Cottus tenuis).*

Other fish present, native to both the upper and lower basins, include: Klamath speckled dace *(Rhinichthys osculus klamathensis),* marbled sculpin *(Cottus klamathensis),* Pacific lamprey *(Lampetra tridentata),* and rainbow trout *(Oncorhynchus mykiss).*

Populations of these native fishes in Upper Klamath Lake are believed to have declined greatly since 1900. Only blue chub and tui chub have been commonly captured during systematic efforts. These two fish have been thought to represent 90 percent of the fish population in the lake (Johnson 1985).

A more recent study (Buettner and Scoppettone, 1990) has cited introduced fish as the numerically predominant species in Upper Klamath Lake. These are the fathead minnow *(Pimephales promelas)* introduced in the 1970s and yellow perch *(Percaflavescens)* introduced in the 1930s. Other non-native fishes include the pumpkinseed sunfish *(Lepomis gibbosus),* brown bullhead *(Ictalurus nebulosus),* and brown trout *(Oncorhynchus trutta).*

Other fish present in the lake are mullet, roach, bass, and white sturgeon. Before the Copco dam was built along the Klamath River in 1910, salmon also migrated through the lake.

Fishing is one of the main recreational uses of the lake. Several resorts are located around the lake mainly on the wooded west side, along with a number of campgrounds, boat launches, and picnic areas. For the recreational fisher, rainbow trout is the major attraction. Klamath Lake Fish Hatchery, established in 1917, has stocked the lake with salmon and trout.

3.2.8 Air Quality and Noise

Although treatment plants are not generally permitted against air quality and noise, there is an increasing need for wastewater facilities to be good neighbors, especially in a climate of increasing public scrutiny and intolerance towards noise and air quality impacts.

Air Quality
Air quality may be impacted during both construction and operation of wastewater facilities. In general, construction impacts primarily relate to the release of dust and particulate matter while operational impacts relate to air contaminants released during normal operation of wastewater facilities.

The Klamath Falls area is subject to the same type of thermal inversion as the Medford and Grants Pass areas which are listed as air quality problem areas by the State of Oregon (Young, 1988). The Klamath Falls area is listed by DEQ as being in non-attainment for particulate matter less than 10 microns in size (PM_{10}) and for carbon monoxide. As is the case in many eastern Oregon cities, blowing soil and dust particles may cause as much as a third of the particulates problem (HGE, 1977). Dust control measures are assumed to be implemented during construction for the alternatives developed.

Operational air quality impact may come from multiple sources throughout the facilities. Air emissions during the preliminary, primary, and secondary treatment of the wastewater typically include various amounts of H_2S, ammonia, methane, VOCs, or other organic compounds. Chlorine and SO_2 emissions may also be expected from disinfection and dechlorination processes. Air emissions from the sludge handling processes may include reduced-sulfur compounds (H_2S, mercaptans, dimethyl sulfide and disulfide, etc.), and ammonia. Other air emissions may be released because of industrial wastewater. Combustion boilers and engines typically emit NO_x, particulate matter, SO_2, VOCs and HAPs. Controlling these emissions and impact on the study area depends on background air quality, the study area's wind and climate characteristics, and proper planning, design, management, and operation of the facilities.

During operation, alternatives developed for this plan are not expected to emit measurable amounts of particulate matter in the study area. Further, the alternatives considered in this plan include considerations of appropriate operational strategies, collection, and treatment system to minimize release of operational contaminants from the wastewater facilities, such as ammonia, sulfides, and mercaptans, based on the basis for planning criteria listed in Section 6.

Noise
Noise emitted both during construction and operation of wastewater facilities may be considered a nuisance by neighbors. Some facilities, like pump stations, may be located in residential areas that could be sensitive to noise, particularly at night. Although the treatment plant is currently located in an industrial area, development adjacent to the north side of the plant is planned for the near future.

The State of Oregon has rules and policy for regulating noise. These rules quantify acceptable types and thresholds of noise. However, the State no longer enforces these rules and relies on the local governments for enforcement.

3.2.9 Environmentally Sensitive Areas

The body of water most directly affected by operation of the Spring Street STP is the Klamath River, which is downstream of the plant's outfall into Lake Ewauna. Oregon administrative

Rule (OAR) 340-41-962 lists beneficial uses of the Klamath River. They include public domestic water supply, private domestic water supply, industrial water supply, irrigation, livestock watering, resident fish and aquatic life, wildlife and hunting, fishing, boating, water contact recreation, aesthetic quality, hydro power, and commercial navigation and transportation.

Many environmentally sensitive areas are located throughout the Klamath Basin. These include areas used by endangered species and a number of wetlands, as discussed below. Most of these areas, with the exception of the main body of Upper Klamath Lake, are already protected as wildlife refuges. The Spring Street STP discharges downstream of Upper Klamath Lake into Lake Ewauna and does not directly affect fish or wildlife in Upper Klamath Lake or any of the marshes.

Endangered sucker fish are present in the downstream reaches of the Klamath River, namely Copco Reservoir, but it is debatable whether plant discharges could affect them. No historical or archaeological sites are likely to be affected by any plant actions.

As discussed in Section 3.2.6 freshwater mussels, especially from the unionid family, have been found in the Klamath River. Unionid mussels have been shown to be the most sensitive to ammonia and EPA has issued an intent to re-evaluate the aquatic life criteria for ammonia based on unionid mussels.

Endangered Species
Large numbers of bald eagles *(Haliaeetus leucocephalus)* winter-over in the Klamath River Basin, mostly situated around Upper Klamath Lake. They are no longer listed as threatened, however. Other bird species present in the Klamath Basin that have been listed as threatened include the Northern spotted owl *(Strix occidentalis caurina)* and the Aleutian Canada Goose *(Branta canadensis leucopareia)*. The recently delisted (August 20, 1999) peregrine falcon *(Falco peregrinus)* has also been reported in the Klamath Basin.

Wolverines *(GuLo Luscus)* and fishers *(Martes pennanti)* inhabit the hills and mountains to the west of the Klamath Falls urban area. Both have been noted as rare.

The shortnose sucker (Chasmistes brevirostris) and Lost River sucker (DeLtistes Luxatus) are listed as endangered by the Federal government and the State of California. They are endemic throughout the Klamath River Basin. Both suckers are lake dwellers but usually migrate up streams to spawn.

Suckers were reported as numerous in Upper Klamath Lake during the late 1800s, but by the 1960s extensive alterations of natural streams and marshes had reduced their reproductive success by an estimated 95 percent and their number was noted to be in decline. The numbers continued to decline during the next 2 decades; in 1985 only 687 lake suckers were harvested from the spawning migration, as compared to 10,000 harvested in 1968.

In 1987, the Oregon Department of Fish and Wildlife closed the Sprague and Williamson rivers snag fishery and the Klamath Tribe passed a resolution prohibiting taking fish. Suckers were subsequently listed as endangered by the Federal government.

The potential exists for a number of endangered plant species to exist within the Klamath Basin, but identification and mapping within the study area has not been done.

Wild and Scenic Rivers
No federally-recognized Wild and Scenic Rivers are located within the study area. However, as part of the Oregon Rivers Initiative, the State of Oregon designated the Klamath River as a State Scenic Waterway (ORS 390.826) from the John C. Boyle dam powerhouse to the California border.

Wetlands
A number of large marshes are present in the Klamath Basin. The largest of these are the Klamath Marsh, Sycan Marsh, and a number of others along the shores of Upper and Lower Klamath Lakes. These marshes are, for the most part, included in wildlife refuges.

The Klamath Basin contains six National Wildlife Refuges. Three are in Oregon, two in California, and one straddles the border between the two states. The State of Oregon also owns two wildlife refuges. The names, locations, and sizes of the refuges are presented in **Table 3.3**. The Klamath Basin also contains the Klamath State Wildlife Management Area of about 6,500 acres.

Table 3.3 Wildlife Refuges in Klamath Basin

Name	Location	Approximate Size, acres
Klamath Forest (Natl.)	Encompasses Klamath Marsh in Oregon	15,400
Upper Klamath (Natl.)	Northwestern edge Upper Klamath Lake in Oregon	12,500
Hank's Marsh (Natl.)	East side of Upper Klamath Lake in Oregon	1,300
Clear Lake (Natl.)	California	33,500
Tule Lake (Natl.)	California	37,300
Lower Klamath (Natl.)	Oregon/California border	81,600
Shoalwater Bay (State)	West side of Upper Klamath Lake in Oregon	1,300
Squaw Point (State)	North edge of Howard Bay in Upper Klamath Lake in Oregon	400

Historical/Archaeological Sites
The Oregon State Historical Preservation Office considers the Klamath Basin to be of great sensitivity for cultural resources. However, no state or federally recognized archaeological or historical sites exist in the area other than the Lower Klamath Wildlife Refuge. Established as the first national wildlife refuge for waterfowl in 1907, it is listed in the National Register of Historic Places.

Repeated volcanic eruptions have covered most early geological formations thereby limiting the number of fossils that are accessible and preventing the area from being designated as a known prehistoric archaeological site.

Sites of past human activity, comprise traces of old roads and homesteads (Klamath Falls, 1986). These date back to the late 1800s when the first large settlement push came into the area. Swan, for instance, is an abandoned agricultural community. Little remains of the abandoned logging settlements: Kirk, Algoma, and Pokegama. The Klamath Indian villages no longer exist, nor does the reservation. No historically significant sites are listed within the City of Klamath Falls.

3.2.10 Land Use Issues

Facilities plans and decisions to fund projects must be consistent with locally adopted comprehensive land use plans and development regulations in compliance with statewide planning goals acknowledged by the Oregon Department of Land Conservation and Development (DLCD).

The predominant land use in the Klamath Basin is Forest (75 percent). Agricultural Land and Range Land each comprise about 10 percent of the basin's area. The remaining land use categories make up about 5 percent of the basin's total area. Within the City's service area, approximately 60 percent of the developed land is classified as single family residential (SFR) and medium family residential (MFR). Approximately 22 percent of the developed land is classified as commercial or industrial (mostly located along the Pacific Railroad corridor) while high commercial use is located along the South Sixth Street, Owens Street, Highway 39, and Highway 140 corridors. The remaining 9 and 10 percent of land within the growth boundary is classified as public facility and open space, respectively.[8] These land uses were presented in **Figure 3.1**.

Applicable to the planning of wastewater facilities, ORS 215.213 states that marginal lands provisions in Klamath County allow the following uses in any area zoned for exclusive farm use:

> (bb) (…) the land application of reclaimed water (…), or biosolids for agricultural, horticultural or silvicultural production, or for irrigation in connection with a use allowed in an exclusive farm use zone under this chapter.

Further, the following sections of ORS 215.246 apply :

> (1)(a) the uses allowed under ORS 215.213 (bb) require determination by the Department of Environmental Quality, in conjunction with the department's review of a license, permit, or approval, that the application rates and site management practices for the land application of reclaimed water, agricultural or industrial process water or biosolids ensure continued agricultural, horticultural, or silvicultural production and do not reduce the productivity of the tract.
>
> (3) When a state agency or a local government makes a land use decision relating to the land application of reclaimed water, agricultural or industrial process water or biosolids

[8] Wastewater Collection System Master Plan, Brown and Caldwell, December 2006

> under a license, permit or approval by the Department of Environmental Quality, the applicant shall explain in writing how alternatives identified in public comments on the land use decision were considered and, if the alternatives are not used, explain in writing the reasons for not using the alternatives. The applicant must consider only those alternatives that are identified with sufficient specificity to afford the applicant an adequate opportunity to consider the alternatives. A land use decision relating to the land application of reclaimed water, agricultural or industrial process water or biosolids may not be reversed or remanded under this subsection unless the applicant failed to consider identified alternatives or to explain in writing the reasons for not using the alternatives.
>
> (4) The uses allowed under this section include:
>
> > (a) The treatment of reclaimed water, agricultural or industrial process water, or biosolids that occurs as a result of the land application;
> > (b) The establishment and use of facilities, including buildings, equipment, aerated and nonaerated water impoundments, pumps and other irrigation equipment that are accessory to and reasonably necessary for the land application to occur on the subject tract;
> > (c) The establishment and use of facilities, including buildings and equipment, that are not on the tract on which the land application occurs for the transport of reclaimed water, agricultural or industrial process water or biosolids to the tract on which the land application occurs if the facilities are located within:
> > > (A) A public right of way; or
> > > (B) Other land if the landowner provides written consent and the owner of the facility complies with ORS 215.275 (4); and
> > (d) The transport by vehicle of reclaimed water or agricultural or industrial process water to a tract on which the water will be applied to land.

Finally, the following section ORS 215.247 on the transport of biosolids to tract of land for application may apply to the facilities:

> If biosolids are transported by vehicle to a tract on which the biosolids will be applied to the land under a license, permit or approval issued by the Department of Environmental Quality under ORS 454.695, 459.205, 468B.050, 468B.053 or 468B.055 or in compliance with rules adopted under ORS 468B.095, the transport and the land application are allowed outright, and a state or local government license, permit or approval in connection with the use is not a land use decision.

3.3 Socioeconomic Environment

Combined with the physical environment, the socioeconomic environment of an area has a significant impact on wastewater facilities planning. Land use and development patterns can affect the location of sewage treatment facilities. The location of residential, commercial, and industrial development dictates the placement and cost of trunk sewers. Local employment market conditions and characteristics have an influence on flows and loads, as does population growth. As a result, historical development and land use trends must be examined to plan for

future development and facilities upgrades. This section reviews economic conditions, population growth and population projections in the Klamath Falls area.

3.3.1 Economic Conditions and Trends

Major industries in the basin include wood products, ranching, agriculture, tourism, and recreation. The following focuses on population trends within the Klamath Falls area.

3.3.2 Population

In determining the Klamath Falls treatment capacity requirements for the future, it is critical to determine the population growth pattern for the future and whether the pattern is likely to continue at current rates, at higher rates, or level off during the planning horizon. In the planning context, it is also useful to know what kinds of uses are likely to be made to the neighborhoods surrounding the plant to maintain the City's good neighbor status.

A 1999 population assessment showed that Klamath County, as of 1998, had a population of approximately 62,000 with a population of 40,500 within the Urban Growth Boundary.[9] The City of Klamath Falls itself had then a population of just under 19,000, almost 30 percent of the county total. The 2006 U.S. Census Bureau population estimates the resident population within Klamath County at about 66,400.

The population of the City of Klamath Falls remained remarkably stable from 1930 to 1980, increasing from 16,100 in 1930 to 16,660 in 1998, an average growth rate of 0.07 percent per year. However, growth has accelerated over the past 2 decades at 0.63 percent per year in the 80s and then 0.82 percent per year between 1990 and 1998.

Overall county population has increased at 0.90 percent per year between 1990 and 1998; however, much of this growth has been in the rural and South Suburban areas. A total population of 40,500 and a serviced population of 19,000 in 1998 suggest that the population within the urban area was then divided almost evenly between the City of Klamath Falls and the South Suburban area.

3.3.3 Population Growth Projections

Since most areas within the city limits are currently built out, the majority of future land use will be new developments outside of the current city limits, such as the Destination Resort Castle Ridge and the Running Y developments. Consequently, future increases in city population will come from annexations of surrounding areas and population growth within the existing city limits.

Population within the city limits is projected by the city planning department to reach 26,000 by the design year of 2028. The city planning department estimates future overall growth at a rate of about 1.2 percent.[10] This growth will come from the addition of residential developments within the service area and growth within the city limits.[11] Developments south of Shasta Way

[9] E.D. Hovee & Company for City of Klamath Falls, Klamath Falls Population and Economic Impact Assessment, May 1999
[10] Communication with Erik Nobel, Klamath Falls Planning Dept, May 20, 2007.
[11] as areas within the Urban Growth Boundary are connected to city services, they are annexed to the city proper

and east of Washburn will be served by SSSD, and population growth specific to the Spring Street STP is estimated at about 1.8 percent. **Figure 3.2** shows the physical location of these developments. With these and the addition of the Kingsley Field area and the Oregon Institute of Technology, the total year 2028 Spring Street service population projection is approximately 42,000.(**Figure 3.8**) .

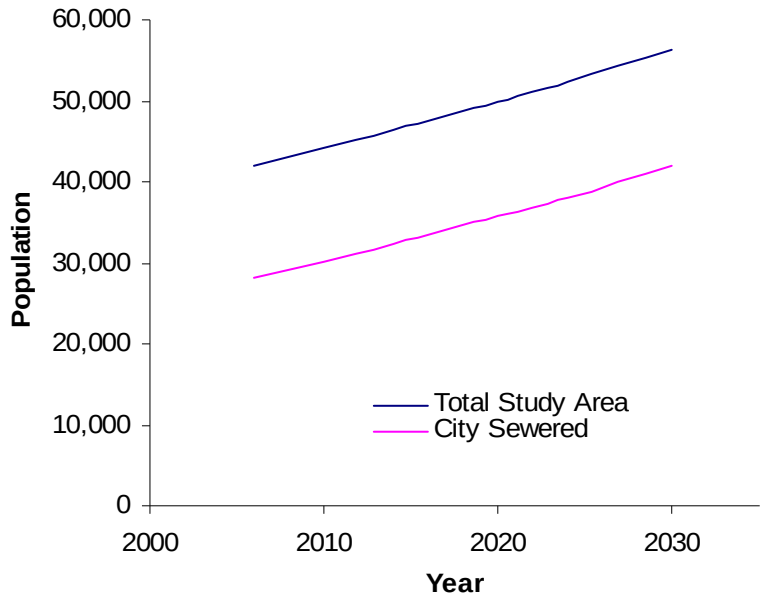


Figure 3.8 Service Area Population Projections

3.4 Land Use Regulations

Oregon Revised Statute (ORS) 197.712, in part, requires cities to develop and adopt a public facility plan for areas within an urban growth boundary containing a population greater than 2,500 persons. The public facility plan shall include rough cost estimates for public projects needed to provide sewer, water and transportation for the land uses contemplated in the comprehensive plan and land use regulations. This Facilities Plan is intended to comply with this statute.

The Spring Street STP is located inside the City of Klamath Falls. Expansion and/or modification of the facility at its present location must conform to the City of Klamath Falls Comprehensive Land Use Plan and its enabling ordinances that are codified in Ordinance Series 45 sections 13 through 55 under the authority of the Oregon Revised Statutes, Chapters 215 and 197.705-795.

Projections of full-buildout land use in Klamath Falls were shown in **Figure 3.1**. The Spring Street STP is currently zoned public and bordered by mixed use zone to the northwest while the property to the south and east is zoned public or industrial. The currently owned property at the Spring Street South Treatment is likely to allow for expansion of the facilities without zoning change requirements.

3.4.1 City or County Comprehensive Plan

This Facilities Plan is consistent with the information compiled for the City's Comprehensive Sewer Plan submitted in December 2006. The Sewer plan's recommendations on the conveyance system are integrated into the recommendations outlined in this Facilities Plan. Flow projections, however, have been reevaluated for the treatment plant design as described in Section 5 of this report, since the flow monitoring for the sewer plan was inconclusive.

3.4.2 City or County Zoning Ordinance

The land use zones to which this Facilities Plan is subject to under the County regulations are contained within the Land Development Code, Ordinance 45. Chapter 50 of Ordinance 45 covers land use zones and is the main source for county zoning regulations. Under City regulations the Facilities Plan land use is governed by Community Development Ordinances Chapters 10 through 14. Chapter 12 of the Community Development Ordinances is the Land Use Regulations for the City of Klamath Falls.

3.4.3 Intergovernmental Agreements

No intergovernmental agreements were found to decide jurisdiction.

Section 4
Existing Wastewater Facilities

The Facilities Plan must take consideration of all existing assets and facilities and their ability to meet future needs. This section describes the service area's existing wastewater collection system and treatment facilities.[1]

4.1 Existing Wastewater Collection System

Characteristics of the existing wastewater collection system influence the peak hydraulic loading at the treatment plant. While it is beyond the scope of this study to review and describe all elements of the collection system, we reviewed the following studies:

- *Sewer System Evaluation Survey* of September 1980 (SSES);
- *Trunk Sewer Master Plan* of May 1981 (TSMP);
- *Wastewater Collection System Master Plan* of December 2006.

This section summarizes relevant information from these studies.

History and Description

Although records of the oldest parts of the collection system are not available; sewers installed before 1932 were generally constructed with clay pipe and mortar joints. Nearly two-thirds of the existing sewer system was installed prior to 1932. Few sewers were constructed between the early 1930s and the mid-1950s. Trunk sewers installed in 1957 were made of reinforced concrete pipe with bell-and-spigot joints and rubber-ring gaskets. Small sewers installed during the 1960s and 1970s were either asbestos cement or polyvinyl chloride (PVC) pipe.

Early manholes were of brick and mortar construction. Later manholes were built with cast-in-place bases and pre-cast concrete sections. Manhole lids were a special casting with four l-inch-diameter holes and two lifting holes. The City of Klamath Falls began using standard lids and frames in the 1970s.

The area is served mainly by gravity flow sanitary sewers. In the City limits, storm runoff is collected and conveyed by a separate storm drainage system to the stormwater pump station at the Spring Street STP. The service area contains eight lift stations: six of the lift stations serve areas near Klamath Lake, one serves the area on the west side of the Klamath River, and one is part of Kingsley Field's decommissioned treatment plant collection system.

4.1.1 Pump Stations and Force Main

Assuming the sewers are not surcharged, the maximum flow that can be conveyed to the plant via the existing trunk sewers and wastewater pumping stations is 18.5 MGD.

[1] Section 4 of the Facilities Plan utilizes information originally contained in the 2000 *Draft Facilities Plan* and the December 2006 *Wastewater Collection System Master Plan* prepared by Brown and Caldwell.

The capacity of a pumping station is defined by DEQ to be the total station capacity minus the capacity of the largest pump.[2] The capacities of the eight existing wastewater lift stations are summarized in **Table 4.1**.

Because head loss through the discharge piping increases exponentially as flow increases, the capacity of two or more pumps operating in parallel is significantly less than the sum of the rated capacities of each pump. The Hanks and Pearl pumping stations each have three pumps; therefore, the capacity of the station is the capacity of two pumps operating together.

Table 4.1 Wastewater Pumping Station Capacities

Pump Station Name	Number of Pumps	Capacity in GPM			Firm Capacity	
		Pump 1	Pump 2	Pump 3	GPM	MGD
California	2	700	1,400	-	700	1.0
Moore Park	2	700	700	-	700	1.0
Lynnwood	2	350	350	-	350	0.5
Shippington	2	85	85	-	85	0.1
Hanks	3	500	500	500	600	0.9
Pearl	3	450	450	450	650	0.9
Link River	2	700	700	-	700	1.0
Gatewood	2	500	500	-	500	0.7

The TSMP identified a number of trunk sewers and pumping stations with insufficient capacity to convey year 2000 peak flows. Flow projections in the TSMP were based on a year 2000 serviced population of 43,000 and extensive commercial and industrial growth. Growth did not occur as rapidly as projected in that plan (2006 serviced population was under 27,000), but the year 2028 area population to be served by the City is projected to be 42,000 (Section 3). Ostensibly, the capacity limitations identified in the TSMP are relevant to this next planning period.

4.1.2 Collection Sewers

Sewer Rehabilitation

To reduce peak plant flows and treatment costs, many municipalities have implemented sewer rehabilitation programs. The extent of these programs usually depends on the amount of infiltration and inflow (I/I) entering the system, the capacity of the wastewater treatment plant, the cost-effectiveness of I/I reduction, and available financial resources.

I/I Study. The SSES presented an I/I analysis based on flow measurements and sampling performed during the late 1970s. Because city population and plant flows have not changed appreciably in the past 15 years, many SSES findings should still be valid.

The I/I analysis separated and quantified plant peak flows into three components:

[2] This is referred to as "firm" capacity

- Wastewater (sewage) - 26% of plant peak flow;
- Infiltration - 19% of plant peak flow;
- Inflow - 53% of plant peak flow.

In general, stormwater inflow, defined as stormwater runoff flowing directly into sewers, is much easier to reduce than infiltration because inflow sources are more accessible. Accordingly, the I/I analysis focused on identifying inflow sources and quantifying the contribution of each source to peak plant flows.

Stormwater infiltration is stormwater that soaks into the ground and seeps into sewers through leaky pipes, pipe joints, and manholes before reaching the groundwater table. It usually takes longer to reach the treatment plant than direct inflow; although infiltration into shallow house laterals may reach the plant quickly and may be easily confused with direct stormwater inflow.

Groundwater and stormwater infiltration are both very difficult to reduce because water migrates through pipe backfill and bedding material until reaching a portion of the sewer that leaks. If a leaky joint is fixed, the water migrates further down the sewer to another leaky joint and infiltrates at that point. As shown in Section 5, high groundwater table and groundwater infiltration occur generally from January through April, consequently impacting the Spring Street STP influent flow rates.

On August 10, 1999, a 50-year storm event dropped 0.92 inches of rain on Klamath Falls in 1 hour. The total duration of the storm was less than 24 hours. Flow at the Spring Street STP surged from 4 MGD to the peak influent pumps capacity of 13.6 MGD. This rapid, high peaking supports the theory that direct inflow is significant in Klamath Falls' collection system. More analysis of groundwater infiltration and precipitation impact on plant influent flow can be found in Section 5. The current ongoing conveyance system monitoring effort will provide more information and should help in identifying critical areas for collection system rehabilitation.

Rehabilitation Methods

A number of techniques are available for rehabilitating sewers to reduce I/I. Inflow is reduced by detaching all storm drainage connections from the sanitary system and sealing and raising manhole covers and cleanouts. Usually, it is much more economical to reduce inflow than infiltration. Replacement of the pipe, grouting, and slip lining can reduce infiltration. Trenchless technologies may also be used to reduce infiltration.

Rehabilitation Program

The City's sewer rehabilitation program consists of sewer replacing, repairing, and televising. In addition, the City repairs and replaces leaking fittings and manholes.

The June 1997 through June 1999 rehabilitation program is summarized in **Table 4.2**.

Table 4.2 June 1997 – June 1999 Sewer Rehabilitation Program[a]

Date	Sewer Pipe Repaired or Replaced, feet	Sewer Pipe Televised, feet	Fittings and Leaks Repaired or Replaced, Number	Manholes Repaired or Replaced, Number
June – Dec 1997	32	-	1	1
Jan – Dec 1998	62[b]	14,875	2	18
Jan – June 1999	8	-	4	9

a. Source: July 27, 1999 letter report from City of Klamath Falls to Oregon DEQ.
b. Report indicates that additional sewer pipe was replaced in November, but exact length is not reported.

4.1.3 Condition, Deficiencies, and Status of Conveyance System

A comprehensive hydraulic analysis of the conveyance system was conducted as part of the December 2006 *Wastewater Collection System Master Plan*. [3] This section summarizes the findings of the study. For more detail, please refer to *Chapter 5 - Hydraulic Analysis* of that study.

The hydraulic model was run based on the following three conditions.

- Existing conditions at the time of the study;
- Intermediate future conditions defined as five years into the future from the time of the study;
- Build-out conditions.
- Each of the above scenarios was evaluated for the average dry weather flow (ADWF) and peak wet weather flow (PWWF) scenarios determined for each pipe section.[4]

As the primary evaluation parameter, the model used the ratio of maximum modeled flow (Q) to the pipe capacity (Qm). Generally, pipes with Q/Qm greater than 0.75 were identified as deficient while those with Q/Qm greater than 1.0 were identified as surcharged.

Assessment of Existing Conditions

Existing condition ADWF model results were used to establish baseline system capacity and to check flow velocities in the pipes. According to the model results, flow velocities in approximately 26 percent of the system pipelines did not exceed the desired 2.0 feet per second to keep debris from settling in the pipes. Also, for ADWF existing conditions, approximately 8 percent of the modeled system was determined to exceed the assessment criteria. The pump stations were found to be adequate under ADWF existing flow conditions.

Under PWWF existing conditions, approximately 20 percent of the modeled system was determined to be undersized.

[3] The City's collection system was modeled using H_2OMAP SEWER, which is a product of MWH Soft, Inc.
[4] Flow information for the conveyance system evaluation can be found in Chapter 4 of the 2006 Wastewater Collection System Master Plan. A discussion of the flow factors is included in Section 5 of this Facilities Plan.

Assessment of Intermediate Conditions

Under ADWF intermediate conditions, approximately 13 percent of the modeled system was determined to be undersized. The pump stations were found to be adequate under ADWF intermediate flow conditions.

Under PWWF intermediate conditions, approximately 28 percent of the modeled system was determined to be undersized. The Link River Pump Station exceeded capacity by 17 percent, while the Stewart Lennox PS was found to be near capacity with only 12 percent remaining. All other pump stations had approximately 60 to 87 percent capacity remaining.

Assessment of Build-out conditions

Under ADWF build-out conditions, approximately 14 percent of the modeled system was determined to be undersized. The Link River Pump Station exceeded capacity by approximately 14 percent. All other pump stations had approximately 61 to 93 percent capacity remaining.

Under PWWF build-out conditions, approximately 29 percent of the modeled system was determined to be undersized. The Link River Pump Station exceeded capacity by 183 percent (approximately 12 cfs) and Stewart Lennox Pump Station was at capacity. All other pump stations had approximately 59 to 81 percent capacity remaining.

4.2 Existing Wastewater Treatment Plant

4.2.1 Plant History

An understanding of the condition and performance of the existing wastewater treatment plant is essential to determining what unit processes should be added or modified in future facilities. In this section, each unit process is evaluated from both operational and structural standpoints, capacities are presented, performance records are examined, and any limitations discussed.

The City of Klamath Falls has operated a sewage treatment plant at the Spring Street site since 1958. The original plant included an influent pumping station, grit channel, primary sedimentation basins, trickling filter, secondary clarifier, and two anaerobic digesters. The plant was modified to a suspended growth biological system in 1971 with the addition of aeration basins, a new secondary clarifier, a gravity sludge thickener, and a centrifuge. The trickling filter was also removed while the existing secondary clarifier was converted to a chlorine contact basin. Plant staff made a number of smaller modifications after 1971, including the construction of sludge drying beds.

The last major upgrades were made in 2001, with reliability improvements made throughout the plant. The existing aeration basin, piping and equipment were modified to increase process flexibility. A new secondary clarifier was constructed, and a dissolved air flotation thickener was added. Sodium hypochlorite replaced chlorine gas for final effluent disinfection. Simultaneous with reliability improvements to the plant, a new pipeline and pumping station was constructed to deliver the majority of treated effluent to a local electricity cogeneration plant. The treated effluent is used as cooling water at the City's cogeneration plant, where the majority of the effluent is evaporated. The remaining warmed effluent is returned to the end of the Spring Street STP and discharged to Lake Ewauna.

Industrial Pretreatment Program

In 1990, the Klamath Falls Pretreatment Act was amended to incorporate changes in federal pretreatment regulations and in response to an Environmental Protection Agency (EPA) audit of the City. The Pretreatment Act has five goals:

1) Protect the wastewater system from chemicals that could affect its operation.
2) Reduce the contamination of air, water, and sewage sludge.
3) Improve the opportunity for wastewater and sludge reuse.
4) Equitably distribute the cost of the wastewater system.
5) Protect city employees.

The Act specifically prohibits the discharge of many chemicals, including strong acids and bases, toxins, and flammable and malodorous substances. The Act also prohibits dilution of wastewater.

The City identifies industrial users (IUs) and mails them data disclosure forms (DDFs). DDFs are completed by each IU and reviewed by the City. If the City deems an IU to be significant (SIU), the IU is issued an industrial waste discharge permit (IWDP), which is valid for 5 years.

Some IUs may be required to submit accidental spill prevention plans (ASPPs) depending on the nature of their operation. The City conducts periodic inspections and sampling to ensure that IUs continue to comply with their IWDPs and ASPPs.

Two SIUs have been identified in Klamath Falls.

- Jeld-Wen
- Pacific Klamath Energy

These dischargers have consistently maintained compliance with their IWDPs.

In addition to the above mentioned SIUs, Herald and News is an IU that operates under a Best Management Practice (BMP) while maintaining good communication with the City concerning their discharge.

Electricity Cogeneration Plant Reuse

In 1998, Pacific Power and the City of Klamath Falls agreed to build an electricity cogeneration plant in southwest Klamath Falls. This plant burns natural gas to generate electricity for regional use and steam for local industries.

The cogeneration plant's operation requires a steady flow of 3.4 MGD of make-up water for the plant's steam condenser cooling water system. The Spring Street STP's treated effluent provides this make-up water. The condenser cooling water system is a recirculating loop system and includes forced air cooling towers that evaporate 2.6 MGD of the effluent. About 0.8 MGD of blowdown water must be removed from the cooling system loop to control the build-up of dissolved solids in the recirculated cooling water. This blowdown water is pumped back to the Spring Street STP and combined with the STP's excess secondary effluent for discharge to Lake Ewauna. The benefit of using effluent for cooling at the cogeneration plant is the reduction of total effluent volume discharged to Lake Ewauna. The resulting effluent, however, has an increased concentration of dissolved solids as a result of the evaporation that occurs through the cooling towers.

Occasionally, untreated sewage is diverted from South Suburban Sanitary District (SSSD) to the Spring Street STP to meet the cooling water make-up needs of the cogeneration plant (generally when Spring Street influent flow falls below 3.4 MGD).

4.2.2 Plant Design

The existing Spring Street Sewage STP is of conventional design. Liquid stream processes and operations include coarse screening, influent pumping, grit removal, fine screening, primary sedimentation, biological treatment, secondary clarification, and disinfection. Normal solids stream processes consist of grit disposal, dissolved air flotation thickening (DAFT), anaerobic digestion, biosolids drying, storage, and composting. The plant layout and flow schematic are shown in **Figure 4.1**, while the design data is presented in **Table 4.4**.

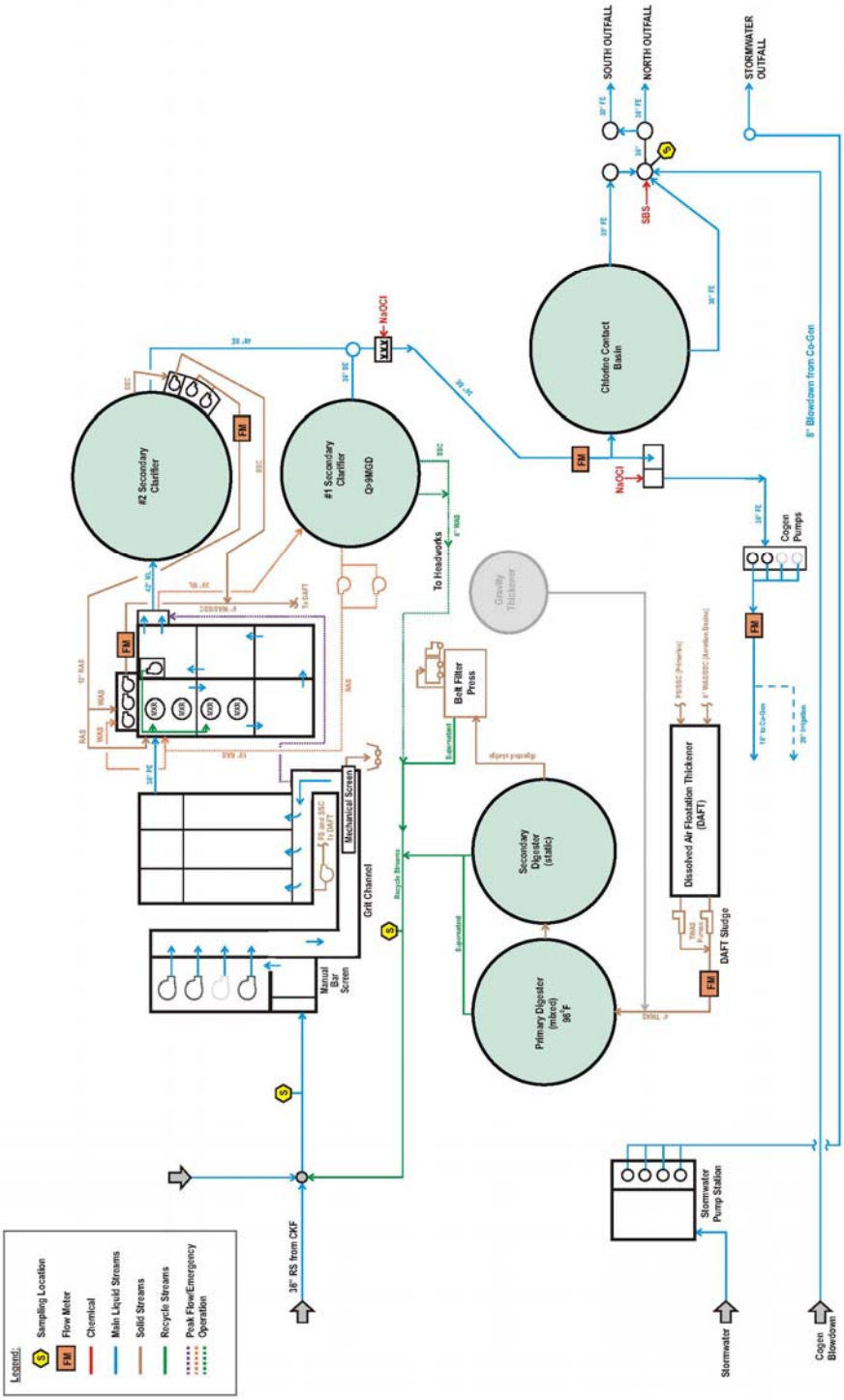


Figure 4.1 Existing Plant Layout and Flow Schematic

Headworks and Primary Sedimentation

Wastewater passes through a manually raked bar screen prior to entering the influent pumping station, which houses three pumps; two pumps have a capacity of 5.2 million gallons per day (MGD) each, while the other is rated at 2.6 MGD. The two larger pumps are controlled by variable speed drives. The station has provisions to add one pump. The pumps discharge into the grit channel. Degritted wastewater then passes through an in-channel screw-type fine screen before being distributed via a distribution channel into the primary sedimentation tanks.

The existing two primary clarifiers are part of the original treatment, making these units over 50 years old. In 1970 the clarifiers were expanded to include secondary treatment. These clarifiers were rehabilitated approximately 15 years ago and the patching done at that time is beginning to fail. The Condition Assessment rated these units as poor to fair with renewal or replacement required in the next 3 to 6 years. Significant problems include exposed aggregate, valving and piping in poor condition and pumps in poor condition. The units are supported on timber piles and show differential settling with respect to stairs and other structures.

The primary sedimentation tanks consist of two 140-foot-long, 9-foot-deep rectangular basins, with the larger unit roughly twice the size of the smaller one: one basin is 18 feet wide, the other is 38 feet wide. Accepted design ranges for surface overflow rates are usually as follows:

- Maximum Month Flow: 800 to 1,200 gpd/sf (current design is 767 gpd/sf)
- Peak Wet Weather Flow: 2,000 to 3,000 gpd/sf (current design is 2,300 gpd/sf)

These ranges are taken from Washington State's Department of Ecology Criteria for Sewage Work ("Orange Book"). With these ranges, the capacity of the existing clarifiers would be as follows:

Table 4.3 Existing Primary Clarifiers Hydraulic Capacities

Capacity, Both Units Operating (MGD)		Capacity, Largest Unit Out of Service (MGD)	
Max Month Criteria(1):	6.2 to 9.3	Max Month Criteria:	2.0 to 3.0
Peak Wet Weather Criteria(2) :	10.5 to 15.8	Peak Wet Weather Criteria:	5.0 to 7.6

Notes:
(1) 800 – 1,200 gpd/sf
(2) 2,000 – 3,000 gpd/sf

Aside from reliability and hydraulic capacity, the performance of the existing units is unknown, as the plant does not routinely measure primary clarifiers removal efficiency (via loadings removal, such as BOD and TSS).

Primary sludge is pumped to the DAFT. A 30-inch bypass is provided to divert flows directly to the aeration basin.

Secondary Treatment

The secondary (biological) treatment process is where organic matter and some inorganic compounds are removed from the liquid stream and converted into biological sludge.

Microorganisms (biomass) are actively processing the pollutants, using them as a food source, hence the "activated sludge" process. Key units associated with the activated sludge process at the Spring Street STP are the aeration basin, aeration equipment and secondary clarifiers.

Primary effluent flows to the aeration basin via a 36-inch pipe. The aeration basin consists of six cells in series with a combined volume of 100,000 cubic feet. Improvements made to the aeration basins in 2001 modified the complete mix open basin to a folded tank design that provides plug flow with six cells in series that are connected with gates. These improvements allow for a variety of process modes including biological nutrient removal. Basins 1 and 2 are equipped with surface mixers to allow operation as a "selector". The selector cells are operated with no external aeration provided at low dissolved oxygen (anoxic or Ax zones) while the final four cells are equipped with medium bubble (WYSS) diffusers to supply oxygen. These last four cells are aerobic zones (Oxic or Ox zones). A mixed liquor pump is provided to recirculate mixed liquor and nitrates from Basin 6 to Basin 1 or 2. Aeration is provided to each basin through fine bubble diffusers. Air is supplied by three 1,000-cubic-foot-per-minute (cfm) positive-displacement blowers. The aeration rate in each basin can be controlled independently. Isolation gates are provided between basins to allow diversion of flow to the secondary clarifiers.

The existing aeration basin is currently operated at an SRT that generally ranges from 3 to 4 days. This is consistent with numerous operating data reporting that at temperatures above 10 degrees C and SRTs greater than 3 days, an effluent soluble BOD lower than 5 mg/L is typically produced. In general, as long as a good settling sludge is produced, SRT and temperature have little effect on effluent BOD. However, SRT and temperature have a significant impact on nitrogen removal. Reported mixed liquor suspended solids concentrations are in the 2,500 mg/L range.

The plant has two circular secondary clarifiers: Clarifier 1 (1971) is 100 feet in diameter and 12 feet deep, while Clarifier 2 (2001) is 110 feet in diameter and 20 feet deep. Both clarifiers are equipped with suction-sweep sludge withdrawal mechanisms and peripheral effluent launders. Under normal operation, when influent flows are below 9 MGD, mixed liquor flows from the aeration basin to secondary Clarifier 2. Secondary Clarifier 1 is operated when plant influent flow exceeds 9-MGD. Each clarifier has its own set of RAS pumps. Waste activated sludge (WAS) is pumped from the RAS lines to the DAFT thickener.

Effluent Disinfection

Secondary effluent is chlorinated with sodium hypochlorite prior to a flow splitting structure that splits the effluent flow to the chlorine contact basin and the cogeneration pumps. Contact time for final effluent disinfection is provided in the 51,000-cubic-foot chlorine contact basin, which is a converted circular clarifier. Effluent flows from the contact basin to Lake Ewauna via the North and the South outfall pipes.

Solids Processing

Solids processing is carried out over a multi-step process to reduce the biological activity of the sludge while also reducing the mass of organic solids and the concentration of pathogenic bacteria. The process configuration at the Spring Street STP currently involves co-thickening

with DAFTs (bringing the sludge to approximately 5% solids content), stabilization with anaerobic digesters (reducing biological activity and inactivating pathogenic bacteria), dewatering with a belt filter press (bringing the sludge to a cake-like or dryer consistency), and composting. Biogas from the anaerobic digesters has corroded the existing boiler equipment and is now flared.

Under normal operation, primary sludge and thickened WAS are pumped to the DAFT, while the 24-foot-diameter, 10-foot-deep gravity thickener is available as a standby. Thickened sludge is pumped from the DAFT to the anaerobic digesters. Two fixed-cover anaerobic digesters, each 50 feet in diameter, are connected in a series. The total combined volume of the digesters is 81,000 cubic feet.

The primary digester is heated by pumping sludge with the recirculation pump through a spiral heat exchanger. The other side of the spiral heat exchanger is connected to the digester building hot water system, which receives its heat from a natural gas fueled boiler in the summer months and from the plant's geothermal system in the winter. Temperature in the primary digester is maintained at approximately 98 Fahrenheit throughout the year.

Digester mixing is limited to the single recirculation pump that pumps through the spiral heat exchanger. Since this pump is shared between the primary and secondary digester, mixing energy cannot be imparted into both tanks. The estimated turnover time from this recirculation pump is approximately 12 hours. Typically, anaerobic digesters are operated with turnover times between 30 minutes and 3 hours.

Transfer from the primary digester to the secondary digester occurs by gravity. The secondary digester remains unheated and unmixed as operation of the sludge recirculation pump and sludge heating HEX is dedicated to the primary digester. Therefore temperatures in the secondary digester vary throughout the year and could also vary spatially within the tank, and the secondary digester operates mostly as a storage tank.

Digested sludge is pumped from the secondary digester to the belt filter press where it is dewatered and put in a container. The container is trucked to the composting area where it is mixed with wood chips and aerated for further stabilization.

Digester supernatant is combined with other plant recycle streams (DAFT overflow, clarifier No 2 WAS, belt filter press filtrate) and returned to the influent pumping station.

Table 4.4 Existing Spring Street STP Design Data

Item	Number/Description
Influent Pumping Station	
Number of pumps	3
Capacity each, MGD	1@2.6
	2@5.2
Pump station capacity (firm), MGD	7.8
Grit Removal Channel	
Length, feet	56
Depth, feet	5
Velocity at PWWF, fps	1
Influent Screening	
Number of screens	1
Type	In-channel, cylindrical
Opening size, inch	0.25
Capacity, MGD	9
Primary Sedimentation	
Number of basins	2
Design BOD removal, percent	40
Design TSS removal, percent	60
Volume, gallons	1@ 343,000
	1@ 164,930
Width, feet	1@ 37.5
	1@ 18.0
Length, feet	140
Average depth, feet	8.75
Surface overflow rate at PWWF, gpd/sf	2,300
Surface overflow rate at Max Month, gpd/sf	767
Detention time at PWWF, hours	0.68
Detention time at Max Month, hours	2.03
Primary Sludge Pumps	
Number of pumps	2
Type	Centrifugal
Capacity, gpm	200
Horsepower, Hp	5
Aeration Basin	
Tanks	
Number	1
Number of cells in series	6
Total volume, gallons	748,100
Sidewater depth, feet	14
	(2.5 feet freeboard)
Anoxic cells	
Number cells	2
Anoxic cell mixing	
Number of mixers per cell	2
Type	Surface mixer
Horsepower, each	3
Aeration System	
Type	Fine bubble

Item	Number/Description
Number of aeration blowers	3
Aeration blower capacity, each, scfm	1,000
Aeration blower horsepower, each	60
Mixed Liquor Recycle	
Number of pumps	1
Type	submersible
Capacity, gpm	8,333
Horsepower	15
WAS Pumps	
Number	3
Type	Rotary lobe
Capacity, each, gpm	88
Horsepower, each	5
Secondary Clarifier No 2 (Flow ≤ 9 MGD)	
Clarifier	
Number	1
Type	Center feed, flat bottom
Volume, gallons	1,421,700
Diameter, feet	110
Sidewater depth, feet	20
Overflow rates	
Max Month, gpd/sf	655
9 MGD (50% PWWF), gpd/sf	947
Weir	
length, feet	346
overflow rate at Max Month, gpd/ft	17,300
overflow rate at 9 MGD, gpd/sf	26,000
RAS Pumps	
Number	2
Type	centrifugal
Capacity, each, gpm	2,100
Horsepower, each	40
Sludge and Scum Collector	
horsepower	0.5
Scum Pumps	
Number	1
Type	Vaughn Chopper Pump
Capacity, gpm	50
Horsepower	7.5
Secondary Clarifier No 1 (storm)	
Number	1
Type	Center feed, cone bottom
Volume, gallons	705,000
Diameter, feet	100
Sidewater depth, feet	12
Overflow rate at Max Month, gpd/sf	750
Overflow rate at 9 MGD, gpd/sf	1,145
Weir length, feet	314
Weir overflow rate at Max Month, gpd/ft	19,110
Weir overflow rate at 9 MGD, gpd/sf	28,660
Number of RAS pumps	2

Item	Number/Description
RAS pumps type	centrifugal
RAS pump capacity, each, gpm	2,100
RAS pump horsepower, each	25
Sludge Collector horsepower	0.5
Disinfection	
Chemical Type	Sodium hypochlorite 12.5%
Storage Tanks	
Number of storage tanks	3
Construction	HDPE
Volume, each, gallons	7,000
Diameter, feet	12
Metering Pumps – Plant Effluent	
Number	2
Type	Watson Marlow-Peristaltic
Capacity, each, gph	30
Maximum delivery, ppd of Cl_2	720
Injector type	Diffuser
Metering Pumps - Cogen Effluent	
Number	2
Type	Watson Marlow-Peristaltic
Capacity, each, gph	30
Maximum delivery, ppd of Cl_2	720
Injector type	Diffuser
Contact Tank	
Type	Circular, converted clarifier
Number	1
Diameter, feet	90
Sidewall depth to V-notch on weir, feet	8.16
Volume, gallons	380,000
Detention time at Max Month Flow, hours	1.5
Detention time at PWWF, hours	0.5
Dechlorination	
Type	Sodium bisulfate
Storage Tanks	
Number	2
Volume, each, gallons	2,000
Number	1
Volume, gallons	1,000
Diameter, feet	8
Construction	HDPE
Metering Pumps	
Number	2
Type	Peristaltic
Capacity, each, gph	5
Sludge Thickening	
DAFT	
Number of units	1
Length, feet	41.5
Width, feet	7.5
Surface area, sf	250
Average WAS concentration, mg/L	1,400-2,200

Item	Number/Description
Average WAS flow, gpm	66
Average WAS solids, lb/sf/hr	0.33
Peak WAS solids, lb/sf/hr	0.75
Thickened sludge concentration, percent	5
Minimum air: solids ratio	0.03
Recirculation/Pressurization System	
Recirculation pumps	
Number	2
Capacity, each, gpm	250
Horsepower, each	15
Air Compressors	2
Air Compressor	
Capacity, scfm	2.5
Air Compressor horsepower	1.5
Minimum pressure, psi	55-75
Pressurization tank	
Number	1
Volume, cuft	10
Detention time at 45 psi, min	1
Sludge Pumps	
Number	1 – Float 1-Bottom,
Type	Progressing cavity
Capacity, each, gpm	100
Normal Operating, each, gpm	55
Horsepower, each	10
Gravity Thickener (standby)	
Number	1,
Diameter, feet	24
Depth, feet	10
Volume, gallons	33,840
Detention time at 200 gpm feed rate, hours	2.8
Digestion	
Primary Digester	
Number	1
Type	Anaerobic
Temperature, F	98
Diameter, feet	50
Center depth, feet	26.5
Volume, gallons	299,000
Detention time, days	12-15
Heating	Geothermal and Natural Gas
Mixing pumps	
Number	1
type	Centrifugal
capacity, gpm	400
Horsepower	10

Item	Number/Description
Secondary Digester	
Number	1
Type	Anaerobic
Temperature, F	85-90
Diameter, feet	50
Center depth, feet	25.5
Volume, gallons	289,000
Detention time, days	10-12
Heating	none
Mixing pumps	
Number	none
type	-
capacity, gpm	-
horsepower	-
Digested Sludge Pumps	
Number	1
Type	Plunger
Capacity, each, gpm	100
Horsepower, each	5
Sludge Dewatering	
Belt Filter Press	
Number of units	1
Belt width, meters	1.5
Horsepower, each	1
Washwater pumps	
Number	1
type	Centrifugal
Horsepower	5
Polymer Feed	
Polymer type	ProMinent
Number of pumps	1
Capacity, each, gph	4.5
Biosolids Stabilization	
Lagoon	
Total area, square feet	17,500
Average depth, feet	5
Drying beds	
Total area, square feet	11,250
Composting	
Type	Windrow
Feed Hopper Conveyor	
Number	1
Capacity, lb/h	N/A
Horsepower	10
Trommel Screen	
Number	1
Capacity, lb/h	N/A
Horsepower	5
Waste Conveyor	
Number	1

Item	Number/Description
Capacity, lb/h	N/A
Horsepower	5
Finished Product Loader	
Number	1
Capacity, lb/h	xx
Horsepower	5
Drive Unit Motor	
Number	1
Horsepower	10
Stormwater Pump Station	
Wet Well	
Volume approximate, gallons	45,000
Pumps	
Number	4
Type	Centrifugal
Capacity, each, gpm	2@2250 2@4500
Horsepower, each	2@10 2@20
Plant Water Pumps	
Number	2
Type	Centrifugal
Capacity, each, gpm	250
Horsepower, each	N/A
Standby Generator	
Number	1
Capacity, kW	500

Effluent Disinfection

Secondary effluent is chlorinated with sodium hypochlorite prior to entering a flow splitting structure that divides effluent flow to the chlorine contact basin and the cogeneration pumps. Contact time for final effluent disinfection is provided in the 51,000-cubic-foot chlorine contact basin, which is a converted circular clarifier. Effluent travels from the contact basin to Lake Ewauna via the North and the South outfall pipes.

Solids Processing

Under normal operation, primary sludge and thickened WAS are pumped to the DAFT, while the 24-foot-diameter, 10-foot-deep gravity thickener is available as a standby. Thickened sludge is pumped from the DAFT to the anaerobic digesters. There are two fixed-cover anaerobic digesters in series, each 50 feet in diameter. The total combined volume of the digesters is 81,000 cubic feet.

The primary digester is heated by pumping sludge with the recirculation pump through a spiral heat exchanger. The other side of the spiral heat exchanger is connected to the digester building hot water system, which receives its heat from a natural gas fueled boiler in the summer months and from the plant's geothermal system in the winter. Temperature in the primary digester is maintained at approximately 98 degrees Fahrenheit throughout the year.

Digester mixing is limited to the single recirculation pump that pumps through the spiral heat exchanger. Since this pump is shared between the primary and secondary digester, mixing energy cannot be imparted into both tanks. The estimated turnover time from this recirculation pump is approximately 12 hours. Typically, anaerobic digesters are operated with turnover times between 30 minutes and 3 hours.

Transfer from the primary digester to the secondary digester occurs by gravity. The secondary digester remains unheated and unmixed as operation of the sludge recirculation pump and sludge heating HEX is dedicated to the primary digester. Therefore, temperatures in the secondary digester vary throughout the year and could also vary spatially within the tank.

Digested sludge is pumped from the secondary digester to the belt filter press where it is dewatered and put in a container. The container is transported to the composting area where its contents are mixed with wood chips and aerated for further stabilization. When the belt filter press is down for maintenance, a one to two day operation, sludge is pumped to drying beds.

Digester supernatant is combined with other plant recycle streams (DAFT overflow, clarifier No. 1 WAS, belt filter press filtrate) and returned to the influent pumping station.

4.2.3 Plant Operations

Plant operations involve wastewater treatment and sludge management and include operational consideration and regulatory concern.

The City is permitted to discharge treated sewage to Lake Ewauna. The main plant's National Pollutant Discharge Elimination System (NPDES) permit was last renewed by DEQ on September 26, 1990. The permit was modified on October 21, 1997 to authorize reuse of treated effluent for condenser cooling make-up water at the cogeneration Facility.

The plant effluent discharge permit regulates discharges of biochemical oxygen demand (BOD), suspended solids (SS), ammonia, and chlorine. Allowable effluent concentrations of BOD and TSS are governed by concentration limits, mass discharge limits, and an 85 percent removal requirement. Discharges of ammonia, chlorine, and temperature are limited by in-stream toxicity standards. Discharge requirements for the main plant effluent are summarized in **Table 4.5**. The quality of reclaimed water provided to the cogeneration facility as authorized in the permit is in **Table 4.6**.

Table 4.5 Current Discharge Permit Requirements –Plant Effluent

Parameter	Average Effluent Concentration, mg/L		Mass Discharge, lb/day		
	Monthly	Weekly	Monthly avg.	Weekly avg.	Daily max.
June 1- October 31					
BOD	20	30	1,000	1,500	2,000
TSS	20	30	1,000	1,500	2,000
Fecal coliform	200 [a]	400 [a]	b	b	b
November 30- May 31					
BOD					
TSS	30	45	1,500	2,250	3,000
Fecal coliform	30	45	1,500	2,250	3,000
	200 [a]	400 [a]	b	b	b

Notes:
1. pH: 6.0 - 9.0
2. Mass load limits are based upon an average dry weather flowof 6.0 MGD.
3. BOD and TSS removal efficiency shall not be less than 85 percent monthly average.
4. The allowable mixing zone shall not extend beyond that portion of the Klamath River within a radius of 100 feet from the point of discharge.
5. Ammonia nitrogen shall not be discharged at rates or in quantities that create acute toxicity within or chronic toxicity outside the allowable mixing zone.

a) Number per 100 mL.
b) Not applicable.

Table 4.6 Current Cogeneration Blowdown Quality Requirement

Parameter	Weekly Grab	Not to Exceed 2-consecutive days	Never to Exceed
Total coliform	23/100 ml	240/100	
Total Chlorine Residual	-	-	5 mg/L

A 1998 DEQ document mentions that even though the plant's discharge to Lake Ewauna has been permitted since 1958, DEQ has no record of approving the lake discharge, which is prohibited under OAR 340-41-206. The document indicates that, "the Department plans to address this issue within the rules to be adopted as part of the TMDL for the Klamath River." OAR 340-041 has been revised substantially since 1998. The administrative rule cited in the 1998 document still exists but is codified as OAR 340-041-0007(4) and states that discharges to reservoirs or lakes is prohibited unless an exception is granted. An exception can be granted provided DEQ determines that the criteria listed in OAR 340-041-0004(9) will be met.

The City also entered into a stipulation and final order (SFO) agreement with the DEQ in September 1990 (SFO no. WQ-CR-90-167). The SFO set a compliance schedule for eliminating toxic chlorine discharges from the Spring Street STP. Accommodations were made as part of the 2001 reliability improvements to add dechlorination facilities. In its March 30, 1998 permit evaluation, DEQ acknowledges that, "the City met the requirements of this SFO" as it relates to chlorine toxicity. The SFO also stipulates a timeline for completion of engineering plans and specifications, and for the pursuant construction.

In 1999, DEQ issued a Mutual Agreement Order allowing transfer of Kingsley Field flow to the Spring Street STP since the Kingsley Field treatment plant was antiquated and functioning poorly. However, the Kingsley Field discharge load permit did not transfer to the Spring Street STP and the City received no extra discharge load allocation for the Kingsley Field wastewater flows and loads.

An MS4 permit is required for municipalities serving more than 50,000 people to comply with the Clean Water Act. Since the service area population is not projected to exceed 50,000 (Section 5), an MS4 may not be required in the future, although the decision is at the Department's discretion.

The NPDES permit, SFO, and Mutual Agreement Order are included in **Appendix A**.

Sludge Management Program

The City of Klamath Falls' sludge management program relies on strong local demand for composted biosolids. In the mid-1990s, the City entered into a sludge-composting agreement with a local tree-trimming company. The City provides sludge and the company provides wood chips. The company hauls chips to the plant site. The chips are mixed with digested sludge (at 2 to 3.5 percent solids content) with a front-end loader and formed into windrows in a large, semi-enclosed building. Maintaining the appropriate moisture content is critical to successful sludge composting. If the moisture content becomes too high, anaerobic conditions can form in the compost, increasing the potential for odor generation. Sludge drying beds are used in the summer to bring digested, stored sludge to acceptable concentrations for composting. The composting process generates temperatures high enough to kill pathogens and make it suitable for unrestricted use (as regulated by the EPA in 40 CFR Part 503). The composting system was recently improved.

Thus far, demand outstrips supply. All of the compost produced at the plant has been hauled away by individuals and local nurseries for use as a soil amendment. This eliminates the need for hauling biosolids to the landfill or for land application. Plant staff believe that demand for the compost will continue to increase as potential users become more familiar with the product.

However, success of the composting operation relies strongly on the availability of woodchips from the local mill and plant staff is concerned with the possibility that this free supply may end.

<u>Operational Considerations</u>

The composting operation is inefficient. The compost operation is mostly open-aired, and weather-dependent. As such, compost production slows in the cold winter months while municipal solids production does not. Front-end loader operation is limited by inclement weather. The compost piles rest on un-asphalted grounds and rocks and ground debris get mixed in with the compost when the windrows are mixed with the front-end loader. The sludge drying beds are using up a large footprint yet they are only used in the summer.

<u>Sludge Management Regulatory Concerns</u>

In its 1998 NPDES permit revision, the Department states that:

"The City also maintains a sludge storage pond, roughly an acre in size, to temporarily store excess sludge until such time as it can be composted. The sludge storage pond is built on natural fine grain material, but does not have an engineered liner. This component, and characterization of its potential impact on groundwater, as mentioned previously, should be addressed in the facility planning process."

4.2.4 Unit Process Performance and Deficiencies

Before evaluating process performance, an assessment of the plant's reliability and of the plants conditions is necessary.

Reliability

The Spring Street STP will be classified under EPA's reliability Class I, defined in **Table 4.7**[5].

Table 4.7 EPA Guidelines for Classifying Sewerage Works

Reliability Class	Guideline
I	These are works whose discharge, or potential discharge, (1) is into public water supply, shellfish, or primary contact recreation waters, or (2) as a result of its volume and/or character, could permanently or unacceptably damage or affect the receiving waters or public health if normal operations were interrupted. Examples of Reliability Class I works are those with a discharge or potential discharge near drinking water intakes, into shellfish waters, near areas used for water contact sports, or in dense residential areas.
II	These are works whose discharge, or potential discharge, as a result of its volume and/or character, would not permanently or unacceptably damage or affect the receiving waters or public health during periods of short-term operations interruptions, but could be damaging if continued interruption of normal operations were to occur (on the order of several days). Examples of a Reliability Class II works are works with a discharge or potential discharge moderately distant from shellfish areas, drinking water intakes, areas used for water contact sports, and residential areas.
III	These are works not otherwise classified as Reliability Class I or Class II.

General requirements to meet reliability class I are listed in **Table 4.8**, with a status of the current plant's facilities against these requirements.

The information in **Table 4.8** shows that many improvements will be required at the plant, regardless of condition, to meet the reliability Class I criteria.

[5] Communication with DEQ (Jayne West), June 2007.

Table 4.8 General Requirements to meet EPA Reliability Class I

General Requirement	Currently met at Spring Street STP (with no consideration of asset condition)?
Mechanically Cleaned Bar Screens. A backup bar screen, designed for mechanical or manual cleaning, shall be provided. Facilities with only two bar screens shall have at least one bar screen designed to permit manual screening.	No
Pumps. A backup pump shall be provided for each set of pumps performing the same function. The capacity of the pumps shall be such that, with any one pump out of service, the remaining pumps will have the capacity to handle the peak flow.	No. Influent pumps at capacity when all pumps are in service and not pumping all flow.
Comminution Facility. If comminution of the total wastewater flow is provided, an overflow bypass with a manually-installed or mechanically-cleaned bar screen shall be provided. The hydraulic capacity of the comminutor overflow bypass should be sufficient to pass the peak flow with all comminution units out of service.	Not applicable.
Primary Sedimentation Basins. The units should be sufficient in number and size so that, with the largest-flow-capacity unit out of service, the remaining units should have a design flow capacity of at least 50 percent of the total design flow.	No. With the largest clarifier out of service, the remaining capacity would be only 33 percent of the flow.
Aeration Basin. A backup basin will not be required; however, at least two equal-volume basins shall be provided. (For the purpose of this criterion, the two zones of a contact stabilization process are considered as only one basin.)	No. Although the basin has six cells, parallel operation is not possible and the current configuration has thus only one basin.
Aeration Blowers or Mechanical Aerators. There shall be a sufficient number of blowers or mechanical aerators to enable the design oxygen transfer to be maintained with the largest-capacity-unit out of service. It is permissible for the backup unit to be an uninstalled unit, provided that the installed units can be easily removed and replaced. However, at least two units shall be installed.	Yes. The plant currently has 3 blowers of 1,000 scfm (60 Hp) capacity each.
Air Diffusers. The air diffusion system for each aeration basin shall be designed so that the largest section of diffusers can be isolated without measurably impairing the oxygen transfer capability of the system.	Yes. Aeration system can be isolated in each of the aeration basin cells.
Final Sedimentation Basins and Trickling Filters. The units shall be sufficient in number and size so that, with the largest-flow-capacity unit out of service, the remaining units shall have a design flow capacity of at least 75 percent of the total design flow.	Yes. Should Clarifier No. 2 be out of service, the remaining capacity (at the current design) would be 8 mgd in Clarifier No. 1, while the current design flow is 6 mgd.
Disinfectant Contact Basins. The units shall be sufficient in number and size so that, with the largest-flow-capacity unit out of service, the remaining units shall have a design flow capacity of at least 50 percent of the total design flow.	No. The plant currently has only one contact basin.

Condition Assessment

A condition assessment of plant assets was performed by CDM in spring 2007. The condition assessment focused on elements of structural integrity, functionality, and operability. While this section summarizes critical condition assessment findings, the full condition assessment report is included in **Appendix B**. **Figure 4.2** illustrates highlights of the condition assessment, which identified the following top criticalities:

1. Primary Clarifiers: the structures are showing clear signs of deterioration while piping and internals were rated in "poor" or "very poor" condition. The clarifier structure is recommended for replacement or at least extensive rehabilitation within the next 5 to 10 years, with clarifier components (bases, valves and decant pipe) replaced in the next 1 to 3 years.

2. Anaerobic Digesters: the digester structures are in poor condition as is the piping within the digester building. A significant number of valves are inoperable, or otherwise difficult to move, presenting a safety hazard to operators.

3. Influent Bar Screen: the main influent screen is manual and presents operational issues.

4. Plant Water Pumps: the plant water pumps show considerable wear and should be replaced within the next 3 to 6 years. The overall water system for the plant should be evaluated and replaced based on poor pressure and flow.

The recommended timeline for addressing these and other recommendations is also illustrated in **Figure 4.2**.

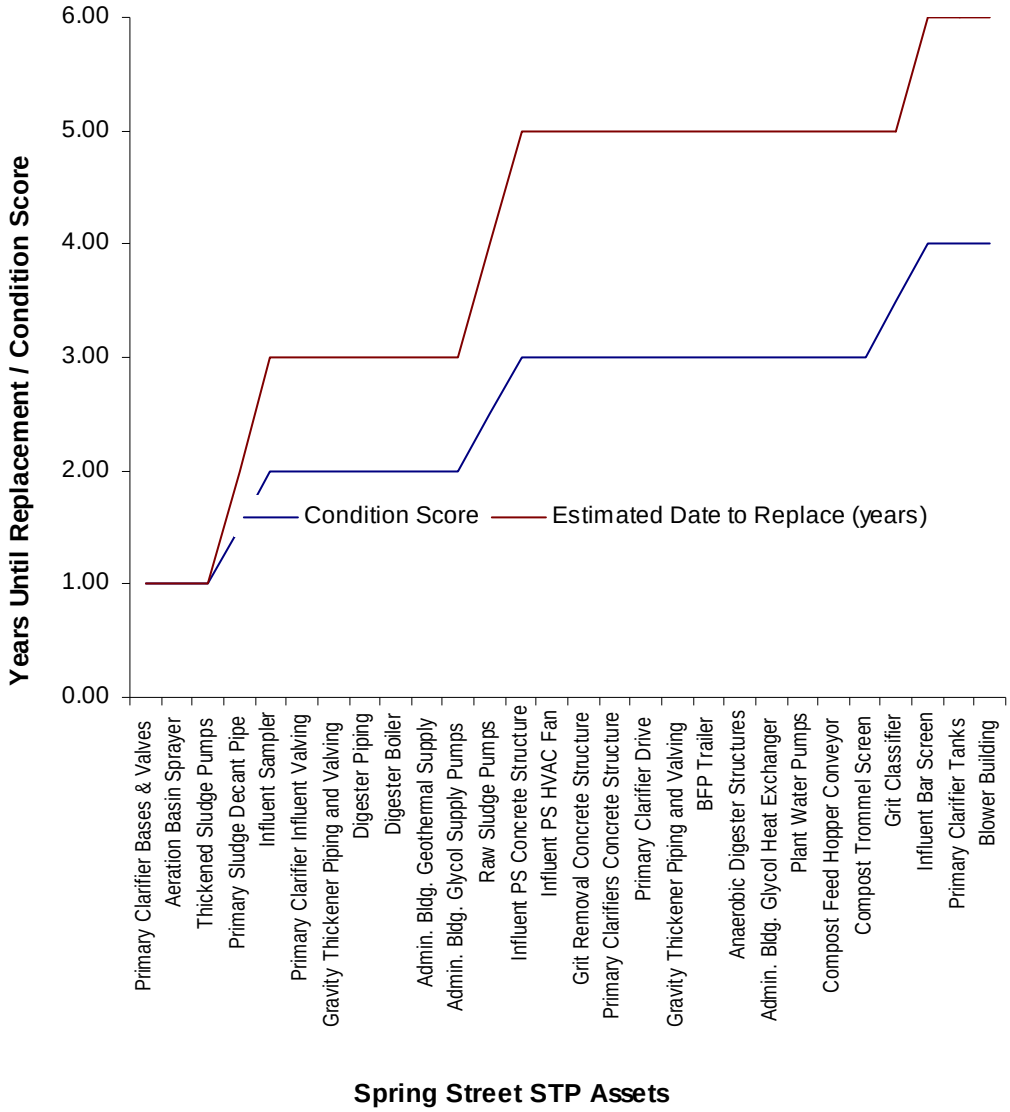


Figure 4.2 Condition Assessment Highlights

Plant Performance

Influent Pumping Station. The influent lift station firm rating is 7.8 MGD; however, it can pump 13.6 MGD with all three pumps running. Examination of past storm events and the corresponding circular flow charts from the influent flow recorder show that during storms, the pumps are already at capacity. An empty slot is provided in the pump station for a fourth pump to be installed, which would provide for some standby capability.

Primary Sedimentation. The combined capacity of the two primary clarifier tanks is 18 MGD (2,300 gpd/sf overflow rate) at design peak wet weather flow, and 6 MGD (770 gpd/sf) at design flow. Expected removals from conventional primary clarifiers are typically 50 to 55 percent TSS and 30 percent BOD. Design data for the existing clarifiers lists 40 percent BOD and 60 percent TSS removal capacity. However, these efficiencies could not be confirmed from plant record. For detailed design purposes, bench scale testing of primary settling should be performed, as the influent is relatively weak and might yield lower removals.

Biological Treatment System. The aeration basin is currently operated in conventional mode, where the internal mixed liquor recycle pump is not used and the first two cells are un-aerated. The plant is performing well for both BOD and TSS removals, consistently achieving more than 95 percent removals for an effluent quality exceeding 15/15, as shown for the year 2006 in **Figure 4.3** and **Figure 4.4**. Upset events are circled in the two figures. One observes that during peak events, the plant performance deteriorates, first with TSS removals shown in **Figure 4.4**. This trend appears to be related to Clarifier No. 1 being put in operation when flow rates exceed 9 MGD.

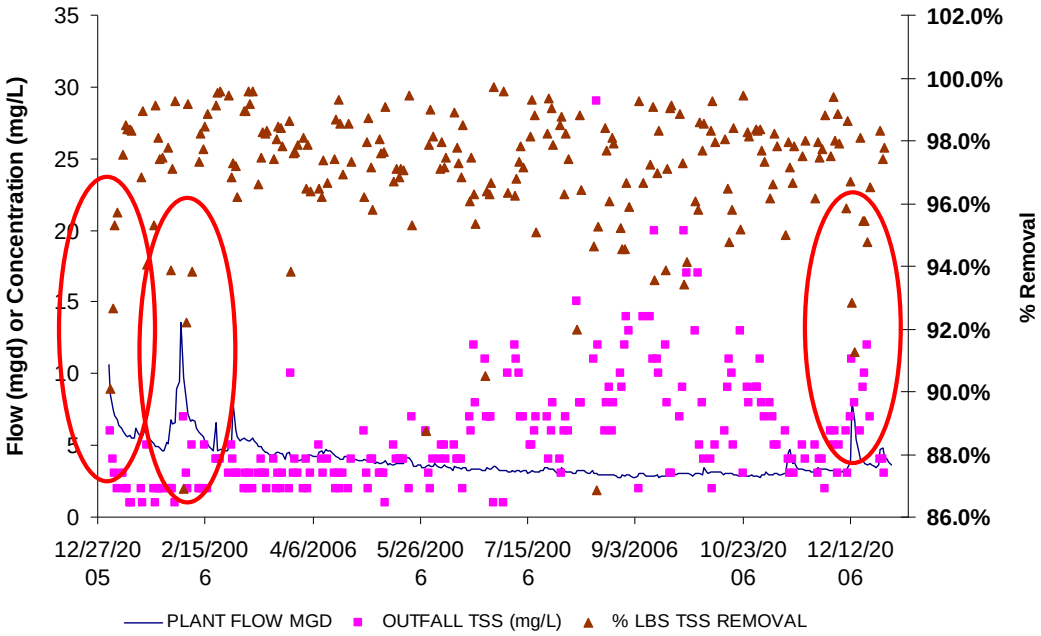


Figure 4.3 Year 2006 Effluent TSS data and Percent Removals

There also seems to be deterioration of performance for BOD removal after a storm, albeit delayed. This trend is likely due to a washout of biomass and/or cooling of the biological system temperature, which in turn slows its activity and reduces its performance. This is particularly expected when operating at relatively short solids residence time (SRT), where a 5 day SRT is typically considered the washout threshold in the winter. Plant records from the Spring Street STP show it operating at SRTs in the 5 to 8 day range.

While this kind of system response is expected during storm events, the extent of it can be critical when faced with a stringent effluent limit. For this reason, an increased number of plants are implementing wet weather management techniques to minimize the required size of the treatment facilities while maintaining performance.

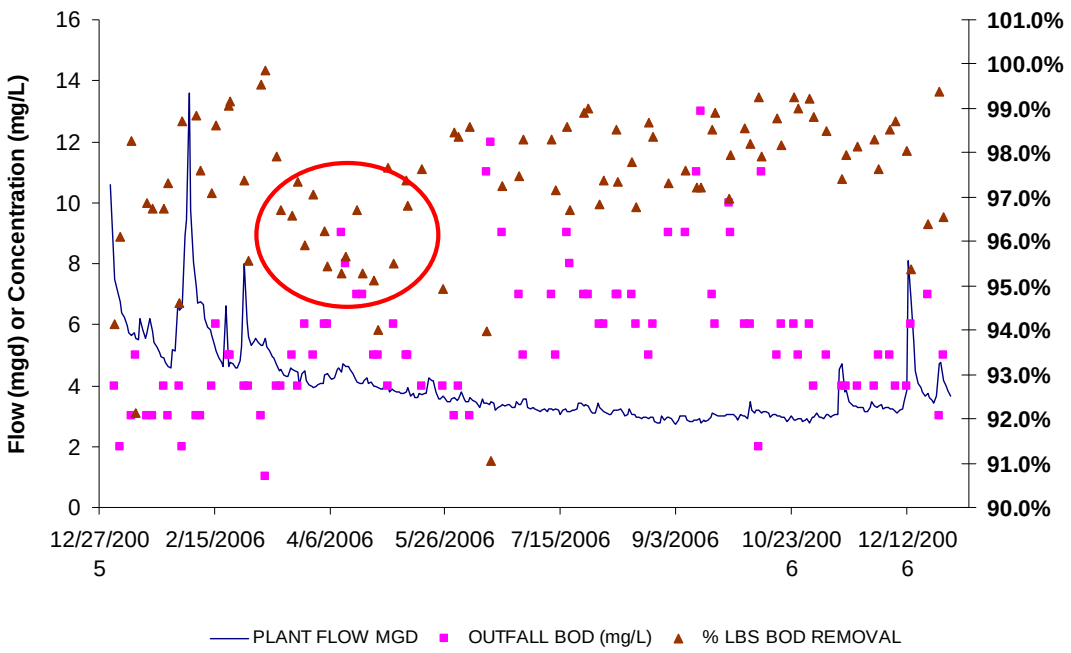


Figure 4.4 Year 2006 Effluent BOD data and Percent Removals

Disinfection and Dechlorination. The sodium hypochlorite delivery system was installed in 2000 and is housed in a new chemical storage building. It is sized to deliver 720 pounds of chlorine per day each at the cogeneration effluent and the main plant effluent. The facilities and equipment are in good condition; however, there are some reliability and operational issues, identified in the condition assessment report, that would need to be addressed.

Solids Thickening. The primary sludge and WAS are thickened via a dissolved air flotation thickener (DAFT) under normal operating conditions. Current operation is to pump down the settled sludge when the blanket reaches about one foot in depth, and the pump operates only about once a week. The target solids concentration for the thickened sludge is 5 percent; however, data is missing for actual performance; additional data would be required during detailed design to confirm actual DAFT performance.

Anaerobic Digestion. The anaerobic digesters are operated in a two phased mesophilic digestion of the thickened sludge, with an approximate combined SRT of 28 days. Temperature in the primary digester is approximately 98 degrees Fahrenheit, although it may not be evenly mixed, while temperature in the secondary digester is approximately 85 degrees Fahrenheit. The secondary digester, which is static and unheated, is presumed to serve more as a holding

tank. This operational approach has produced mixed results with volatile solids reduction varying from 34 percent to 68 percent over the course of 2005 with no clear correlation to ambient temperature; lower VSRs were observed both in summer and winter.

Dewatering. Communications with City staff and best engineering practices suggest that the digested sludge has a solids content of roughly 2.5 percent, which is then brought to 15 percent via the addition of polymer and dewatering through the belt filter press. The press is currently operated for about 3 to 4 days a week, from 6:30AM to 3PM, with a digested sludge feed rate of about 33,000 to 34,000 gpd. Current polymer dosage is roughly 6 to 8 gpd depending on the amount of sludge to be processed that day.

Composting. Composting at Spring Street has been an extremely successful method of sludge management. In 2005, roughly 2,700 tons of sludge was disposed of via the composting program. Success of the composting at Spring Street is directly tied to the free woodchips that it receives from a local paper mill to use as a bulking agent. Should this supply be curtailed, the return on the composting process would lessen as another bulking agent source would need to be found.

Outfall Mixing Zone Study

The Spring Street STP discharges treated effluent through two open-end outfall pipes at the river's edge within a small embayment into Lake Ewauna. Mixing zone tests were performed in the Klamath River at the City of Klamath Falls WWTP outfalls on July 19, 1991. The tests were accomplished by injecting a tracer dye into the effluent at the treatment plant and tracking the dyed effluent plume in the river with special instrumentation. The flow measured along the Link River feeding the Klamath River was approximately 606 cubic feet per second during the test. The average effluent flow from the plant was 3.7 MGD.

Prior to beginning measurements in the river, the dyed effluent plume was observed pooling within the outfall embayment, then drifting north slowly. There was little or no wind during this period. After winds picked up from the west-northwest in the afternoon, the effluent plume moved south along the shore, centered approximately 100 feet from shore.

Because of shallow water depths within the outfall embayment, no dye measurements were obtained within approximately 100 feet of the outfalls. However, peak dye and conductivity data indicate that there would have been virtually no effluent dilution mid-plume within 100 feet of the outfalls. The mid-plume values are worst case and represent a fairly small area a specified distance from the outfalls.

The rate of effluent dilution beyond 100 feet from the outfalls was relatively constant, likely governed primarily by wind-induced currents in the river. The minimum dilution 300 feet from the outfalls was approximately 1.8:1; at 500 feet it was approximately 2.9:1; and at 1,000 feet it was approximately 6:1.

Effluent Bioassay Analysis

Three effluent samples from the WWTP were collected in January 1999, and again in July 1999. Northwestern Aquatic Sciences ran bioassays on the three samples using fathead minnows and

ceriodaphnia in accordance with the bioassay plan approved by DEQ and listed in the NPDES permit.

The survival rate of fathead minnows in 100 percent effluent during the 7-day test was 100 percent. No significant effects on either survival or growth were observed in a 30 percent effluent mixture. Ceriodaphnia reproduction and mortality were unaffected by plant effluent, even at 100 percent strength.

The bioassays indicated that aquatic organisms will not be adversely affected at the point of discharge.

Section 5
Wastewater Flows

Consistent with ODEQ's guidelines, the City of Klamath Falls is required to develop plans that are consistent with handling flows and loads over the next 20 years. Appropriate sizing, design, and phasing of the upgrades of the collection, treatment, and disposal facilities is thus largely dependent upon estimates of future flows and loadings throughout the planning period.

Peak wastewater flow (or volume) projections are critical for hydraulic sizing of the facilities and are usually intimately tied to rainfall events for the service area throughout the planning horizon. This is especially true in Western Oregon (that is west of the Cascades), for which ODEQ has developed Guidelines for Making Peak Wet-Weather and Peak Flow Projections for Sewage Treatment in Western Oregon. Wastewater volume projections are detailed in **Section 5.1** below.

Wastewater loadings projections are typically used as a basis for the biological system design and the solids handling facilities. Loadings projections are directly related to the planning goals and estimated serviced population over the planning horizon. **Section 5.2** describes the wastewater loading characteristics.

5.1 Wastewater Volume

The total volume of wastewater to be treated consists of a combination of the four following parameters, each of them contributing to various degrees at any given time:

- Base Sanitary Flow, generated by residents, workers, and visitors within the service area.
- Base Industrial Flow, generated as the result of manufacturing or processing activities and discharged within the service area.
- Groundwater Infiltration (GWI), water that enters the wastewater collection system from surrounding soils, typically via leaking pipe joints, cracked pipes, and manhole walls. Greater GWI will occur during the winter and spring, when groundwater levels are higher.
- Storm-related Infiltration and Inflow (I/I), stormwater runoff that enters the wastewater collection system during or immediately following a rainfall. Stormwater will typically enter the collection system via storm drain connections, manhole covers, and roof and area drains.

Definition of Flow Factors and Abbreviations

A number of flow factors can be used to define the service area's characteristics. Where applicable, the working definitions of ODEQ's wet-weather planning directive will be used, with some additional terms also defined in **Table 5.1**.

Table 5.1 Definition of Flow Factors and Abbreviations

Acronym	Definition	Use and Notes
AAF	Annual Average Flow, the daily average flow over a given year.	Used for annual operation and maintenance cost estimates
ADWF	Average Dry Weather Flow, the daily average flow in the dry season	Typically from May through end of October. Historically used by DEQ as a basis for calculating dry weather mass discharge limits for BOD and TSS.
AWWF	Average Wet Weather Flow, the daily average flow during the wet season	Typically from November through end of April. AWWF has historically been used by DEQ as the flow basis to determine mass discharge limits during wet weather.
PDAF	Peak Daily Average Flow	Used for hydraulic sizing of facilities. PDAF is likely to occur during the months of January through May, when groundwater levels are high.
PIF	Peak Instantaneous Flow	Used for hydraulic sizing of facilities. Also referred to as Peak Hour Flow.

5.1.1 Dry Weather Flow

Dry weather flows consist mainly of sanitary base flow, commercial and industrial wastewaters with minimal inflow and infiltration. For the purpose of determining wastewater permit discharge limits, ODEQ has historically defined the dry-weather season as that including the months of May through October, while the wet-weather season is usually defined as the other half of the year, from November through April.

In order to determine the baseline wastewater flows – the wastewater volumes that are not related to storm events or groundwater infiltration – it is sometimes helpful to define the driest months within the dry weather season. Rainfall data for the years 2001 through 2006 was plotted to identify those months. Link River monthly flow rates were also evaluated to identify the lowest river flows, which vary with the Link River dam operation and may influence water quality requirements. **Figure 5.1** shows the driest months as those including June, July, August, and September, and that the lowest Link River flow rates occur late in the summer season because of fish protection measures.

Historical and projected dry weather flows are presented in **Section 5.1.4** and **Section 5.1.5**, respectively, while the basis of design as it relates to flows and loads, is given in **Section 6**.

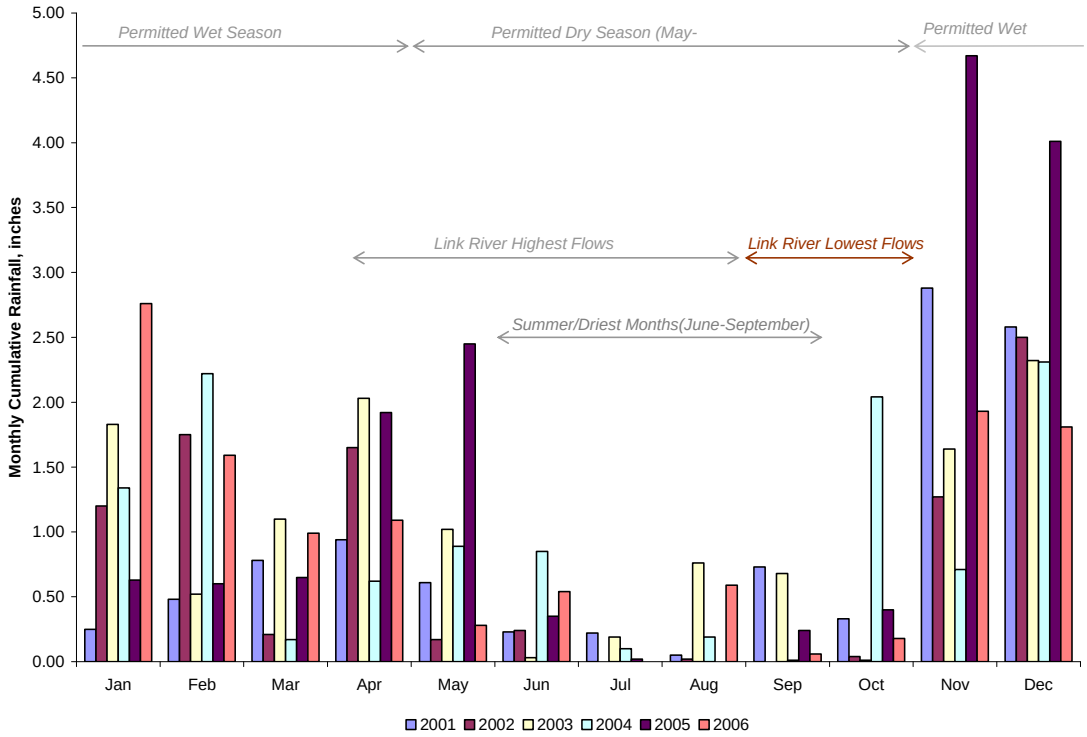


Figure 5.1 Klamath Falls Monthly Rainfall Data, 2001-2006

5.1.2 Wet Weather Flow

Wet-weather flows consist mainly of sanitary base flow, commercial and industrial wastewaters, ground water infiltration, and wet weather storm-related inflow and infiltration. In Klamath Falls, snowmelt in mid to late winter is another wet weather contributor.

For the purpose of determining wastewater permit discharge limits, ODEQ has historically defined the wet weather season as the months of November through April. The Maximum Monthly Average Wet Weather Flow (MMWWF) occurs within the wet weather season and typically refers to the plant's design flow. As such, the current Spring Street STP is a 6-mgd plant. The MMWWF is used as a reference because it generally represents the flow condition under which the biological treatment system must both hydraulically pass and biologically treat the wastewater.

Historical and projected wet weather flows are presented in **Section 5.1.4** and **Section 5.1.5**, respectively, while the basis of design as it relates to flows and loads, is given in **Section 6**.

5.1.3 Infiltration and Inflow

Infiltration and Inflow (I/I) relate to stormwater runoff that enters the wastewater conveyance system during or immediately following a rainfall. I/I related flows enter the system via cracks, failing joints, manholes, and illicit connections to the sewer lines (roof drains, downspouts, etc).

High groundwater levels will magnify the I/I problem, which is why the highest peaks experienced at a plant are usually in the second part of the winter.

Treatment plants should be designed to hydraulically pass all flows without overflowing tank walls or creating major backups in the treatment or conveyance system. For this reason, plants that are tributary to conveyance systems with high levels of I/I will generally require larger infrastructures for the same baseline flows and loads. Recognizing the impact of I/I on a treatment plant's flows and loads can affect the choice of treatment technologies, assist in developing wet-weather flow-management strategies that maintain the required water quality standards and effluent quality, and support funding efforts to rehabilitate the conveyance system.

Figure 5.2 illustrates the magnitude of past daily rainfall in the Klamath Falls area. From the historical records, rain events up to 1.5 inches per day can be expected, while the cumulative rainfall per month, shown in Figure 5.1, exceeded 4.0 inches in both November and December 2006.

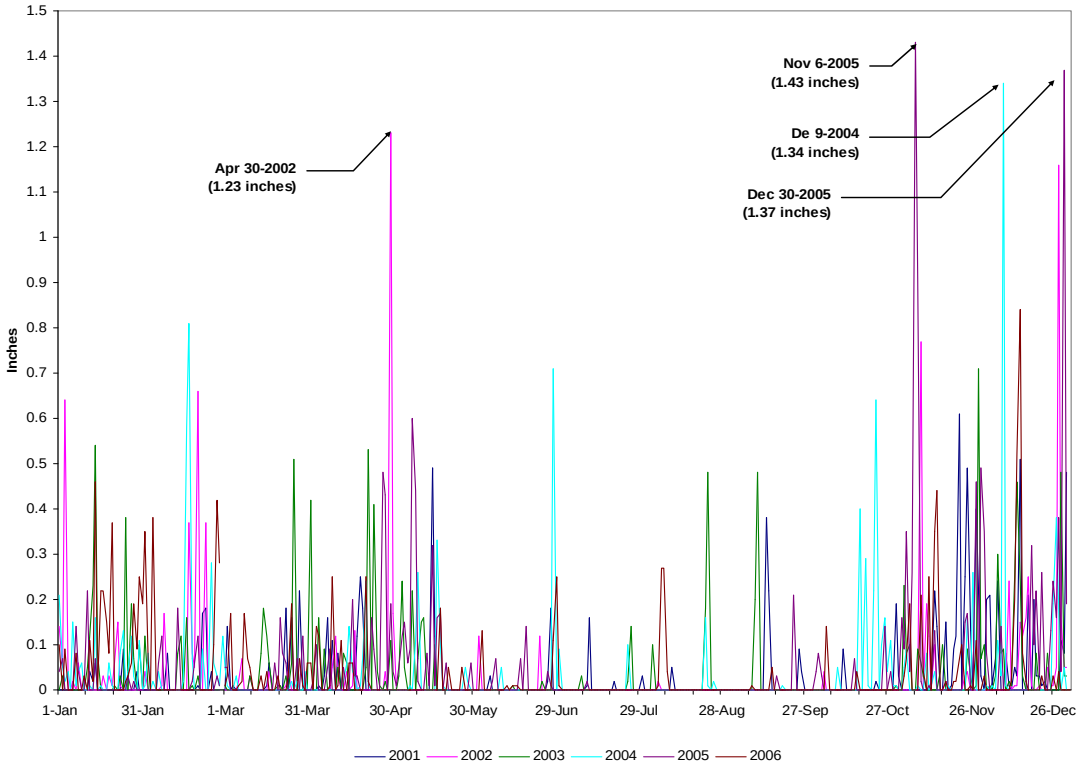


Figure 5.2 Daily Rainfall, Klamath Falls International Airport Gauge, 2001-2006

Spring Street STP's Response to I/I

Klamath Falls' conveyance system response to I/I was evaluated with plots of daily rainfall data and plant influent flow against time. The analysis presented in **Figure 5.3**, **Figure 5.4**, and

Figure 5.5 focuses on the winter of 2004-2005, the winter of 2005-2006, and the spring/summer of 2005, respectively.

Winter of 2004-2005

Figure 5.3 illustrates some I/I characteristics over the winter of 2004-2005, which started relatively dry with cumulative rainfall of about 5 inches by the end of December. A look at the plant influent flow rate indicated on the secondary y-axis to the right, shows a slight increase in the plant baseline flow in the second half of the winter, from about 3.2 mgd to about 3.6 mgd. This increase, highlighted with a gray rectangle on the figure, is likely related to groundwater infiltration. Prior to December, rainfall did not have a major impact on plant influent flow rate, which supports the theory that groundwater levels are still low and that rainfall seeps in the ground. Late in December though, a large rainstorm hit the area, causing a plant influent flow exceeding 9 mgd correlating directly with the magnitude of the precipitation. However, this kind of response to rainfall is not consistent throughout the winter: late January, plant influent flow increases broadly over a period of two weeks while there is no precipitation reported. Discussions with plant staff have later correlated these broad peaks with snowmelt, which typically occurs in January-February.

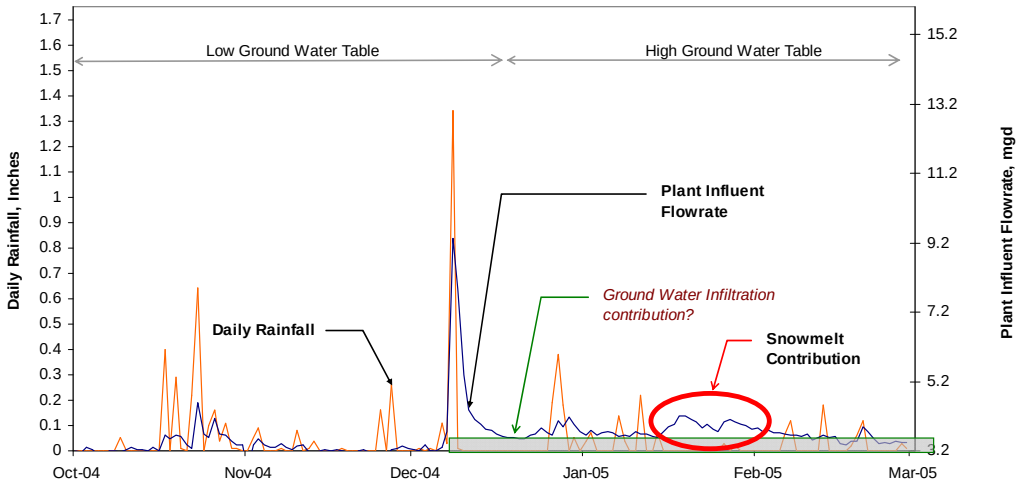


Figure 5.3 Daily Rainfall vs Daily Plant Influent Flowrate, Winter 2004-2005

Winter of 2005-2006

By January 2006, the area had received almost twice as much rain as during the previous winter, which suggests a higher degree of ground saturation. This assumption is supported when daily precipitation and plant influent flow rate are superimposed against time (see **Figure 5.4**). The suspected groundwater infiltration impact, highlighted with a gray box, is larger than the one for the previous (dry) year, with the baseline flow going up from 3.2 mgd to a sustained 4.7 mgd and above. This represents a steady additional million gallons per day requiring treatment in the winter compared to the previous winter.

The impact of high groundwater levels on plant influent peak flow is visible when comparing the two similar storms, which occurred in fall (low groundwater) in October and in December

(high groundwater). The resulting flow rate in October peaked at 5.9 mgd for the day, while it peaked significantly higher at 14.8 mgd in December. Snowmelt events can again be identified in **Figure 5-4** (circled), where warm weather causes both rainfall and snowmelt, and associated peak flows at the treatment plant.

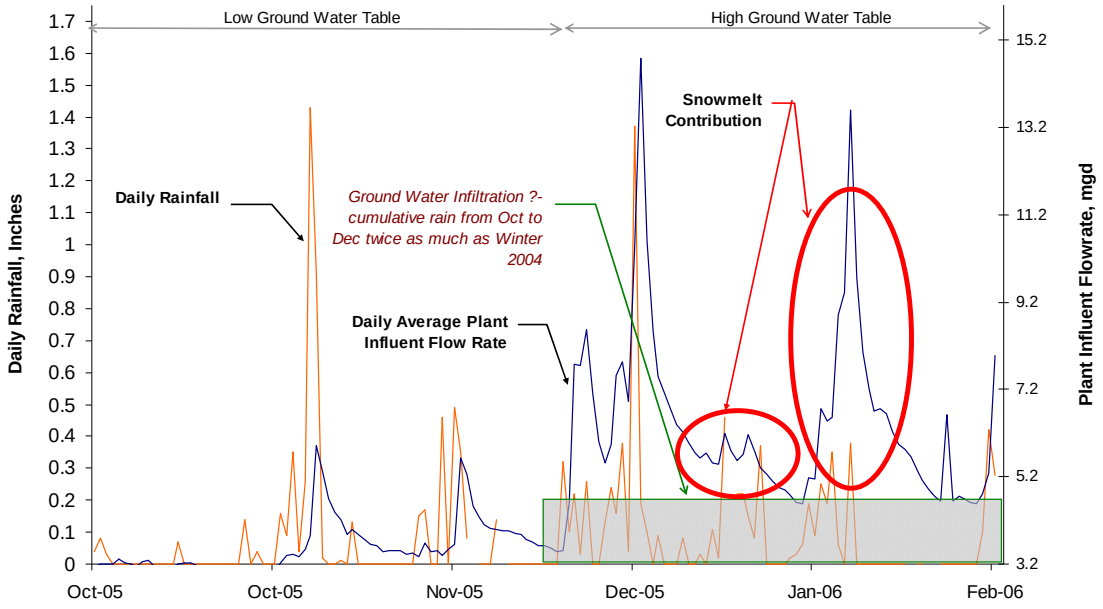


Figure 5.4 Daily Rainfall vs Daily Plant Influent Flowrate, Winter 2005-2006

Spring/summer 2005

Finally, dry weather behavior was examined with the spring/summer 2005 data (see **Figure 5-5**). As expected, the baseline plant flow slowly decreases with the receding groundwater table. In late spring, when the groundwater table is still relatively high, the plant influent flowrate follows heavy rains in April and May, and then gradually decreases to its dry weather baseline level of about 3.2 mgd.

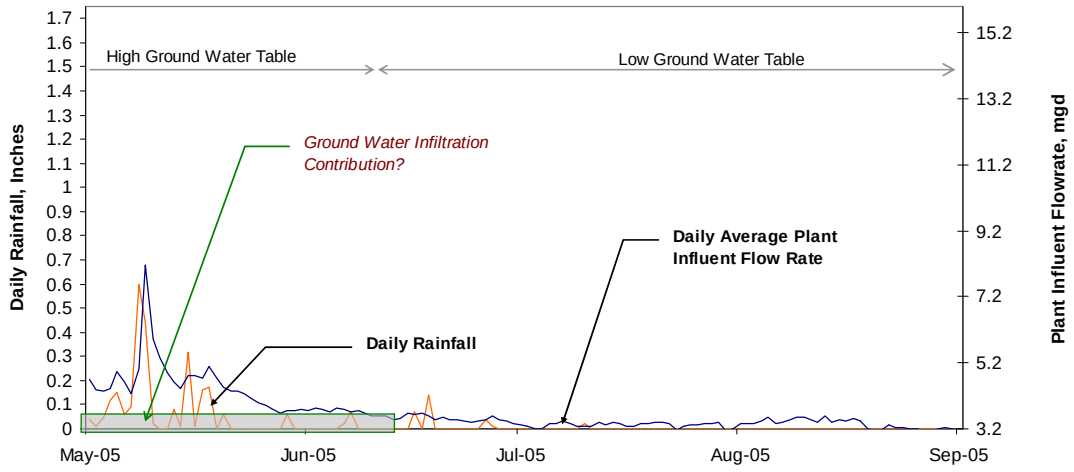


Figure 5.5 Daily Rainfall vs Daily Plant Influent Flowrate, Spring/Summer 2005

This analysis confirms the impact of groundwater infiltration on the treatment plant's influent flow rate, impacting peak day flows with peaking factors exceeding 4 from the baseline flow, and impacting peak week and peak month flows as snowmelt and rainfall contribute to higher sustained plant influent flow rates. The analysis also agrees with the conclusions of the 1980 *Sewer System Evaluation Survey* and associated I/I study (r.f. **Section 4. 1.2**), which had quantified peak flows to the plant as being 26 percent base sanitary flow and 72 percent related to I/I. In 2005, the base sanitary flow contribution for the December 2005 peak of 14.8 mgd represents 24 percent.

5.1.4 Summary of Existing Flows

Existing flows and flow patterns are used to develop and support flow projections. Dry weather flows combine the base sanitary flow generated by the population in the service area, and the base industrial/commercial flows within the service area. **Table 5.2** gives a summary of past influent flow rates, as well as dry weather flow contributions. Dry weather flow contributions in the Klamath Falls area are on the high end of the typical range of 100 to 120 gallons per capita per day (gpcd). Baseline flow during the driest months of June through September is only 0.1 mgd or less than the baseline flow, with a per capita contribution of 120 gpcd instead of 124 gpcd. The current definition of dry weather was thus kept for the remainder of the analysis.

Table 5.2 Summary of Existing Spring Street STP Influent Flows (2002-2006)

Flow Parameter	2002	2003	2004	2005	2006	Average
Annual Average Daily (mgd)	3.9	3.6	3.9	3.8	4.0	3.8
Dry Weather Average Daily(1) (mgd)	3.7	3.4	3.6	3.5	3.2	3.5
Per Capita Contribution (gpcd)	134	121	127	125	114	124
Wet Weather Average Daily(2) (mgd)	3.8	4.1	3.7	5.1	3.9	4.1
Maximum Monthly Average Daily (mgd)	4.8 (Jan)	4.2 (Jan)	5.0 (Feb)	5.6 (Dec)	6.4 (Feb)	5.4
Peak Day (mgd)	10.8 (Dec)	5.7 (Apr)	10.5 (Feb)	14.8 (Dec)	13.7 (Feb)	12.4(3)
Peak Instantaneous (Peak Hour) (mgd)	Peak instantaneous flow is currently limited by the influent pump capacity; influent flow meter pegs out at about 14 mgd, which is consistent with the pumps capacity.					

Notes:

(1) Defined as the period including the months of May through October.

(2) Defined as the period including the months of November through April, and overlaps two calendar years; e.g. November-December 2005 and January-April 2006.

(3) Average excludes the year 2003 as unusually dry.

The historical data show that peak days and maximum month typically occur during the mid-winter months of December through February when the soil is saturated and groundwater infiltration is high. Peak day events do not necessarily occur during peak month, e.g. in 2002 and 2003; a peak day peaking factor should thus be reported on an AWWF basis rather than a peak month. Current average dry weather flows at the Spring Street STP average 3.5 mgd, representing 87.5% of the current design capacity of 4 mgd. The current peak month design capacity of 6 mgd was exceeded in February of 2006.

5.1.5 Projected Wastewater Flows

Flow projections for facilities planning build on historical characteristics while taking into account population growth, land use issues as applicable, and reasonable I/I rehabilitation. Future baseline, or average dry weather flow, is estimated first based on urban growth projections; wet-weather and maximum month projections are determined with historical peaking factors and adjusted as necessary based on I/I analysis; peak day and peak hour flows are estimated with a combination of historical data, empirical methods, I/I analysis and good engineering judgment.

Projected Baseline Flow

Based on discussions with the City planning department, major annexations to the urban growth area are not expected; growth is expected to occur within City limits. Although there are discussions about potential industrial contributors in the future, such as an ethanol plant, not enough information is available about discharges from those potential contributors. In terms of flowrate, it is assumed that the impact of these contributors would not be significant.

From these considerations, baseline flow projections are based on population projections and historical per capita contributions.

The total residential population estimates for the study area that will be serviced by the Spring Street STP is 42,000, corresponding to a population growth of approximately 1.8% (with a 1.2% growth in the overall urban growth area). Based on a historical per capita contribution of 124 gallons per day (listed in **Table 5.2** above), the projected average dry weather flow would be 5.2 mgd in year 2030, a 30 percent increase over the current design capacity of 4 mgd.

Flow Peaking Factors

Historical flow peaking factors are used to project other flow parameters from the baseline flow. Historical peaking factors developed from the Spring Street plant's historical flow records are presented in **Table 5.3**. With the exception of the peak day peaking factor, design peaking factors were selected as the highest factor for the five years of record, representing a 1 in 5 year probability. For the Spring Street STP, it is not recommended to use peaking factors as a basis for flow projection; with little future land annexation and assuming similar precipitation and snowmelt patterns, peak events should not increase with the same magnitude as the baseline flow. Therefore, peaking factors for peak day and peak instantaneous flow were not used for flow projection in this planning effort. Peak event projections are discussed below.

Table 5.3 Flow Peaking Factors for the Spring Street STP (2002-2006)

Flow Parameter(1)	2002	2003	2004	2005	2006	Average	2030 Design
AADF/ADWF	1.05	1.06	1.08	1.07	1.24	1.1	1.2
ADWF/ADWF	1.00	1.00	1.00	1.00	1.00	1.00	1.0
AWWF/ADWF	1.03	1.23	1.04	1.45	1.21	1.2	1.5
MMWWF/ADWF	1.28	1.25	1.40	1.58	2.00	1.5	2.0
PDAF (2)/AWWF	2.83	1.38	2.85	2.89	3.49	2.68	Not applicable(3)
PIF(2)/PDAF	Not known	Not known	Not known	Not known	Not known	Not known	Not applicable(3)

Notes: (1) AADF =Annual Average Daily Flow; ADWF = Average Dry Weather Flow, May through October; AWWF= Average Wet Weather Flow, November through April; MMWWF=Maximum Month Wet Weather Flow; PDAF= Peak Day Average Flow; PIF= Peak Instantaneous Flow, or peak hour flow.

(2) Existing influent flow meter pegs out at approximately 14 mgd while influent pumps limit capacity around 14.6 mgd. Current PIF is thus limited at less than 15 mgd but is suspected to be higher.

(3) Peak events peaking factor are not deemed applicable for the Spring Street STP facilities planning, assuming similar precipitation patterns and little annexation of land. Peak day flows are discussed below.

Peak Flows Discussion

Data for peak instantaneous flow at the Spring Street STP is unknown because of influent pump capacity and influent flow meter records pegging out at about 14 mgd. Although the current listed hydraulic design capacity of the plant is listed at 18 mgd for peak instantaneous flow, no

records were found to support this value, which represents a peaking factor of 3.0 over the current peak month design flow of 6 mgd.

Growth within the Klamath Falls area is expected to occur within the existing service area with minimal annexations. New developments will benefit from new conveyance installation with no or little leakage, while it is assumed that the City will undertake a rehabilitation program for its current conveyance system. The City is currently monitoring the conveyance system to gather detailed flow information that will help in determining the most critical pipe sections. Illegal connections to the sewer should also be identified and corrected to minimize I/I impact on plant influent flow rate. For this facility planning effort, these considerations were used as a basis to avoid the use of historical peaking factors for peak day and peak hour events.

Historical data presented earlier showed the impact of I/I when the soil is saturated, with plant influent flowrate peaking significantly on those occasions. The magnitude of peak hour events is frequently unknown either because the plant has a totalizing meter or because the meter may "peg out" at a certain value.

Various methods of estimation are usually accepted by regulatory agencies. In Oregon, DEQ has published its Peak Flow Projection Guidelines for Western Oregon. Although developed for western Oregon, which is typically exposed to more precipitation than east of the Cascades, the basis for the guideline is universally applicable: where rain falls and ground water levels are high, peak events are usually directly related to the total amount of rain over the service area over a certain period of time, usually within hours. As such, DEQ recommends that peak events should be based on the magnitude of rainfall events. East of the Cascades, where there is relatively little rainfall, only a few events qualify (heavy rains coinciding with high groundwater levels) each year, providing a small database for statistical analysis. Using all the data points for the years 2002 through 2006 showed no correlation between monthly influent flowrate and cumulative rainfall, with an R-squared value of 0.23. Reducing the data set to the winter of 2005-2006 (see **Figure 5-6**), which was the wettest during the 2002 through 2006 period, yields only a slightly better correlation with an R-squared value of 0.64. This value is considered too weak for flow projection purposes. Because of the lack of qualifying events, this statistical method was not further developed for peak day or peak instantaneous flow estimation.

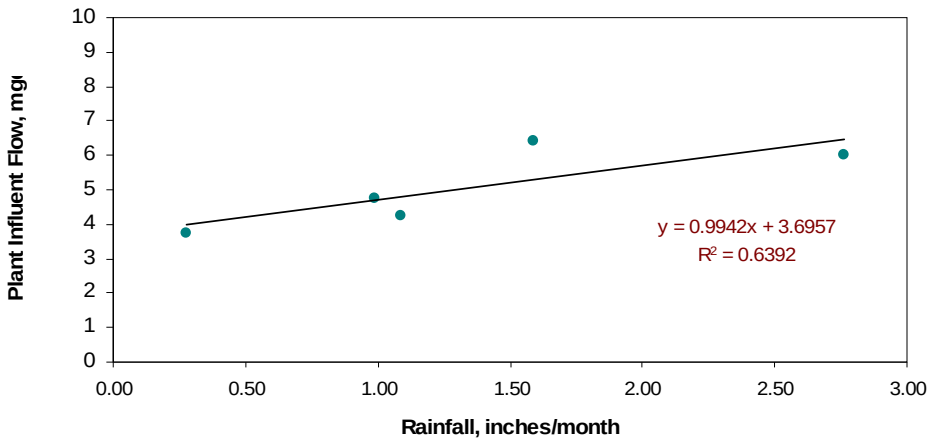


Figure 5.6 Monthly Average Flowrate vs Monthly Cumulative Rainfall, January through May 2006 [1]

Peak Day Estimates

Although current plant capacity is limited by the influent pumps, no overflows are reported within the upstream system during heavy rain while examination of past record show peak day flows in the 13 to 14 mgd range. Should the records show consistent 14 mgd values for peak days, it could have been argued that peak days are consistently higher. Values in the 13 to 14 mgd range suggest that peak day flows of 14 mgd are close to the service area saturation for the current conveyance system. The projected average dry weather flow of 5.2 mgd represents a 1.7 mgd baseline flow increase over the currently observed 3.5 mgd. Assuming rehabilitation of portions of the conveyance system, no significant increase in service area and new connections for new developments, and a safety factor of 10 percent, a peak day value of 17.3 mgd (corresponding to current peak day flows of 14 mgd plus additional 1.7 mgd baseline flow, plus an additional 1.6 mgd as a safety factor (10%)) is judged appropriate for the Spring Street STP. This would represent a peaking factor of 3.3 over the average dry weather flow for comparison. Peak day factors of 2.5 over average dry weather flow are commonly used in Western Washington State, which experiences heavier rainfall than Klamath Falls.

Peak Hour Flows

Washington State's Criteria for Sewage Work Design ("Orange Book") reference book recommends the use of published empirical peaking curves to determine peak instantaneous flow. **Figure 5.7** shows a correlation between population estimates and peak hour (peak instantaneous) flow. When applied to Klamath Falls, this correlation would yield a peaking ratio of 2.34 over the design average flow to determine peak hour flows.

[1] Corresponds to DEQ Peak Flow Projections Guidelines Graph #1

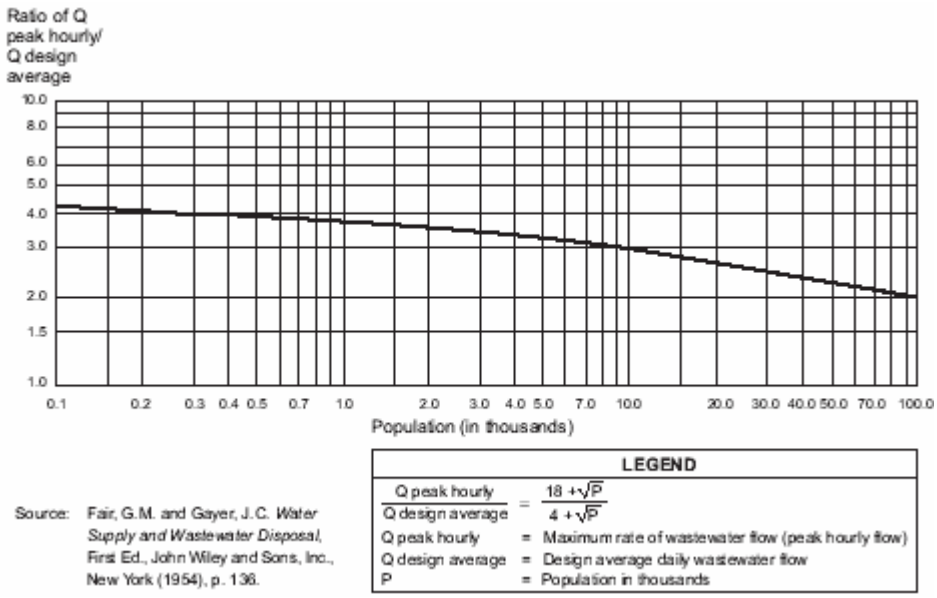


Figure 5.7 Empirical Curve to Estimate Peak Hourly Flow, *Criteria for Sewage Works Design*, Washington State Department of Ecology, 2006, Figure C1-1

Applying the 2.34 peaking ratio extracted from **Figure 5.7** to an increased 1.7 mgd in baseline flow yields a 4.0 mgd additional peak contribution over the current peak flows. When added to the assumed current 18.0 mgd peak hour flows (plant current design, representing a current peak hour to peak day peaking factor of 1.3), the total peak day flow in year 2030 is estimated at 22.0 mgd.

It should be noted that the current conveyance system capacity has been determined to be 18.5 mgd in the 2006 Sewer Master Plan.

Summary of Projected Flows

Table 5.4 lists the projected design flows for the Spring Street STP expansions.

Table 5.4 Spring Street STP Projected Design Influent Flows

Flow Parameter(1)	2010	2014	2020	2024	2030
AADF	4.5	4.8	5.3	5.7	6.2
ADWF	3.7	4.0	4.4	4.7	5.2
AWWF	5.6	6.0	6.6	7.1	7.8
MMADF	7.5	8.0	8.9	9.4	10.4
PDAF	14.7	15.4	16.0	16.7	17.3
PIF	18.7	19.6	20.4	21.2	22.0

Notes: (1) AADF =Annual Average Daily Flow; ADWF = Average Dry Weather Flow, May through October; AWWF= Average Wet Weather Flow, November through April; MMWWF=Maximum Month Wet Weather Flow; PDAF= Peak Day Average Flow; PIF= Peak Instantaneous Flow, or peak hour flow.

5.2 Wastewater Composition

Population growth and industrial development will increase organic and solids collected and conveyed to the Spring Street STP. As this report was being prepared, no new major industrial contributors were confirmed to be added to the service area. Therefore, wastewater loading projections were based on historical peaking factors and per capita contribution applied to population projections.

5.2.1 Analysis of Plant Records

Plant records indicate wastewater composition trends and characteristics that are used to develop and support loading projections throughout the planning horizon. Plant records were evaluated for 2002 through 2006. In the absence of industrial dischargers, daily loading should remain fairly constant on a pound per day basis, while flows will fluctuate with rainfall and I/I. Historical daily plant influent BOD and TSS are illustrated in **Figure 5.8** and **Figure 5.9**, respectively.

The extreme peaks shown in February and early March 2006 are related to belt press and polymer dosing issues, which increased the TSS and BOD loadings coming back to the influent meter via the recycle streams, and because the plant had not yet started subtracting the recycle streams data from the influent meter (downstream of the recycle stream return, as shown on **Figure 4.1**) in its records. So with the exception of February and early March 2006, the records show little variability in BOD loadings through the years, with annual average loadings of 5,000 pounds per day and peaks up to 13,200 pounds per day. Reported TSS loadings show more variability, with an annual average daily base loading of about 4,500 ppd and peaks up to 14,500 ppd. Interestingly, the peaks do not appear to be related to storm events and associated conveyance system flush.

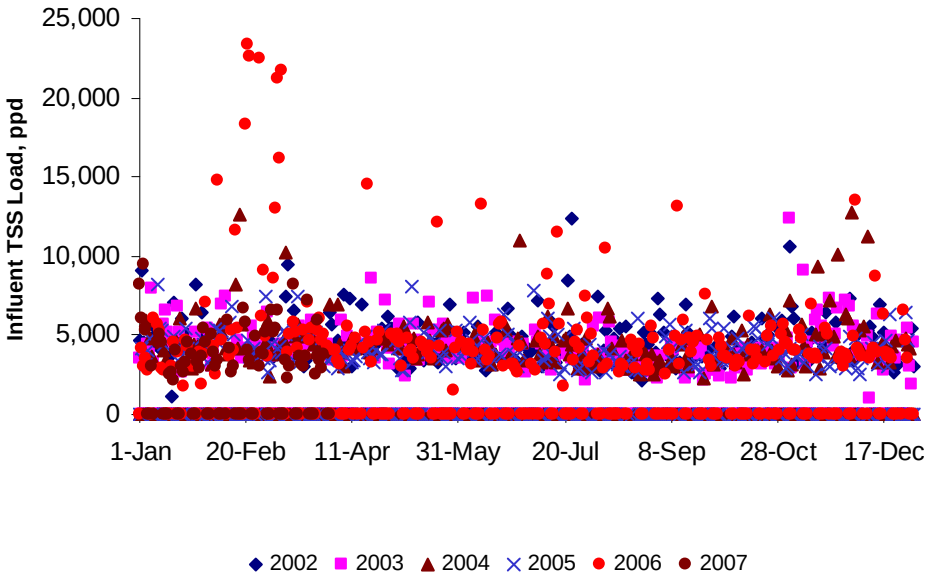


Figure 5.8 Historic Daily BOD Influent Load
(zeros represent no data)

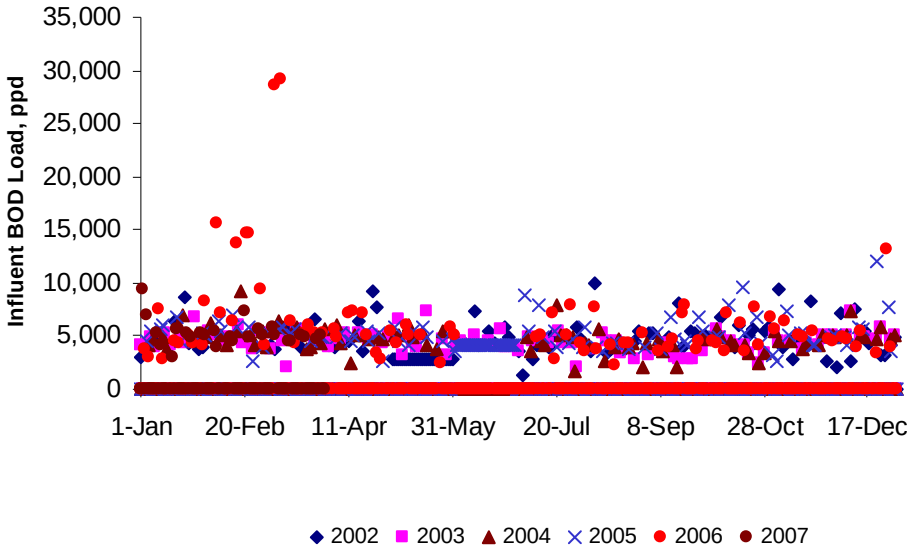


Figure 5.9 Historic Daily TSS Influent Load

(zeros represent no data)

Table 5.5 and **Table 5.6** summarize plant BOD and TSS loadings over the years 2002 through 2006. Average pounds per capita per day (pcpd) contribution over those years are lower than typical, at 0.16 pcpd and 0.14 pcpd BOD and TSS, respectively.

Table 5.5 Summary of Existing Spring Street STP Influent BOD (2002-2006)(1)

BOD Loading Parameter	2002	2003	2004	2005	2006(2)	Average
Annual Average Daily (ppd)	5,000	4,500	4,700	5,300	5,100	4,900
Average Day during ADWF(ppd)	4,100	3,500	3,700	4,400	4,100	4,000
Per Capita Contribution (pcpd)	0.148	0.126	0.132	0.155	0.145	0.14
Average day during AWWF (ppd)	4,800	5,000	5,100	5,200	5,300	5,100
Average day during MMAF (ppd)	4,800	4,800	5,500	6,100	NA	5,300
Peak month load (ppd)	5,400	5,700	5500	6,200	5,700	5,700
month	Apr	Nov	Feb	Oct	Dec	
Peak Day Load (ppd)	9,900	9,500	9,200	12,000	13,300	10,800
Day	8-Aug	8-Nov	18-Feb	21-Dec	9-Mar	

Notes:

(1) Numbers rounded for clarity.

(2) Excludes February 2006 data because of recording issues.

Table 5.6 Summary of Existing Spring Street STP Influent TSS (2002-2006)(1)

TSS Loading Parameter	2002	2003	2004	2005	2006(2)	Average
Annual Average Daily (ppd)	4,600	4,400	4,600	4,100	4,600	4,500
Average Day during ADWF(ppd)	3,700	3,400	3,600	3,400	3,900	3,600
Per Capita Contribution (pcpd)	0.133	0.123	0.126	0.121	0.139	0.13
Average day during AWWF (ppd)	4,700	4,900	4,600	4,300	4,500	4,600
Average day during MMADF (ppd)	5,000	4,800	5,000	4,200	NA	4,800

Peak month load (ppd)	5,100	5,900	5,400	4,600	5,300	5,300
month	April	Nov	Dec	Feb	Jul	
Peak Day Load (ppd)	12,400	12,400	12,700	8,200	14,500	12,000
Day	23-Jul	3-Nov	1-Dec	9-Jan	18-Apr	

Notes:

(1) Numbers rounded for clarity.

(2) Excludes February 2006 data because of recording issues.

Nutrients

The City is sampling influent nutrient data twice a year. Analytical reports for 2004 through 2006 show influent nutrient composition listed in **Table 5.7**. The average ratio of BOD:N:P for these records is 38:7:1.

Table 5.7 Summary of Existing Spring Street STP Influent Nutrients (2004-2006)

	Constituents				Ratios	
	NH_3-N	TKN	Ortho-P	Total P	NH_3-N /TKN	OrthoP/Total P
min	9	12	1.8	2.4	0.6	0.1
max	21	30	5.4	18.8	0.9	1.1
avg	15	22	3.4	7.3	0.7	0.7

5.2.2 Projected Wastewater Composition

As with flow projections, loading projections for facilities planning build on historical wastewater characteristics expanded to account for growth within the service area. For Klamath Falls, most growth is expected to occur from residential population within the service area and base sanitary loadings were estimated using population estimates and historical per capita contributions. Other loading factors, such as peak day and peak month, were developed based on historical peaking factors.

Base Sanitary Loading Rates

For an estimated projected serviced population of 42,000 and historical per capita contribution of 0.14 pounds per day BOD and 0.13 pounds per day TSS, the average dry weather loadings for year 2030 are 6,700 pounds per day BOD and 5,900 pounds per day TSS.

Loadings Peaking Factors

Table 5.8 and **Table 5.9** list the historical peaking factors for the Spring Street STP influent over the years 2002 through 2006, which were used to estimate other loading parameters. Except for peak day loading, design values for peaking factors were taken as the peak value for the five years of records (1 in 5 year probability). Peak day loading factor was taken as the average value over the 5 years of record. Since peak loadings do not coincide with peak flow loadings, peaking factors were developed for both peak flows and peak loading conditions. Appropriate

selection of flow rate is critical for treatment process sizing, when loadings are usually converted into concentrations.

Table 5.8 Historical BOD Influent Loading Peaking Factors for the Spring Street STP

Loading Parameter(1)	2002	2003	2004	2005	2006(2)	Average	2030 Design
$AA_{BOD}/ADWF_{BOD}$	1.2	1.3	1.3	1.2	1.2	1.2	1.2
$ADWF_{BOD}/ADWF_{BOD}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0
$MMADF_{BOD}/ADWF_{BOD}$	1.2	1.4	1.5	1.4	NA	1.4	1.5
Peak Month $BOD/ADWF_{BOD}$	1.3	1.6	1.5	1.4	1.4	1.4	1.6
Peak Day $BOD/ADWF_{BOD}$	2.4	2.7	2.5	2.7	3.2	2.7	2.7
$AWWF_{BOD}/ADWF_{BOD}$	1.2	1.4	1.4	1.2	1.3	1.3	1.4

Notes: (1) AA_{BOD}= annual average BOD; . $ADWF_{BOD}$= average BOD during average dry weather flow (May through October); $MMADF_{BOD}$= average BOD during maximum month average daily flow; Peak Month BOD = average daily BOD loading during peak month loading; Peak Day BOD = average daily BOD for the peak loading day; $AWWF_{BOD}$= average BOD during average wet weather flow;
(2) February 2006 data was deemed unrepresentative and excluded from the record.

Table 5.9 Historical TSS Influent Loading Peaking Factors for the Spring Street STP

Loading Parameter(1)	2002	2003	2004	2005	2006(2)	Average	2030 Design
$AA_{TSS}/ADWF_{TSS}$	1.3	1.3	1.3	1.2	1.2	1.2	1.3
$ADWF_{TSS}/ADWF_{TSS}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0
$MMADF_{TSS}/ADWF_{TSS}$	1.4	1.4	1.4	1.2	NA	1.4	1.4
Peak Month $TSS/ADWF_{TSS}$	1.4	1.7	1.5	1.3	1.4	1.5	1.7
Peak Day $TSS/ADWF_{TSS}$	3.4	3.6	3.6	2.4	3.7	3.3	3.3
$AWWF_{TSS}/ADWF_{TSS}$	1.3	1.4	1.3	1.3	1.1	1.3	1.4

Notes: (1) AA_{TSS}= annual average TSS; . $ADWF_{TSS}$= average TSS during average dry weather flow (May through October); $MMADF_{TSS}$= average TSS during maximum month average daily flow; Peak Month TSS = average daily TSS loading during peak month loading; Peak Day TSS = average daily TSS for the peak loading day; $AWWF_{TSS}$= average TSS during average wet weather flow;
(2) February 2006 data was deemed unrepresentative and excluded from the record.

Projected Wastewater Loadings

Wastewater loading characteristics were developed using the base sanitary flow contribution and the peaking factors in **Table 5.8** and **Table 5.9** above. **Table 5.10** and **Table 5.11** list the estimated BOD and TSS loading characteristics over the planning horizon. Nitrogen and

phosphorus loadings were estimated using the historical TKN to BOD and Total Phosphorus to BOD ratio of 0.18 and 0.04, respectively, and applying them to the appropriate flow parameters. Projected influent TKN and TP are listed in **Table 5.12** and **Table 5.13**.

Table 5.10 Spring Street STP Projected Design Influent BOD(1)

Loading Parameter(2)	Units	2010	2014	2020	2024	2030
AA_{BOD}	ppd	5,800	6,200	6,900	7,300	8,100
$ADWF_{BOD}$	ppd	4,800	5,200	5,700	6,100	6,700
$AWWF_{BOD}$	ppd	6,800	7,200	8,000	8,500	9400
$MMADF_{BOD}$	ppd	7,300	7,800	8,600	9,100	10,100
Peak Month BOD	ppd	7,700	8,300	9,100	9,800	10,700
Peak Day BOD	ppd	15,500	16,600	18,300	19,500	21,500

Notes: (1) Values rounded for clarity.
(2) AA_{BOD}= annual average BOD; . $ADWF_{BOD}$= average BOD during average dry weather flow (May through October); $MMADF_{BOD}$= average BOD during maximum month average daily flow; Peak Month BOD = average daily BOD loading during peak month loading; Peak Day BOD = average daily BOD for the peak loading day; $AWWF_{BOD}$= average BOD during average wet weather flow;

Table 5.11 Spring Street STP Projected Design Influent TSS(1)

Loading Parameter(2)	Units	2010	2014	2020	2024	2030
AA_{TSS}	ppd	5,500	5,900	6,500	6,900	7,600
$ADWF_{TSS}$	ppd	4,200	4,500	5,000	5,300	5,900
$AWWF_{TSS}$	ppd	5,900	6,300	7,000	7,500	8,200
$MMADF_{TSS}$	ppd	5,900	6,300	7,000	7,500	8,200
Peak Month TSS	ppd	7,200	7,700	8,500	9,100	10,000
Peak Day TSS	ppd	15,700	16,800	18,500	19,700	21,700

Notes: (1) Values rounded for clarity.
(2) AA_{TSS}= annual average TSS; . $ADWF_{TSS}$= average TSS during average dry weather flow (May through October); $MMADF_{TSS}$= average TSS during maximum month average daily flow; Peak Month TSS = average daily TSS loading during peak month loading; Peak Day TSS = average daily TSS for the peak loading day; $AWWF_{TSS}$= average TSS during average wet weather flow;

Table 5.12 Spring Street STP Projected Design Influent TKN

Loading Parameter(1)	Units	2010	2014	2020	2024	2030
AA_{TKN}	ppd	1,060	1,130	1,250	1,330	1,470
$ADWF_{TKN}$	ppd	880	940	1,040	1,110	1,220
$AWWF_{TKN}$	ppd	1,230	1,320	1,460	1,550	1,710

$MMADF_{TKN}$	ppd	1,320	1,410	1,560	1,660	1,830
Peak Month TKN	ppd	1,410	1,510	1,660	1,780	1,950
Peak Day TKN	ppd	2,380	2,540	2,810	3,000	3,300

Notes: (1) AA_{TKN}= annual average TKN; . $ADWF_{TKN}$= average TKN during average dry weather flow (May through October); $MMADF_{TKN}$= average TKN during maximum month average daily flow; Peak Month TKN = average daily TKN loading during peak month loading; Peak Day TKN = average daily TKN for the peak loading day; $AWWF_{TKN}$= average TKN during average wet weather flow;

Table 5.13 Spring Street STP Projected Design Influent TP

Loading Parameter(1)	**Units**	**2010**	**2014**	**2020**	**2024**	**2030**
AA_{TP}	ppd	232	248	274	293	322
$ADWF_{TP}$	ppd	193	207	229	244	268
$AWWF_{TP}$	ppd	361	386	427	455	501
$MMADF_{TP}$	ppd	290	310	343	366	403
Peak Month TP	ppd	309	331	366	390	429
Peak Day TP	ppd	522	559	617	658	725

Notes:

(1) Values rounded for clarity

(2) AA_{TP}= annual average TP; . $ADWF_{TP}$= average TP during average dry weather flow (May through October); $MMADF_{TP}$= average TP during maximum month average daily flow; Peak Month TP = average daily TP loading during peak month loading; Peak Day TP= average daily TP for the peak loading day; $AWWF_{TP}$= average TP during average wet weather flow;

Summary of Projected Wastewater Characteristics

Table 5.12 summarizes the main wastewater characteristics developed for the Spring Street STP facilities plan. These characteristics will be used for the basis of design as described in **Section 6** of the plan.

Table 5.14 Spring Street STP Projected Design Influent Characteristics (1)

Parameter	**Units**	**2030**	**Notes**
Flows			
AADF	mgd	6.2	
ADWF	mgd	5.2	
MMADF	mgd	10.4	
Peak Day	mgd	16.5	
PIF	mgd	22.0	
BOD(2)			

Parameter	Units	2030	Notes
AA_{BOD}	ppd	8,100	
$ADWF_{BOD}$	ppd	6,700	
$MMADF_{BOD}$	ppd	10,100	
Peak Month BOD	ppd	10,700	Doesn't necessarily apply to max month flow
Peak Day BOD	ppd	21,500	Doesn't necessarily apply to peak day flow
TSS(3)			
AA_{TSS}	ppd	7,600	
$ADWF_{TSS}$	ppd	5,900	
$MMADF_{TSS}$	ppd	8,200	
Peak Month TSS	ppd	10,000	Doesn't necessarily apply to max month flow
Peak Day TSS	ppd	21,700	Doesn't necessarily apply to peak day flow
TKN(4)			
AA_{TKN}	ppd	1,470	
$ADWF_{TKN}$	ppd	1,220	
$MMADF_{TKN}$	ppd	1,830	
Peak Month TKN	ppd	1,950	Doesn't necessarily apply to max month flow
Peak Day TKN	ppd	3,300	Doesn't necessarily apply to peak day flow
TP(5)			
AA_{TP}	ppd	322	
$ADWF_{TP}$	ppd	268	
$MMADF_{TP}$	ppd	403	
Peak Month TP	ppd	429	Doesn't necessarily apply to max month flow
Peak Day TP	ppd	725	Doesn't necessarily apply to peak day flow

Notes:

(1) Values rounded for clarity

(2) AA_{BOD}= annual average BOD; . $ADWF_{BOD}$= average BOD during average dry weather flow (May through October); $MMADF_{BOD}$= average BOD during maximum month average daily flow; Peak Month BOD = average daily BOD loading during peak month loading; Peak Day BOD = average daily BOD for the peak loading day; $AWWF_{BOD}$= average BOD during average wet weather flow;

(3) AA_{TSS}= annual average TSS; . $ADWF_{TSS}$= average TSS during average dry weather flow (May through October); $MMADF_{TSS}$= average TSS during maximum month average daily flow; Peak Month TSS = average daily TSS loading during peak month loading; Peak Day TSS = average daily TSS for the peak loading day; $AWWF_{TSS}$= average TSS during average wet weather flow;

(4) AA_{TKN}= annual average TKN; . $ADWF_{TKN}$= average TKN during average dry weather flow (May through October); $MMADF_{TKN}$= average TKN during maximum month average daily flow; Peak Month TKN = average daily TKN loading during peak month loading; Peak Day TKN = average daily TKN for the peak loading day; $AWWF_{TKN}$= average TKN during average wet weather flow;

(5) AA_{TP}= annual average TP; . $ADWF_{TP}$= average TP during average dry weather flow (May through October); $MMADF_{TP}$= average TP during maximum month average daily flow; Peak Month TP = average daily TP loading during peak month loading; Peak Day TP= average daily TP for the peak loading day; $AWWF_{TP}$= average TP during average wet weather flow;

Section 6
Basis of Planning

A number of general common planning factors and criteria are necessary to evaluate, compare, and recommend facilities on a similar basis. As such, common regulatory requirements and cost estimating factors were used. Because planned facilities must protect public health and preserve the quality of both surface waters and groundwater resources, a discussion on water quality impacts is also included. This Section discusses the common planning factors used for the Spring Street STP wastewater facilities following the Oregon State Department of Environmental Quality's (DEQ) recommended outline for facilities plans.

6.1 Basis for Design

6.1.1 Regulatory Requirements

Oregon Revised Statutes (ORS) are adopted, repealed and amended by the Oregon legislature and signed into law by the governor. As per Oregon state statute, no wastewater collection, treatment or disposal facilities may be constructed unless DEQ has issued a permit and has approved engineering plans, regardless of the source of funding for facilities. The following statutes apply to the planning, construction, and operation of sewage facilities:

- ORS Chapter 183 Civil Penalties; Administrative Procedures and Rules of State Agencies
- ORS Chapter 192 Public and Private Records; Public Reports and Meetings
- ORS Chapter 454 Sewage Treatment and Disposal Systems
- ORS Chapter 459 Solid Waste Management
- ORS Chapter 459a Reuse and Recycling
- ORS Chapter 465 Hazardous Waste and Hazardous Materials I
- ORS Chapter 466 Hazardous Waste and Hazardous Materials II
- ORS Chapter 467 Noise Control
- ORS Chapter 468 Environmental Quality Generally
- ORS Chapter 468a Air Quality
- ORS Chapter 468b Water Quality

In addition to Statutes, specific water quality regulations have been adopted by the Environmental Quality Commission as Oregon Administrative Rules (OARs). Facilities plans are currently required to address the following water quality regulations:

- Discharges of wastes to lakes or reservoirs may not be allowed except as provided in sections **OAR 340-041-0004(9)** and **OAR 340-41-0007(4).**

- New sources of wastewater discharge must meet specific anti-degradation criteria outlined in **OAR 340-41-0004**.

- A new or expanded discharge must demonstrate that in-stream water quality standards will not be violated as a result of the proposed discharge. These standards have been established in **OAR 340-41**.

- Effluent quality must be consistent with the minimum design criteria listed in **OAR 340-41** and the federal secondary treatment standards listed in **40 CFR, Part 133**.

- Components of existing or proposed sewage works must be evaluated to determine their impacts on groundwater quality. Examples include sludge storage ponds, wastewater treatment lagoons, constructed wetlands, irrigation disposal systems, and drainfields. If the evaluation indicates that there is potential for adverse impact, a groundwater protection program is required by **OAR 340-40**.

- Reuse of treated effluents must conform to the reclaimed water standards presented in **OAR 340-55**. If reuse of treated effluent is anticipated for irrigation purposes an OWRD registration must be completed. Biosolids management must comply with the provisions of **OAR 340-50** and the current federal biosolids management regulations.

NPDES Permit

Under the authority of the federal Clean Water Act and Oregon Revised Statute, it is DEQ's responsibility to establish and enforce water quality standards, as well as to develop wastewater discharge limits and other appropriate conditions via the issuance of a National Pollution Discharge Elimination System (NPDES) permit. The Spring Street plant NPDES permit was last issued on September 26, 1990. Conditions and limitations of the permit were presented and discussed in **Section 4** of this Facilities Plan.

This facilities plan is being developed as part of the wastewater discharge permit compliance process to identify facilities that will reliably meet current and anticipated NPDES discharge permit requirements.

TMDL Requirements

TMDLs are a requirement of the federal Clean Water Act and are required for those water bodies where pollutant concentrations exceed those levels necessary to meet adopted water quality standards. As it applies to the City of Klamath Falls, the TMDL will set pollutant load limits for the Spring Street facility such that the facility will not contribute to in-stream water quality standards violations.

Stormwater Discharge Permit

Under phase 2, the Clean Water Act requires stormwater discharge permits for urbanized areas with a population of more than 50,000 and, at the discretion of the State, for those with a population more than 10,000. These are commonly referred to as MS4 permits. Since the population of the Klamath Falls urbanized area is not expected to exceed 50,000 within the planning horizon of this Plan (see **Section 5**), an MS4 permit is not expected to be required in the foreseeable future and was not included in this Plan. Although the population does exceed 10,000, DEQ, at this time, has determined not to require a MS4 permit.

Solid Waste Disposal

The Spring Street STP currently produces Class A biosolids via their composting facilities. None of the biosolids are disposed on site; therefore, no solid waste disposal permit is currently required for biosolids. Only alternatives ultimately producing Class A biosolids are considered

for this facilities plan. Class I biosolids are deemed safe under federal regulations for distribution to the general public for use as fertilizer and soil amendment.

A solid waste disposal agreement with the local landfill is required for grit and screenings. The landfill will serve as a backup for biosolids disposal if composting cannot continue to process all biosolids. It is possible that biogas treatment may be added in the future and spent media would be disposed of in a landfill.

Dam Safety Evaluation of Lagoon

Spring Street STP operates a lagoon for digested sludge storage, and may continue to have a lagoon in the future. Oregon dam safety requirements are not likely to be applicable to this facility due to sizing criteria.

6.1.2 Effluent Quality

Base Case – Antidegradation Policy

Each alternative evaluated was developed to meet, as a minimum, the requirements of the applicable NPDES permit within the limits of DEQ's Antidegradation Policy. For wastewater treatment facilities, abiding to the policy (OAR 340-041-0026(1)(a)) means that, unless otherwise approved, increasing flows and loads need to be accommodated with increased efficiencies to limit mass discharges to the water bodies to the current levels. Therefore, the less stringent effluent discharge conditions for the City are dictated by the current NPDES permit mass limitations. Because of increased projected flows, this represents lower effluent concentrations than what is currently allowable. Effluent quality goals meeting the requirements of the Antidegradation Policy are used as the base case in the alternatives developed for this Facilities Plan.

Other Effluent Quality Scenarios

Because of the uncertainty of the TMDLs being developed for the Klamath Basin, various effluent disposal options meeting different discharge criteria were developed and evaluated in the *Effluent Disposal Options Technical Memorandum* (Appendix C). However, effluent disposal options that would take the effluent out of Lake Ewauna would be in response of strict TMDLs that could not be met even with an increased level of sophistication, or with facilities that could not be afforded by the City. The approach in this facilities plan is thus to define increasing levels of effluent quality while alternatives are developed so as not to preclude the inclusion of future upgrades to meet these stricter levels. The four treatment levels listed in **Table 6.1** thus correspond to effluent quality levels that are typical and achievable with current available technology.

Table 6.1 Effluent Quality Assumptions - Monthly Averages

Level of Treatment	$cBOD_5$ mg/L	TSS mg/L	TIN mg/L	TP mg/L	NTU	Coliforms cfu/100ml
Status Quo – Antidegradation Policy	23(1) 23(2)	23(1) 23(2)	-	-	-	126 (E. Coli)
Reuse - Unrestricted(3)	5(4)	5(4)	-	-	2	2.2 (Total)
Conventional Nutrient Removal (NR-1)	10	10	10	1	-	126 (E. Coli)
Stringent Nutrient Removal (NR-2)	10	10	3	0.1	-	126 (E. Coli)

Notes:

(1) Based on 1,500 ppd BOD and TSS current max month mass discharge limit during average wet weather flow (November through April) , applied to projected average wet weather daily flow (AWWF) of 7.8 mgd in year 2030 (Table 5-4). Should the limit be applied to the projected maximum month average daily flow of 10.4 mgd, the target concentration would be 17 mg/L.

(2) Based on 1,000 ppd BOD and TSS current max month mass discharge limit during average dry weather flow (May through October) , applied to projected average dry weather daily flow (ADWF) of 5.2 mgd in year 2030 (Table 5-4).

(3) Based on treatment level IV as defined by OAR 340-55.

(4) Numeric concentration limits for BOD and TSS are not usually given, however 5/5 mg/L is the practical level that must be achieved to meet a2 NTU turbidity standard.

6.1.3 Treatment Effectiveness

Treatment effectiveness can be defined as the ability of the processes to operate correctly and proficiently. In terms of overall processes, the effectiveness represents the ability to remove specific compounds from the wastewater based on the effluent quality sought. On a unit process scale, the required treatment effectiveness may vary depending on the downstream and upstream processes. Within this context, each technology or process evaluated in **Section 7** defines a minimum level of effectiveness. These levels are listed in a Basis of Design data table. The effectiveness of overall alternatives developed in this Plan will vary depending on the effluent quality sought, while unit processes were developed in the context of each alternative.

6.1.4 Plant Reliability Criteria

As presented in **Section 4** of this Facilities Plan, the reliability class of the Spring Street Wastewater Treatment Plant (SSWTP) is determined by EPA Publication 430-199-74-001 *Design Criteria for Mechanical, Electric, and Fluid System and Component Reliability.* Many reliability improvements were completed in 2001, however, as presented in **Table 4.7**, several improvements are still needed in the existing Spring Street STP to meet the requirements of Reliability Class I.

All alternatives in this facilities plan were developed to at least meet Reliability Class I requirements, while pumps and processes were sized conservatively and with redundant units

during to maximize reliability. Specific redundancy criteria are indicated for each unit process or technology evaluated in **Section 7**.

6.1.5 Design Concepts and Constraints

The development of alternatives in this facilities plan was based on a number of common general design concepts and constraints, from the length of the planning period to seismic zone consideration, to the appropriateness of the alternatives for the specific treatment plant and staff.

Planning Period
This document addresses a 20-year planning period, from 2010 (expected construction start up) to 2030.

Seismic Conditions
Klamath Falls is located in Seismic Zone 3 as defined by the Uniform Building Code. All structures, piping, and equipment anchorage were developed to be designed to withstand the seismic forces as required by the code for Zone 3.

Groundwater Table
High groundwater levels were assumed, requiring dewatering during construction. This assumption will need to be confirmed during design, as there is indication that the soil is fairly impermeable.

Geotechnical conditions
Actual soil conditions will need to be confirmed during design. For this plan, poor soil bearing capacity was assumed, requiring pilings for new construction. Piles similar to existing pilings were assumed for cost estimating of new tanks and buildings.

Flexibility
Flexibility expands on the requirements of reliability, by providing the ability to take units out of service for maintenance without overloading the units remaining in service, and allowing for future addition of treatment units with minimum interference in plant operations.

Given the uncertainty of the TMDL development process and required effluent quality, alternatives that are most flexible were developed and favored for the Spring Street STP. Fortunately, the plant benefits from a large available footprint for expansion.

Plant Water
Water supply is a critical resource. Use of nonpotable, treated effluent was favored for landscaping, flushing, and similar purposes where public contact is minimal and potable water is not required.

Automation
Automated process controls are usually provided whenever reliable, consistent operation can be obtained with significant cost savings over manual operation. Automated controls also can be used for gathering and reporting data for regulatory requirements. The appropriate level of automation for a given plant is also a function of the plant staff's philosophy and level of

comfort with the technology.

Geothermal Availability
Geothermal energy currently is used for digester heating in the winter. Geothermal energy is available on-site, and the facilities plan will consider opportunities to use this unique site specific energy source and distribution system.

Operational Considerations
One size never fits all, and the success of a wastewater facility is also strongly dependent on operational considerations and a specific agency's philosophy. Complex technologies that maximize flexibility may create a burden because of the additional training and staff unfamiliarity. Operational considerations include those that affect operators or the public, including minimization of odors and noise, equipment, access, health and safety measures, including locker and day room facilities, handrails, number of stairs, lifting weight of covers and small equipment, etc. Finally, plant staffing schedules have a significant impact on the selection and/or level of automation of unit processes, especially for solids processing.

Alternatives developed for this facilities plan were developed to reflect Klamath Falls' preferences regarding operational considerations, and, where complex processes were evaluated and developed, the need for additional training and support was considered. For Klamath Falls, it was assumed that the plant would normally be staffed up to 7 days a week, 10 hours a day.

6.1.6 Unit Design Considerations

Specific design considerations are tabulated and described for each unit process in Section 7.

6.2 Basis for Cost Estimate

After preliminary screening of treatment alternatives (see **Section 7**), estimates of probable costs for four overall plant alternatives were developed. For this planning level, a number of common economic criteria were used and are described below.

6.2.1 Construction Costs

Construction costs for the shortlisted alternatives are based on conceptual plant layouts. Cost estimates were prepared using construction costs of similar treatment plants, ASCE cost curves, and EPA design manuals. Additionally, the construction costs were evaluated against CDM's recent experience in the design, bidding and construction of similar projects as well as quotations from local suppliers and contractors. An escalation factor of 6% at midpoint of construction was used to inflate the costs at midpoint of construction.

6.2.2 Contingencies

The limitations of cost estimates based on conceptual designs require that we allow for variation in final lengths and depths of pipelines and other structures. We must also consider adverse construction conditions, and other presently unforeseeable difficulties that tend to increase the final construction cost. For this planning document, a variation of -20 percent to +50 percent of the estimated construction cost should be expected. Estimates of probable cost generated for this plan include a +30% contingency factor.

6.2.3 Engineering

The cost of engineering services for major projects typically includes special investigations, a predesign report, surveying, foundation exploration, preparation of contract drawings and specifications, construction management, start-up services, and preparation of operation and maintenance manuals. Depending on the size and type of project, engineering costs may range from 10 to 15 percent of the contract cost. This percentage was adjusted for the specifics of each alternative.

6.2.4 Environmental, Legal and Administrative

The City of Klamath Falls has its own administrative costs associated with any major construction project. These costs are associated with internal planning and budgeting, the administration of engineering and construction contracts, legal services, and liaison with regulatory and funding agencies. Based on a typical project similar in size and scope to the works described in this report, the administrative costs to the City of Klamath Falls is estimated to be about 2 to 4 percent of the contract cost. With the addition of environmental and legal costs, the total allowance for each alternative was assumed to be 10 to 12 percent of the contract cost.

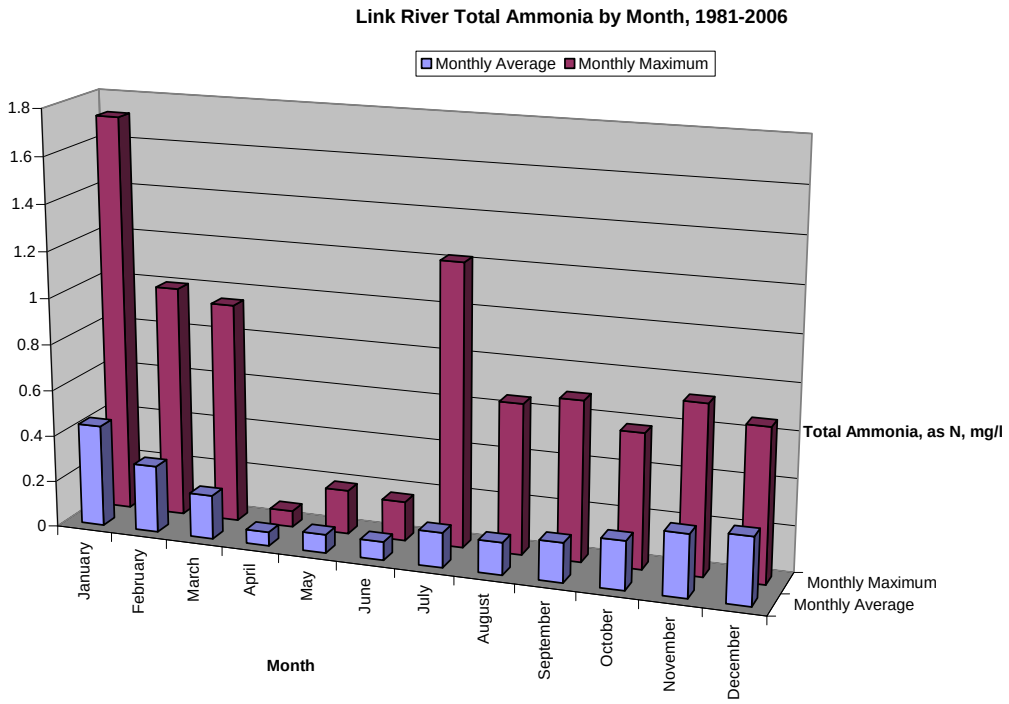
In this plan, engineering, environmental, legal and administrative costs were estimated together at 25 percent of the total construction cost.

6.3 Water Quality Impact

6.3.1 Background Water Quality Data on the Receiving Stream

With respect to water resources, the Klamath Basin is one of the more intensely managed of Oregon's basins. Out-of-stream agricultural uses and in-stream uses for fish protection are, perhaps, the major competitors for water while forestry, transportation, hydroelectric, tribal, municipal, and wildlife refuge management interests also have water demands.

Water quality in Lake Ewauna and in the Klamath River is dominated by the poor quality water flowing down Link River from Upper Klamath Lake. Upper Klamath Lake is highly eutrophic, creating high concentrations of algae. As the outflow from Upper Klamath Lake tumbles down Link River, some of the algal cells break apart, releasing ammonia-nitrogen and phosphorus. The released ammonia-nitrogen and phosphorus provide a nutrient source for additional algal growth in Lake Ewauna and the Klamath River. In addition, the ammonia, in combination with high, day time pH levels caused by algal growth, creates extremely toxic conditions for fish and



other aquatic life. During the night when no sunlight exists to drive the photosynthetic process that promotes algal growth, the algae respire, reducing in-stream oxygen concentrations to near zero at the bottom of the river. The decaying of dead algae also contributes to the depletion of oxygen in the water.

Figure 6.1 shows the ammonia levels in Link River. Data are from Oregon DEQ water quality database.

Figure 6.1 Link River Ammonia by Month, 1981-2006

Figure 6.2 and **Figure 6.3** demonstrate the diurnal fluctuation in dissolved oxygen and pH in the Klamath River at Keno, which is down stream from Klamath Falls. These data are also from Oregon DEQ water quality data base.

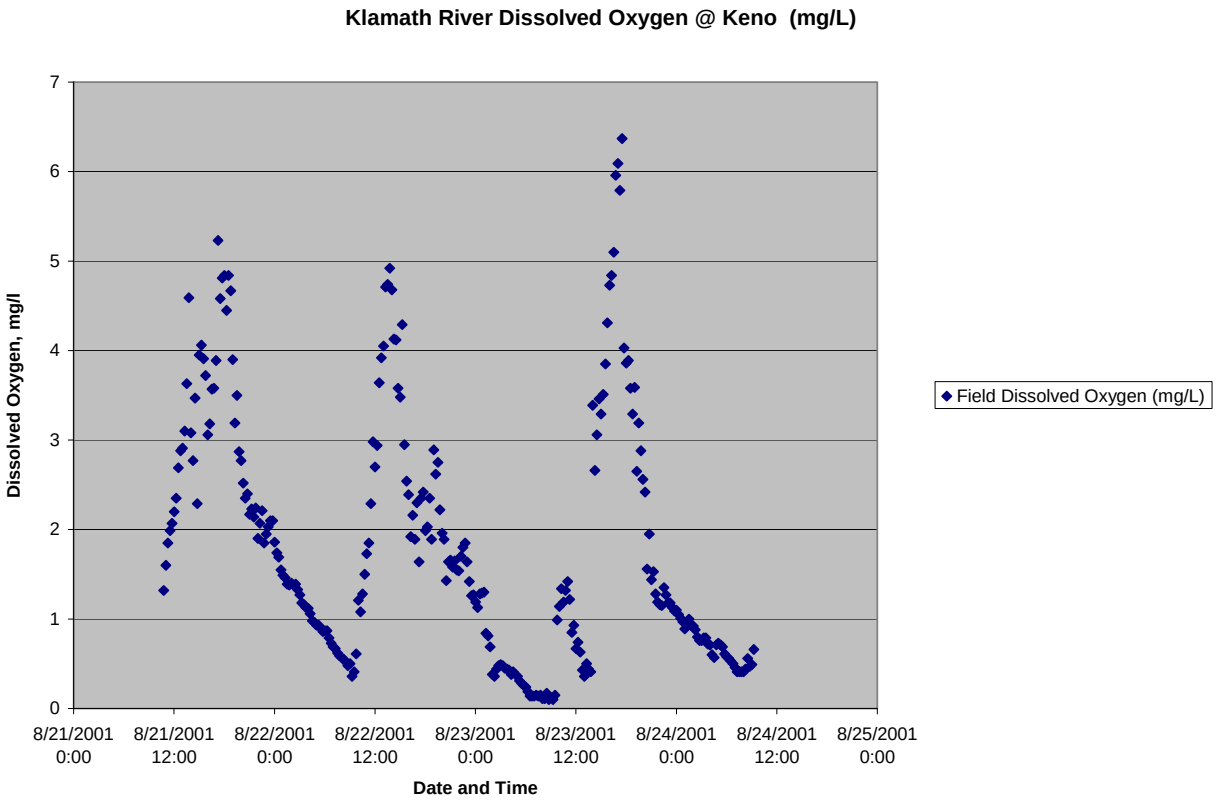


Figure 6.2 Klamath River Dissolved Oxygen at Keno

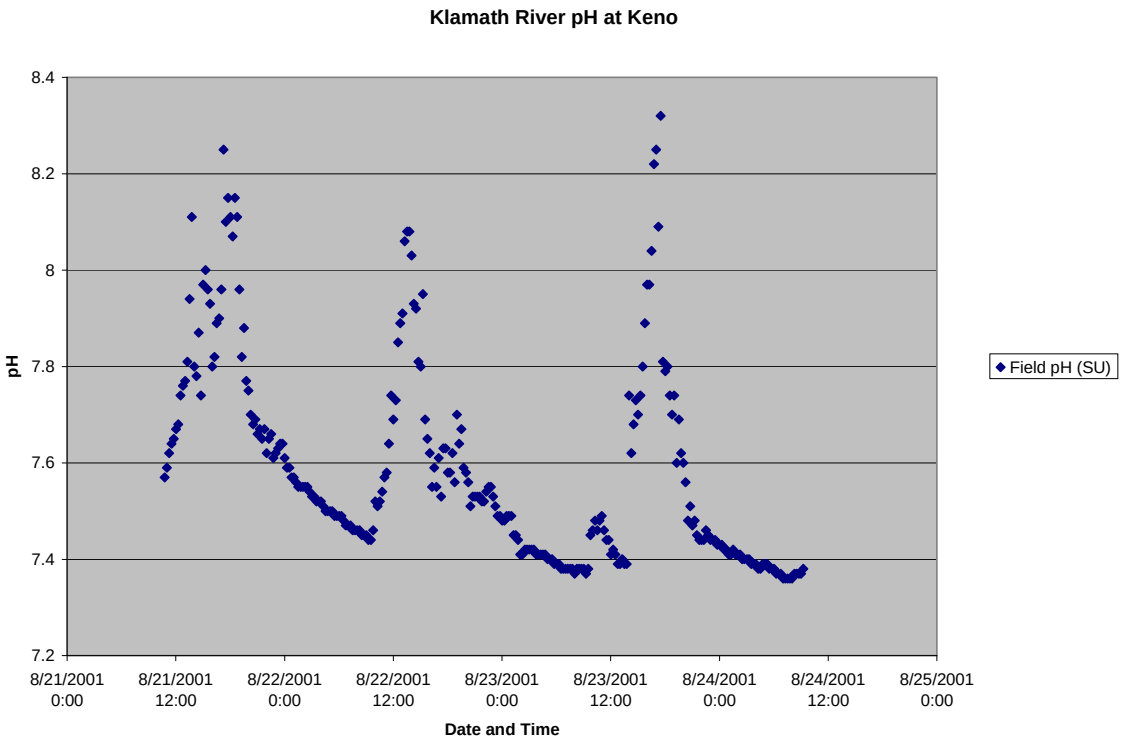


Figure 6.3 Klamath River pH at Keno

In addition to the specific water quality data reflected in the graphs above, Oregon DEQ also uses the Oregon Water Quality Index (OWQI) to indicate general water quality. The OWQI is a single number that expresses water quality by integrating measurements of eight water quality variables (temperature, dissolved oxygen, biochemical oxygen demand, pH, ammonia & nitrate nitrogen, total phosphorus, total solids, and fecal coliform). Its purpose is to provide a simple and concise method for expressing the ambient water quality of Oregon's streams for general recreational use, including fishing and swimming. The OWQI, originally developed in the 1970s, has been updated over the years based upon improved understanding about water quality behavior.[1] **Table 6.2** below demonstrates the generally poor water quality of the Klamath River.

Table 6.2 Klamath Basin OWQI (Oregon DEQ online database)

Site	Summer Average	Fall, Winter, Spring Average
Link R. @ Mouth(Entrance to Lake Ewauna)	34	73
Klamath R. @ Keno	28	52
Klamath R. d/s Big Bend Powerhouse	60	65

Summer: June - September; FWS (Fall, Winter, & Spring): October - May

Scores - Very Poor: 0-59, Poor: 60-79, Fair: 80-84, Good: 85-89, Excellent: 90-100

[1] Curtis G. Cude, *Oregon Water Quality Index: A Tool for Evaluating Water Quality Management Effectiveness*, Journal of the American Water Resources Association, Volume 37, Number 1 (AWRA Paper Number 99051), February 2001, pages 125-137.

To address the poor water quality in Lake Ewauna and the Klamath River, Oregon's Department of Environmental Quality has worked with local water users groups and various federal, state (Oregon and California), and local agencies for several years to develop a Total Maximum Daily Load (TMDL) for nutrients and for other pollutants in the river. Due to the complexity of the river system and the difficulty in establishing background conditions, this TMDL has been particularly difficult to complete. TMDLs are a requirement of the federal Clean Water Act and are required for those water bodies where pollutant concentrations exceed those levels necessary to meet adopted water quality standards. In the most simplistic terms, a TMDL is a pollutant budget in which pollutant discharges are allocated to all sources (including natural sources) such that the total pollutant load is low enough so as to not violate in-stream water quality standards. As it applies to the City of Klamath Falls, the TMDL will set pollutant load limits for the Spring Street facility such that the facility will not contribute to in-stream water quality standards violations. These limits will be inserted into the next NPDES permit issued for the Spring Street facility.

The next NPDES permit may address other pollutants, such as toxic metals, that were not addressed in the TMDL process or in the previous permit, but have been determined by DEQ to have a reasonable potential to exceed in-stream water quality standards. Reasonable potential will depend upon the level of a specific pollutant in the Spring Street effluent and existing background concentrations in the Klamath River.

Table 6.3 contains the current, available water quality data for Link River. Some of the listed contaminants are considered toxic by Oregon DEQ and have established, in-stream water quality standards.

Table 6.3 Link River Toxics Data (Oregon DEQ online database)[(a)]

		Date						
Compound	Units	Nov 1979	Dec 1979	Jan 1980	Mar 1980	May 1980	July 1980	Aug 1980
Alkalinity as $CaCO_3$	mg/L	53	53	48	44	45	45	47
As	mg/L	0.005				0.005		0.006
Ba	mg/L	<0.1				0.14		<0.1
B	mg/L	<0.2				<0.2		<0.2
Cd	mg/L	<0.001				<0.001		<0.001
Ca	mg/L	7.6				7.5		7.4
Cl^-	mg/L	4	3	3	3	2	3	3
Cr	mg/L	<0.05				<0.05		<0.002
Cu	mg/L	<0.05				<0.05		<0.002
F^-	mg/L	0.1				0.1		0.1
Fe	mg/L	0.36				0.47		0.29
Pb	mg/L	<0.01				<0.01		<0.01
Mn	mg/L	<0.02				<0.02		0.03

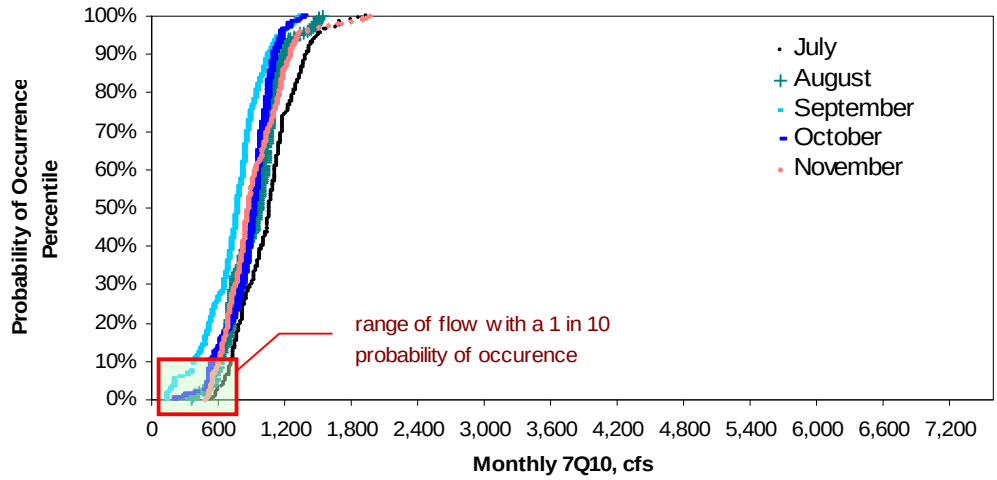
Link River Toxics Data (Oregon DEQ online database)[(a)] (cont.)

Compound	Units	Date						
		Nov 1979	Dec 1979	Jan 1980	Mar 1980	May 1980	July 1980	Aug 1980
Hg	mg/L	<0.0005				<0.0005		<0.0005
Se	mg/L	<0.005				<0.005		<0.005
Ag	mg/L	<0.01				<0.001		<0.001
Zn	mg/L	<0.01				<0.01		<0.01

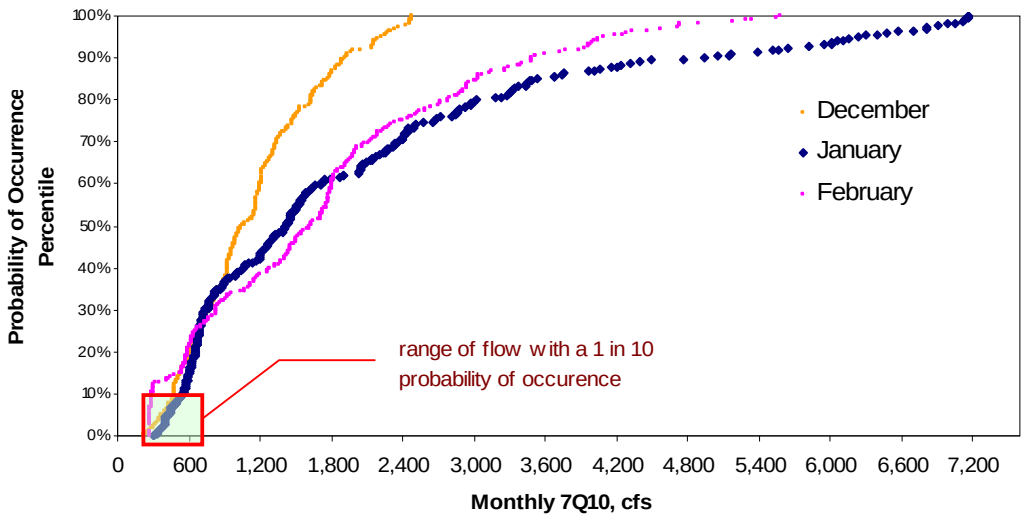
Notes:

(a) from station 10768 at Link River's mouth.

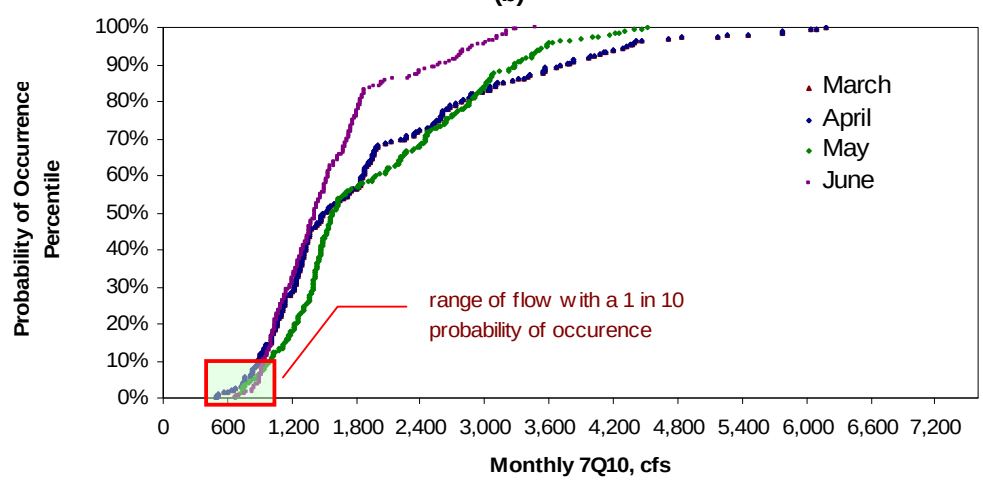
As described in **Section 3** of this Facilities Plan, the flow in Link River is maintained at higher levels early in the summer, and at reduced rates late in the summer. These patterns are illustrated in **Figure 6.4 (a)(b)(c)**. Because of this flow regulation, the most critical period for treatment plant effluent quality may be during the months of September and October when cooler temperatures slow the treatment plant's biological system's efficiency while dilution from the river will be at its lowest. **Figure 5.1** illustrates these various seasonal characteristics. Depending on water quality goals, recognizing the impact of river flow may have an influence on wastewater process sizing and configuration. DEQ is familiar with writing flexible NPDES permits in recognition of site specific conditions (an example is a recent permit developed for Clean Water Services). The extent of the river flow impact is evaluated during alternatives development in **Section 7**.



(a)



(b)



(c)

Figure 6.4 (a)(b)(c) Link River Monthly 7Q10 Flow Probability Analysis (1997-2006).
Effluent discharge must be related to river flows which vary during the year.

6.3.2 Water Quality Impacts from Existing Sewerage Facility

Although the major water quality problems in Lake Ewauna and the Klamath River are due to excessive nutrients, the contributions from the Spring Street sewerage facility is quite small compared to that contributed by Upper Klamath Lake and other sources. According to a mass balance analysis conducted and documented by Brown and Caldwell in a technical memorandum dated June 23, 2006, the Spring Street sewerage facility contributes between two and three percent of the total phosphorus found in Lake Ewauna and less than one percent of the total nitrogen.

Nevertheless, DEQ's TMDL may require a reduction in total nutrients discharged from Spring Street if the river water quality modeling shows that the discharge contributes to in-stream water quality standards violations at any point down-stream.

In addition to the far-field water quality issues being addressed in the TMDL, this facility plan will also need to address possible water quality standards violations associated with inadequate mixing at the outfall. DEQ's regulations prohibit the creation of acute toxicity outside a zone of initial dilution (ZID) and prohibit chronic toxicity outside a regulatory mixing zone set forth in the NPDES discharge permit. The existing outfall discharges treated effluent from the Spring Street sewerage facility into Lake Ewauna in a quiescent section that is also fairly shallow. As a result, there is little mixing of effluent with the ambient water of the lake and river. Because of the more concentrated toxic metals concentration in the return flow from the cogeneration facility and because of ammonia in the treated effluent, toxic conditions may be occurring in the vicinity of the outfall. These conditions will have to be addressed in the selected alternative proposed in this facility plan either by advanced treatment, with a new outfall that is designed to provide much better mixing with the river or both.

6.3.3 Water Quality Impacts from Proposed Alternative Wastewater Control Systems

Water quality impacts from the various wastewater control alternatives will be discussed in **Section 7** of this facility plan.

6.4 Design Capacity of Conveyance System and Wastewater Treatment Plant

6.4.1 Conveyance System

Design capacity of the City of Klamath Falls conveyance system can be found in the December 2006 *Wastewater Collection System Master Plan* prepared by Brown and Caldwell.

6.4.2 Wastewater Treatment Plant Facilities

Design flows and loads over the planning horizon are listed in **Section 5** of this facilities plan.

6.4.3 Seasonal Land Irrigation

At this time, no seasonal land irrigation is used by Spring Street Land Irrigation. Potential for seasonal irrigation is discussed in the *Effluent Disposal Option Technical Memorandum*, in Appendix C.

Section 7
Development and Evaluation of Alternatives

Combined with an aging infrastructure, the City of Klamath Fall's Spring Street Sewage Treatment Plant (STP) faces increased flows and loads and more restrictive discharge permit limits. Facilities' improvements are driven by the following:

- Reliability needs, dictated both by aging facilities and by EPA Reliability Class I requirements
- Growth needs, related to increasing flows and loads due to population increase
- Permitting needs, related both to TMDLs and water quality standards
- Operational needs

Figure 7.1 breaks down upgrades to the existing facilities by unit process according to reliability needs, physical integrity needs, growth needs, and operational improvement needs. As shown in **Figure 7.1**, several improvements to the existing facilities are required without consideration for TMDLs or water quality, due to growth, reliability, and/or operational needs.

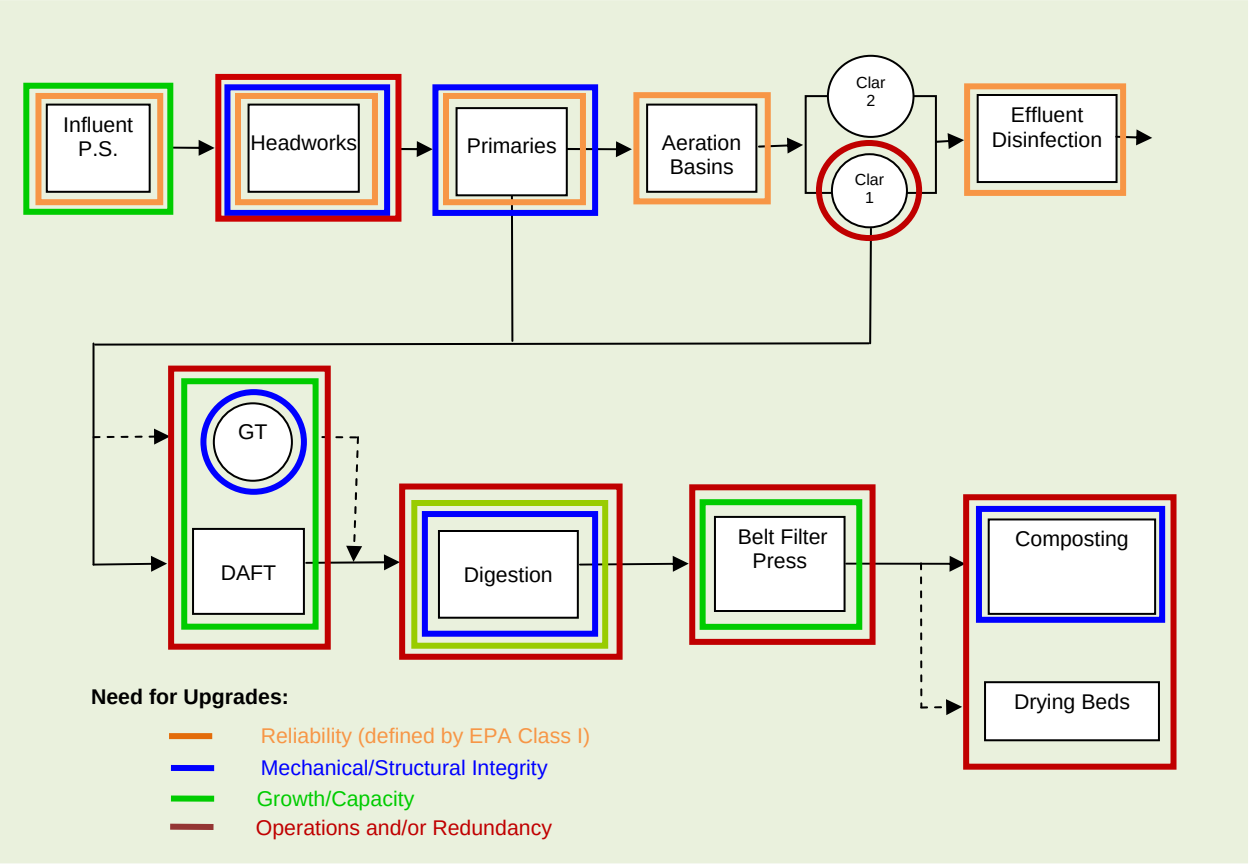


Figure 7.1 Spring Street STP Existing Unit Process Deficiencies that are Independent of the TMDL Outcome

This Section of the Facilities Plan presents and compares unit process alternatives developed to address the deficiencies highlighted in **Figure 7.1** as well as the expected TMDLs. As with other sections in this Plan, the outline largely follows the outline in DEQ's *Guidelines for Facilities Plan* and sequentially goes through Conveyance, Liquid Stream, Effluent Disposal, and Biosolids Management alternatives.

Methodology for Evaluation

In **Section 7.1** through **Section 7.4**, alternatives are presented and compared sequentially on a unit process basis. For each unit process, such as headworks or sludge thickening, a brief description of the existing system is given that highlights specific deficiencies for which a list of options is presented. To compare options, pros and cons are listed along with estimated total project costs and annual costs. A recommendation is given for the unit process based on this preliminary screening. **Section 7.5** describes other recommended upgrades.

In **Section 7.6** and **Section 7.7**, based on the preliminary screening and other considerations, two plant-wide alternatives are compared side by side to arrive at a final recommendation for the complete plan.

7.1 Conveyance System Alternatives

Information contained in this conveyance subsection is a summary of the 2006 Wastewater Collection Master Plan and included for reference only. The reader is referred to the original document for details.

7.1.1 Basic Alternatives

The alternatives and recommendations developed in the Collection Master Plan were made both on conveyance system and pump stations. These alternatives are described below.

Conveyance

The 2006 Wastewater Collection System Master Plan contained five improvement alternatives based on service level objectives for the City:

- Alternative 1 – Pipe Replacement Sized for Q/Qm(1) < 0.75
- Alternative 2 – Pipe Replacement Sized based on hydraulic grade line (HGL)(2)
- Alternative 3 – Relief Sewers
- Alternative 4 – Lake Ewauna Diversion
- Alternative 5 – Basin View Flow Splitting (Diversion from Basin 15-18 to Basins 4 and 5)

Notes:
(1) Q/Qm = ratio of maximum modeled flow to pipe capacity
(2) HGL is defined by the elevation to which water would rise in an open pipe, or manhole.

Pump stations were evaluated with regard to their condition and suitability for long-term use in the wastewater collection system. Condition assessments of the pump stations were conducted by interviewing City O&M staff and inspecting each station while pump run-time meter data was reviewed to provide an indication of the pump capacity. Condition ratings were then given for each pump station illustrated in **Figure 7.2**, with "H" for High Priority, "M" for Moderate Priority, and "L" for Low Priority.

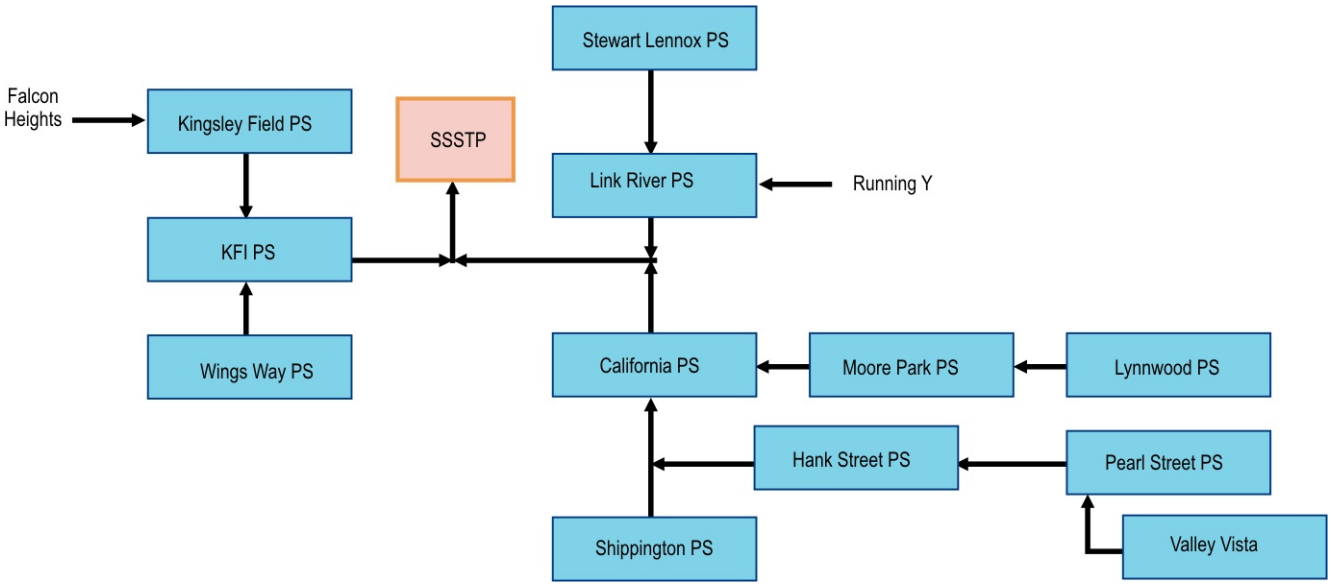


Figure 7.2 City of Klamath Falls Service Area Pump Station Relationship Schematic (adapted from 2006 Collection System Master Plan)

7.1.2 Selection

A priority ranking process was taken to develop, prioritize, and phase conveyance system capital improvement projects for the City. The Master Plan notes that updates to the priority ranking will need to be updated as more complete information on the condition of the collection system is obtained, as the priorities were mainly identified based on hydraulic deficiencies while structural and operational condition of the sewer system were largely unavailable. As such, the recommended collection system improvements focused on addressing deficiencies in Basins 1, 11, and 20 in the next few years and totaled $ 7.3 M reported on a September 2008 basis (from **Table 8.2** of the Sewer Plan, recommended upgrades total $5.7 M in December 2006).

Upgrades to the following five pump stations ranked high in priority:

- California :

  Largest pump station operated by the City, constructed in the 1960s and rehabilitated in 1999. Currently houses one 700 gpm and two 2,800-gpm pumps equipped with VFDs. Failure would lead to overflow into storm drain, A-Canal, and Lake.

  Ranked high in priority because it serves a critical service area that includes five pump stations. The structure is old and has poor maintenance access. Pump station is operated at high head due to depth, and has the highest run time of all City pump stations.

- Link River:

  Below grade pump station constructed in 1983, with a 30-foot deep access tube and three constant-speed, 1,050-gpm pumps. The influent sewer is 22 feet deep.

  Ranked high in priority because it serves a large service area with expected growth, while it already experiences a high run time. Pump station will be difficult to expand due to package station.

- Pearl Street:

  Below grade package pump station with three 350-gpm pumps. Station is over 25 years old. All pumps operate during high flows. Previous failures have caused property damage.

  Ranked high in priority because it serves a large service area while already experiencing a high run time and requiring all pumps operating at high flows. Expansion will be difficult due to the package station configuration.

- Hanks Street:

  Below grade package pump station with three 950-gpm constant speed pumps, constructed in 1978 as a package station. Pump vibration has been reported by City staff. Previous failure of the pump station has caused property damage along Hank Street.

  Ranked high in priority because it serves a large service area, presents potential for property damage, and requires confined space entry for maintenance. Expansion will be difficult due to the package station configuration.

- Shippington:

  Oldest pump station in the City, constructed in the 1920s, equipped with two 350-gpm pumps that were moved from the Hanks Street pump station in the 1990s. A wet well bubbler failure in 2004 caused considerable property damage in a new building.

Although the capacity of the pump station seems adequate, it ranked high in priority for significant electrical and fire code deficiencies (wet well opens into the electrical room; although not specified in the Master Plan, it is assumed that the electrical equipment is neither explosion-proof rated nor the room fully ventilated). The pumps are connected to the piping system via flexible hoses, presenting a risk of failure.

Costs for these pump station upgrades were not included in the 2006 Sewer Plan, but the City should consider at least $500,000 to $2,000,000 total project costs for each upgrade, more for total pump station replacements and depending on the level of controls desired.

7.2 Liquid Stream Treatment Alternatives

Liquid stream treatment is generally comprised of preliminary treatment, primary treatment, biological/secondary treatment, and disinfection. **Figure 7.3** illustrates the existing Spring Street STP Liquid Stream Flow Schematic, and will be referenced throughout the section.

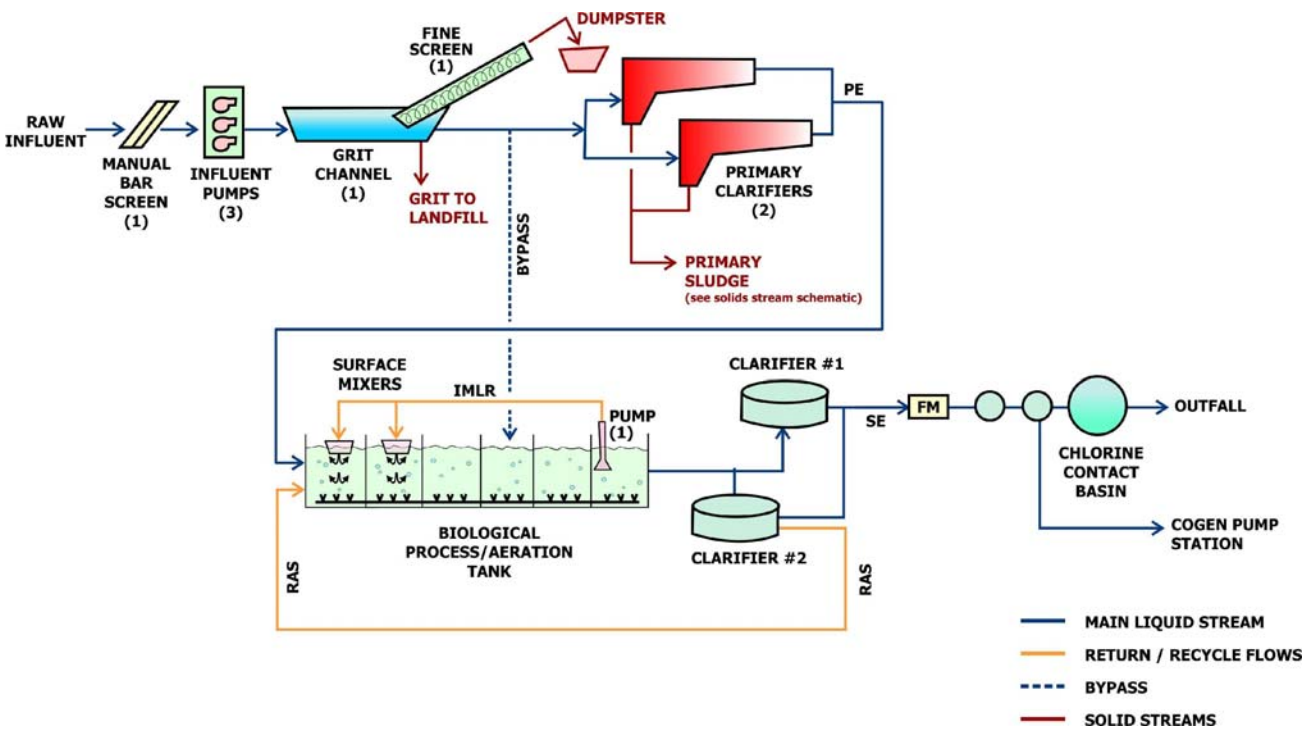


Figure 7.3 Existing Spring Street STP Liquid Stream Flow Schematic

Where discharge requirements are stringent, an additional liquid polishing treatment may be required, called tertiary treatment. Tertiary treatment can be applied either before or after disinfection, but is generally accomplished before disinfection to reduce interference from suspended solids in destabilizing/killing bacteria.

In this Section, the following major unit processes were considered in this order, as appropriate for the Spring Street facility:

- Headworks (influent pumping, raw screening, and grit removal)
- Primary Treatment
- Secondary Treatment
- Tertiary Treatment
- Disinfection

While this Facilities Plan was under progress, TMDL and water quality standards were still under discussion, with Draft allocations shared by DEQ in May 2008. As a result, alternatives were first developed to accommodate 4 different levels of effluent quality, ranging from the status quo to very stringent nutrient levels. The latest indications from DEQ then pointed to imposing year-round permit limits with some level of ammonia and phosphorus removal, and the alternatives and evaluations were adjusted accordingly. Alternatives were considered based on the following:

- Flows and loads as projected in **Section 5**
- Conventional nutrient removal requirements to achieve full nitrification

Several options were developed for each unit process, as shown in **Figure 7.4**. Note that cost estimates were developed with the cost factors and assumptions given in **Section 6** of this Plan.

Headworks	Primary Clarification	Biological Treatment	Tertiary Treatment	Disinfection	Effluent Disposal (*)
Expand Existing	Upgrade + 1 New	CAS	Chemical Addition Only	New Chlorine Contact Basin	Existing
Add Wet Weather PS	Replace in Same Location	SAS	Disk Filtration	In-Line UV	New Outfall (Hwy 97)
New HW - Upstream Screen	New in New Location	MBR-SAS	Sand Filtration		No Discharge
New HW - Downstream Screens	No Primary Treatment	IFAS			
	Chemically Enhanced	COxD			
	High Rate/Ballasted				

(*) Effluent Disposal Option are discussed in Section 7.3

Figure 7.4 Matrix of Liquid Stream Options Evaluated

In the following subsections, the options are described for each unit process, followed by a table of pros and cons. A final recommendation is made for each unit process. Financial costs were determined only for the options considered to be most viable and short-listed as candidates for the final recommendation.

7.2.1 Headworks

Existing System

As shown in **Figure 7.3**, the existing headworks include an influent pump station, manual bar screening, open channel degritting, and fine screening. Main deficiencies at the headworks include:

- Lack of redundancy and firm capacity at the influent pump station (IPS)
- Lack of redundant screen
- Structural deficiencies at the grit channel
- Relative poor condition of MCC cabinet

Alternatives

Alternatives were developed to address the IPS, screening, and degritting deficiencies. Although primary sludge degritting was considered as an alternative for all headworks improvements, this alternative was eliminated because of the very low primary sludge concentration it would yield, essentially tripling or quadrupling the sludge flow, and the associated burden on the sludge thickening facilities. Four full-scale options to expand the current capacity of the existing headworks were further explored:

Option 1- Expand the existing headworks

Option 2 - Add a wet weather pumping station

Option 3 - Build an all new headworks with screens before the pumps

Option 4 - Build an all new headworks with screens behind the pumps

Unit Process	Headworks
Option 1	Expand Existing
Option 2	Add Wet Weather PS
Option 3	New HW with Upstream Screen
Option 4	New HW with Downstream Screens

Each option is discussed below.

Option 1. Expand the Existing Headworks

Figure 7.5 shows the process schematic for this option. Expansion of the existing headworks will require addition of two new 11 mgd pumps inside the existing structure to meet firm capacity requirements in 2030. To limit cavitation and vortexing, and properly proportion flow, wet well modifications will need to be designed and constructed. The wet well modifications will address current poor suction on the inlet side and will provide the necessary physical access for maintenance.

In addition to wet well modifications, a new electrical building will be required to house the MCC and VFDs for the new pumps. The existing MCC cabinet is in poor condition and will need to be replaced as part of the electrical upgrade.

The grit channel will require structural upgrades to address cracks in the channel and separation at the expansion joints. The existing Helisieve has a 9 mgd capacity. When flows exceed 9 mgd, flows are bypassed directly to the primaries. Although space exists for an additional unit, the largest Helisieve currently available on the market is only 7 mgd, which would not provide enough capacity to pass the projected peak hydraulic flows. For this alternative, and to fit within the existing channel while providing the full hydraulic capacity, the existing Helisieve would need to be decommissioned, removed, and replaced by two new climbers or chain driven screens. The new climber screens would be installed within the existing split channel. Contact with manufacturers indicate that two 20 mgd units could be installed within the existing channel

Screen washer compactors will be included to reduce the head loss of the existing unit.

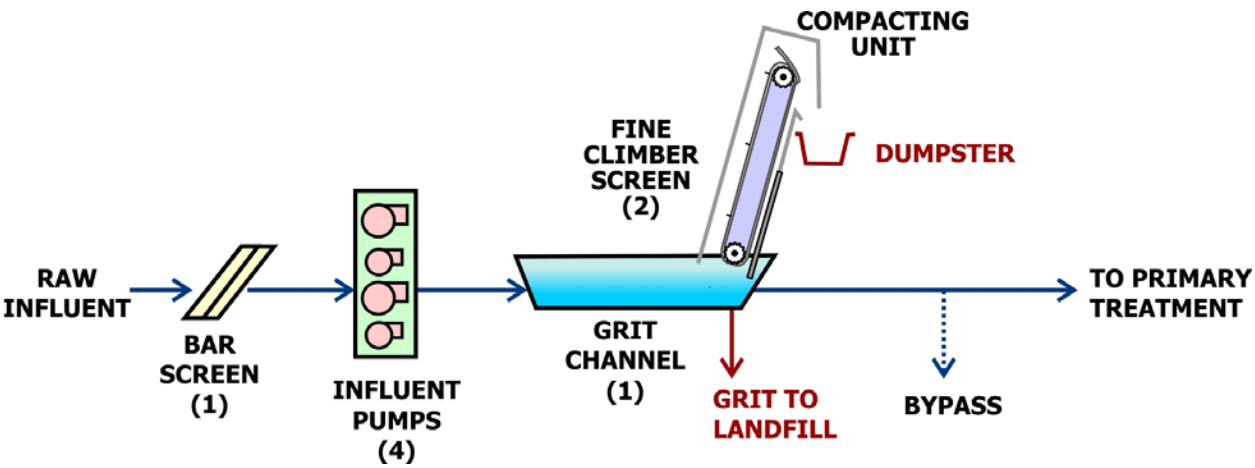
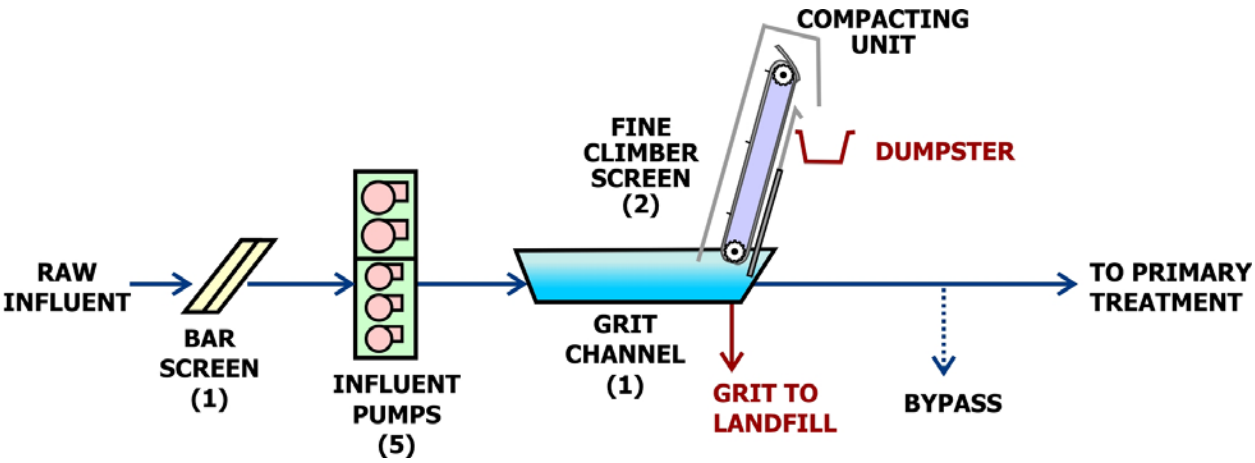


Figure 7.5 Headworks Option 1 : Expand Existing

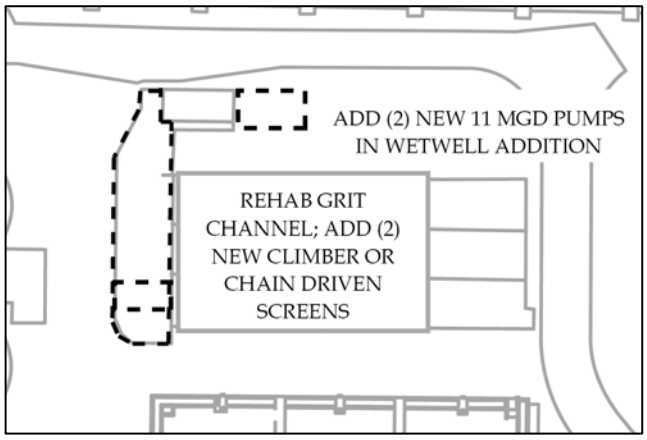
Option 2. Add a Wet Weather Pumping Station and Expand Existing Headworks

In this option, a new wet weather pump station would be added in a separate structure to increase the firm capacity of the pump station, and provide the necessary capacity to handle the peak flows in 2030. The new structure would include 2 new 11 mgd pumps, and space for the headworks electrical components such as the MCC and VFDs.

The same upgrades required in Option 1 will be required to address the deficiencies and reliability of the grit channel and screens: repairing cracks and replacing the Helisieve with 2 new climbers or chain driven screens within the grit channel. **Figure 7.6** shows a process schematic for this option.



(a) Schematic



(b) Plan View

Figure 7.6 Headworks Option 2: Add a Wet Weather Pumping Station

Option 3. All New Influent Pump Station and Headworks with Upstream Screening

In this option, an entirely new headworks would be constructed to address the structural and process deficiencies of the existing influent pump station and headworks. **Figure 7.7** shows the process schematic of this alternative. To reduce wear on the pumps and their impellers, the new pump station would be configured with screens and bar racks upstream of the pumps. Initial screenings would be conveyed by flume to chopper pumps, and pumped up to additional screens, dewatering, and compacting at ground level.

The existing horizontal grit removal channel would be replaced by a vortex grit removal chamber, the turbulent flow of the vortex keeps the organics suspended, and typically reduces odors associated with the grit while the circular shape of the vortex has a compact footprint, preserving space.

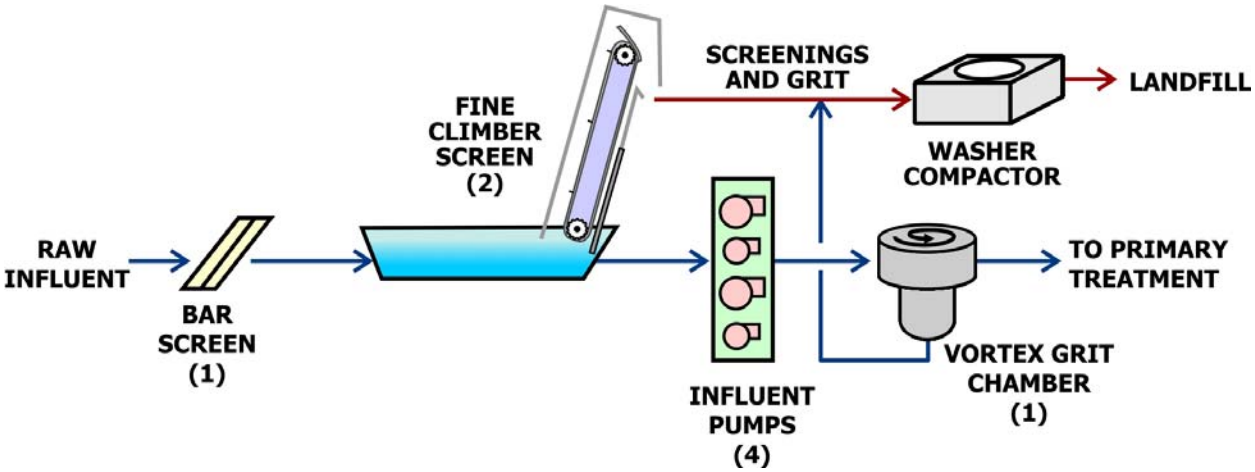


Figure 7.7 Option 3: New Headworks with Screens Before Influent Pumps

Option 4. All New Headworks with Downstream Screening

As in Option 3, in Option 4 an entirely new headworks would be constructed to address all deficiencies for the long term; however, the screens would be located downstream of the pumps to minimize the overall depth of the station and avoid pumping solids up. A schematic of this option is shown in **Figure 7.8**.

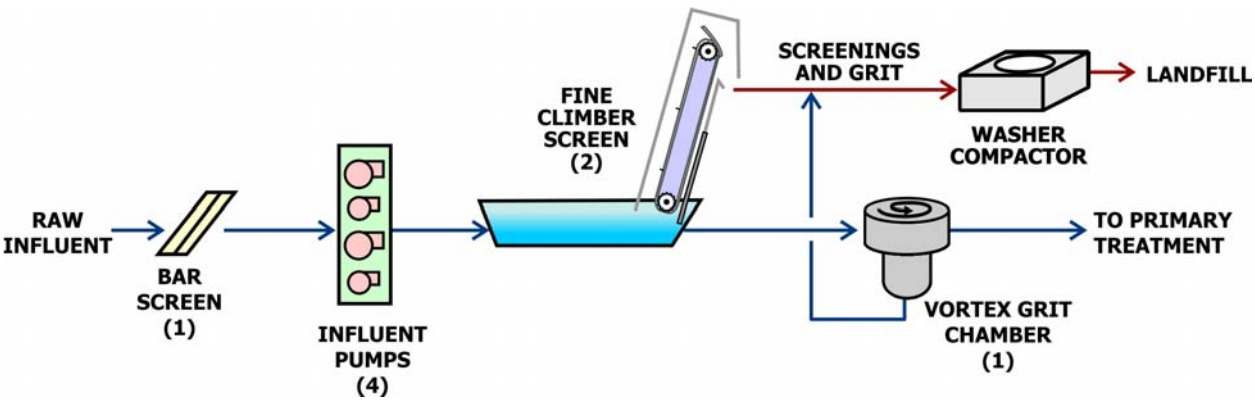


Figure 7.8 Option 4 : New Headworks with Screens Behind Influent Pumps

Comparison of Alternatives

A comparison of the pros and cons for each option is described in **Table 7.1**. The capital and O&M costs are included for each alternative. For direct comparison, annual O&M costs are calculated using 2011 as the base year.

Table 7.1 Pros, Cons, and Costs of Headworks Alternatives

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
1.Expand Existing	▪ Lowest cost option ▪ Footprint remains mostly unchanged ▪ Increases firm capacity ▪ Provides capacity to handle peak flows in 2030	▪ Construction difficult – requires major bulkheads be installed in the existing wet well ▪ Existing structure may not be able to handle major construction and new seismic code requirements may require major modifications ▪ Requires bypass pumping during construction ▪ Hydraulic head relatively unchanged and may limit primaries and aeration upgrades downstream ▪ Not compatible with a regional treatment option – leaves little room for easy expansion	3.9	54,000
2. Add Wet Weather Pumping Station and Expand Existing	▪ Preserves land area ▪ Increases firm capacity ▪ Provides capacity to handle peak flows in 2030	▪ Adding a new wet weather pump station does not address deficiencies of the existing pump station (i.e., poor suction on the inlet side) ▪ Existing structure may not be able to handle major construction and new seismic code requirements may require major modifications ▪ Difficult construction – requires major bulkheads be installed in the existing wet well ▪ Requires bypass pumping (around screening and grit channel) during construction ▪ Hydraulic head relatively unchanged at average flows and may limit primaries and aeration upgrades downstream ▪ Not compatible with a regional treatment option – leaves little room for easy expansion	4.3	55,000
3. All New Influent Pump Station and Headworks with Upstream Screening	▪ Influent pumps are protected and O&M on pumps is reduced ▪ Most flexibility ▪ Compatible with a regional treatment option – leaves room for easy expansion	▪ Most expensive option ▪ Placing the screens before the pumps requires the entire headworks to be constructed deep, a construction concern with the high groundwater table. ▪ Pumping or conveying screenings up to ground level is usually not preferred by operators and increases O&M costs for solids handling	7.3	50,000
4. All New Headworks with Downstream Screening	▪ Wet well not as deep (simpler construction) ▪ No high screenings pumping required ▪ Allow for above ground maintenance ▪ Compatible with a regional treatment option – leaves room for easy expansion		6.6	46,000

Notes:

(a) September 2008 basis. Total project cost estimates reflect planning level and were developed including materials, equipment, and labor, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%). See Section 6.

Recommendation

Repairing and upgrading the headworks in its existing location would leave the City with a facility that could not be expanded to accommodate flows beyond 2030, more wet weather flow, or flow from a regional solution. The risk of encountering unforeseen conditions during detailed design and construction is also high with Options 1 and 2. Therefore, Options 3 or 4 with new influent pump station and headworks, are recommended to meet the future needs of the plant. Plant staff indicates that pump wear has not been a concern on the existing pumps; excessive pump wear would be an issue best addressed with Option 3, with screens upstream of the pumps, but requiring a deeper facility. For planning level and CIP development, however, it should be assumed that the most expensive option (Option 3) would be constructed.

7.2.2 Primary Clarification

Existing System

The Spring Street Sewage Treatment Plant has two rectangular primary clarifiers, with the larger unit roughly twice the size of the smaller one. The existing clarifiers face three significant deficiencies:

- Their structural integrity is questioned (see Condition Assessment).
- They lack hydraulic capacity both for projected maximum month condition and peak wet weather flow condition, even with the most optimistic overflow rates and with all units in service (see Section 4 for hydraulic capacity based on overflow rates).
- They lack redundancy to meet EPA reliability Class I criteria, where primary clarifier units should be sufficient in number and size so that, with the largest-flow-capacity unit out of service, the remaining unit(s) should have a design flow capacity of at least 50% of the total design flow.

Aside from reliability and hydraulic capacity, the performance of the existing units is unknown as the plant does not routinely measure primary clarifier removal efficiency (via loadings removal, such as BOD and TSS).

Alternatives

Four main conventional primary clarification options addressing the shortfalls of the primary clarifiers were developed:

Option 1 – Upgrade Existing and Add one New Clarifier

Option 2 – Replace Existing Primaries at Same Location

Option 3 – Build all new in new location

Option 4 – No primary treatment

In addition, two options were also examined to evaluate the benefits of higher efficiency primary clarification (as opposed to the conventional options above):

Option 5 – Chemically Enhanced Primary Clarification (CEPT)

Option 6 – High Rate Clarification (HRC)

These options are presented and discussed below.

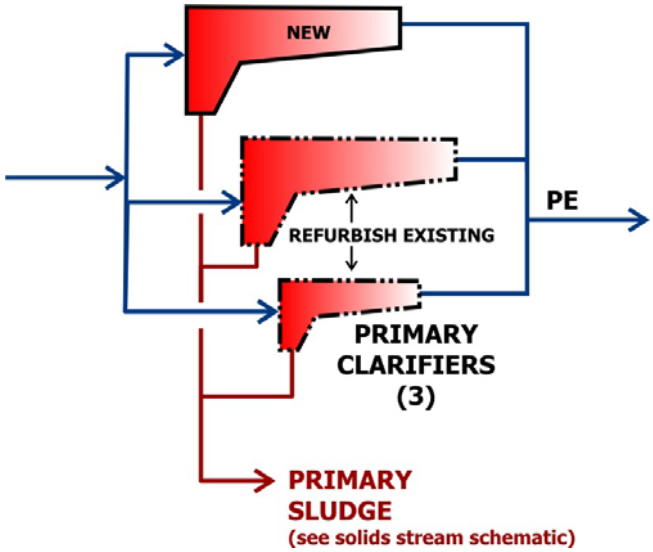
Unit	Primary Clarification
Option	Upgrade + 1 New Clarifier
Option	Replace in Same Location
Option	New in New Location
Option	No Primary Treatment
Option 5	Chemically Enhanced
Option 6	High Rate/Ballasted

Option 1. Upgrade Existing and Add one New Clarifier

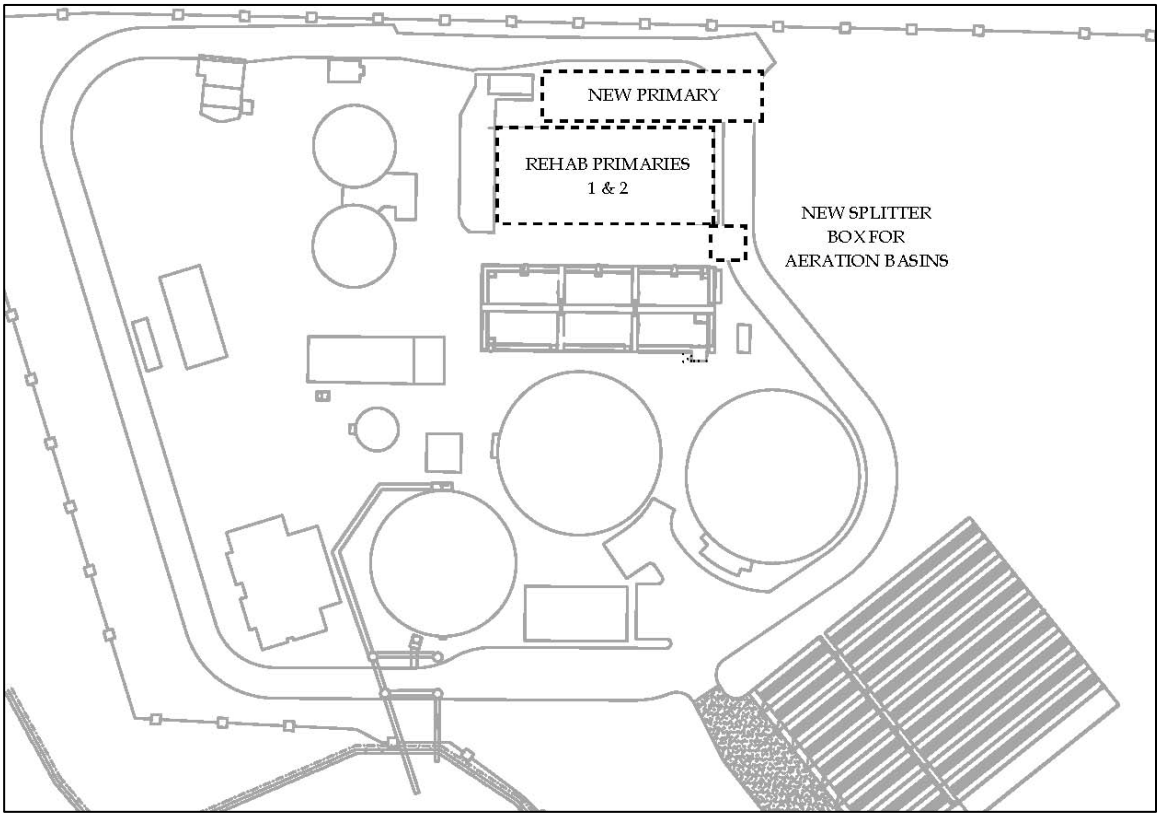
Since replacing the existing clarifiers is a significant investment, the option of upgrading while adding a new unit for reliability purposes was investigated. The minimum upgrades required to keep the existing units in service would be similar but more comprehensive than the periodic improvements accomplished since 1991. Those upgrades would include:

- High pressure water blasting and coating of all surfaces at or near the water line
- Replacement of in-tank piping and appurtenances
- Replacement of pumps and valving
- Fixing leaking effluent weirs
- Replacement of all sampling equipment
- Covers and odor control may be needed
- Positive flow splitting to the units

To meet reliability criteria and increasing flows, one new primary clarifier would be added to the north side of the existing tanks while a new primary sludge and scum pump station would serve both the old and new tanks. A preliminary evaluation of the hydraulic grade line shows that it will be above the existing walls at a 2030 peak hour flow of 22 mgd. This means that for this option, a greater proportion of flow would be routed to the new clarifiers for a few peak wet weather events. A schematic and site plan of this option is shown in **Figure 7.9**.



(a) Schematic

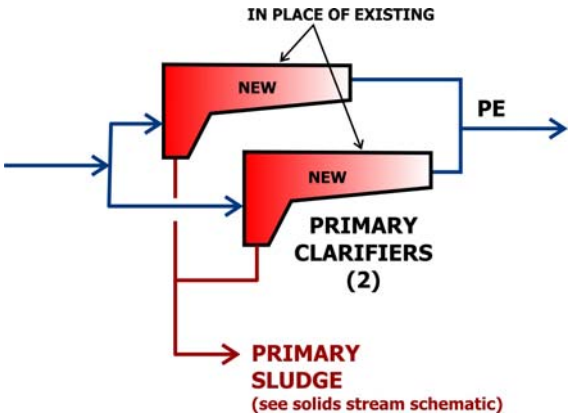


(b) Plan View

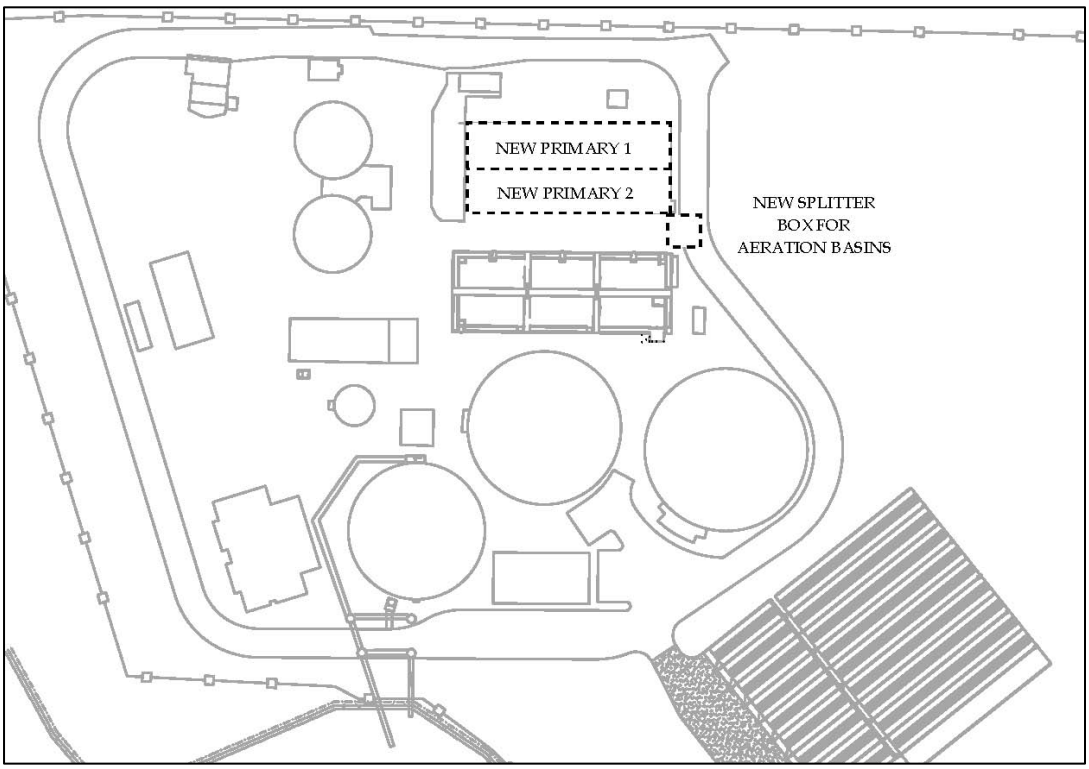
Figure 7.9 Primary Clarifier Option 1 Schematic : Upgrade Existing and Add One New Clarifier

Option 2. Replace Existing Primaries at Same Location

In this alternative, two new large rectangular primary clarifiers would be put in the location of the existing two tanks. This option would require the plant to operate without primary treatment during the period when these new facilities are under construction. A process schematic of Option 2 and a site plan of Option 2 are shown in **Figure 7.10**.



(a) Schematic



(b) Site Plan

Figure 7.10 Primary Clarifier Option 2 Schematic : Replace Existing Primaries at Same Location

Option 3. Build New Primaries in New Location

This option is similar to Option 2, except that the existing units can be abandoned in place or demolished to make room for other processes. A process schematic of this option is shown in **Figure 7.11**, with a site plan in **Figure 7.12**. Some design features of this option include:

- Headworks will have to be raised to get flow the extra distance to the new location
- The length of primary sludge and scum pumping would be extended by 200 feet
- The hydraulic grade line of the new primary clarifiers should be higher than the existing primary clarifiers to allow gravity flow through the aeration basins

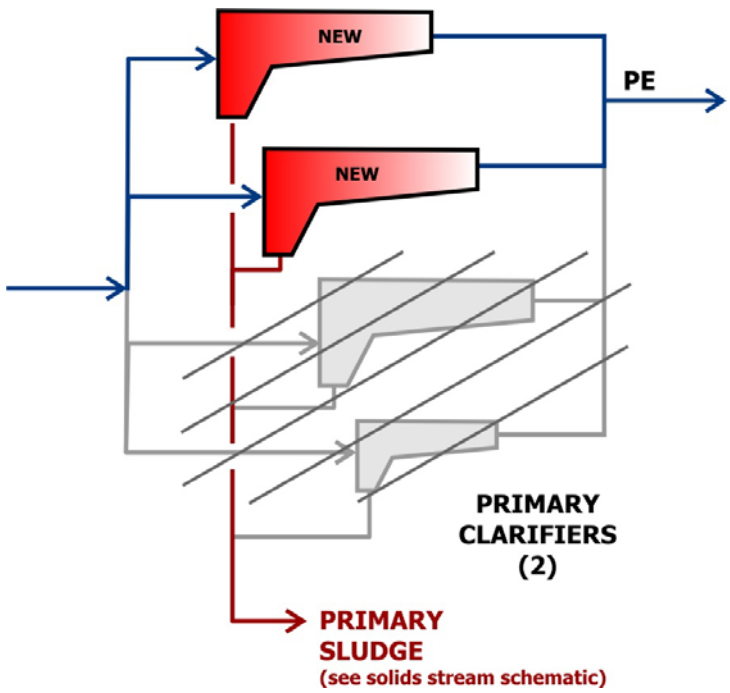


Figure 7.11 Primary Clarifier Option 3 Schematic: New Primaries in New Location

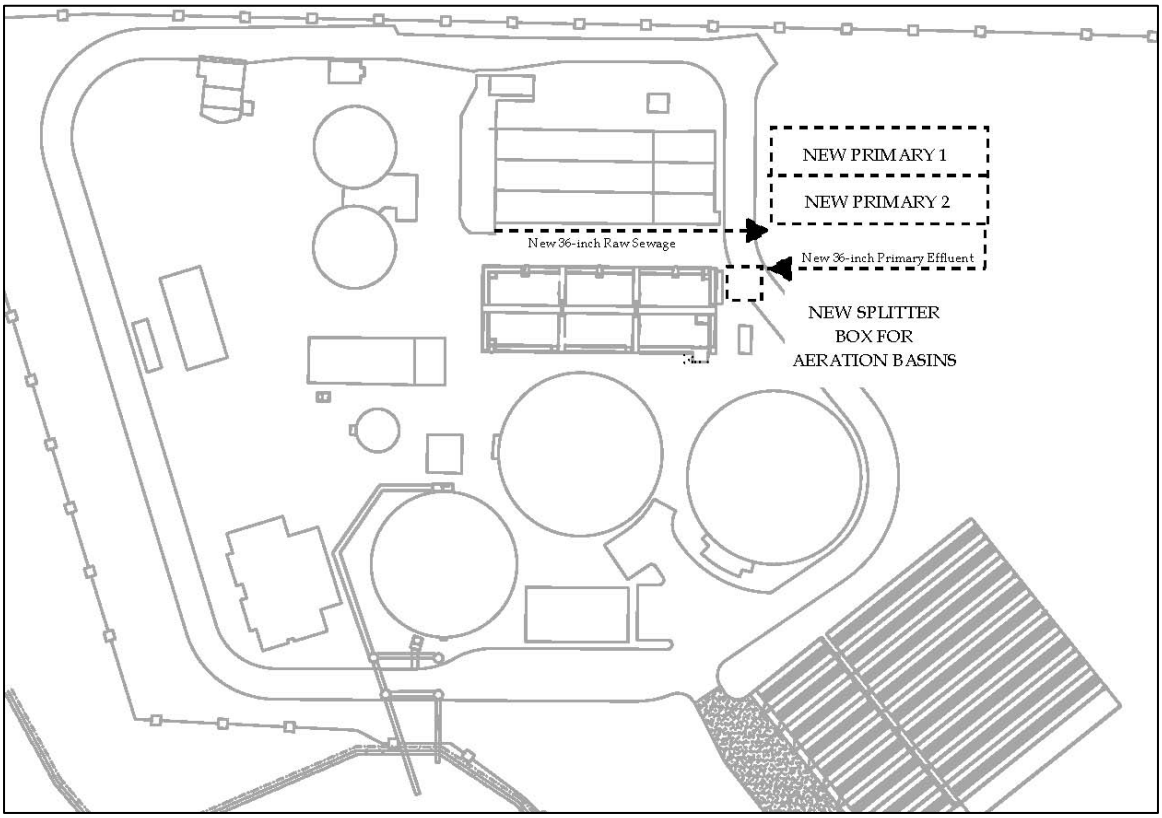


Figure 7.12 Primary Clarifier Option 3 Site Plan : New Primaries in New Location

Option 4. No primary treatment

Many treatment plants operate successfully without primary clarifiers, and because of the investment required for building new clarifiers, it is fair to evaluate the "no-clarifier" option (schematic shown in **Figure 7.13**). This option can also be used to illustrate how the Spring Street STP would be impacted should Option 2 – Replace Primaries in the Same Location, be selected. In this evaluation, the costs and impact of having no primaries is evaluated downstream, mainly on aeration basin size and sludge handling facilities.

Operating without primaries can have a significant impact on the biological treatment system as the biological treatment would be required to treat the entire raw influent load rather than primary effluent, which typically removes 30 to 35 percent of the influent BOD. Having no primaries increases aeration demands and aeration basin size due to the increased BOD load, but it may be acceptable for a few initial years, when the aeration system is oversized for the initial loads.

Removal of the primaries has a significant impact on sludge production in terms of quality and quantity. No primary sludge would be generated, and biological or waste-activated sludge (WAS) production would approximately double due to the increased BOD load on the aeration basins. Aeration basins would need to be sized to account for this increased sludge production, effectively doubling their size (assuming a constant mixed liquor suspended solids (MLSS) concentration). Total sludge production without primaries is anticipated to be approximately 8

percent greater than total sludge production with primaries. **Table 7.2** provides solids production information with and without primary clarification.

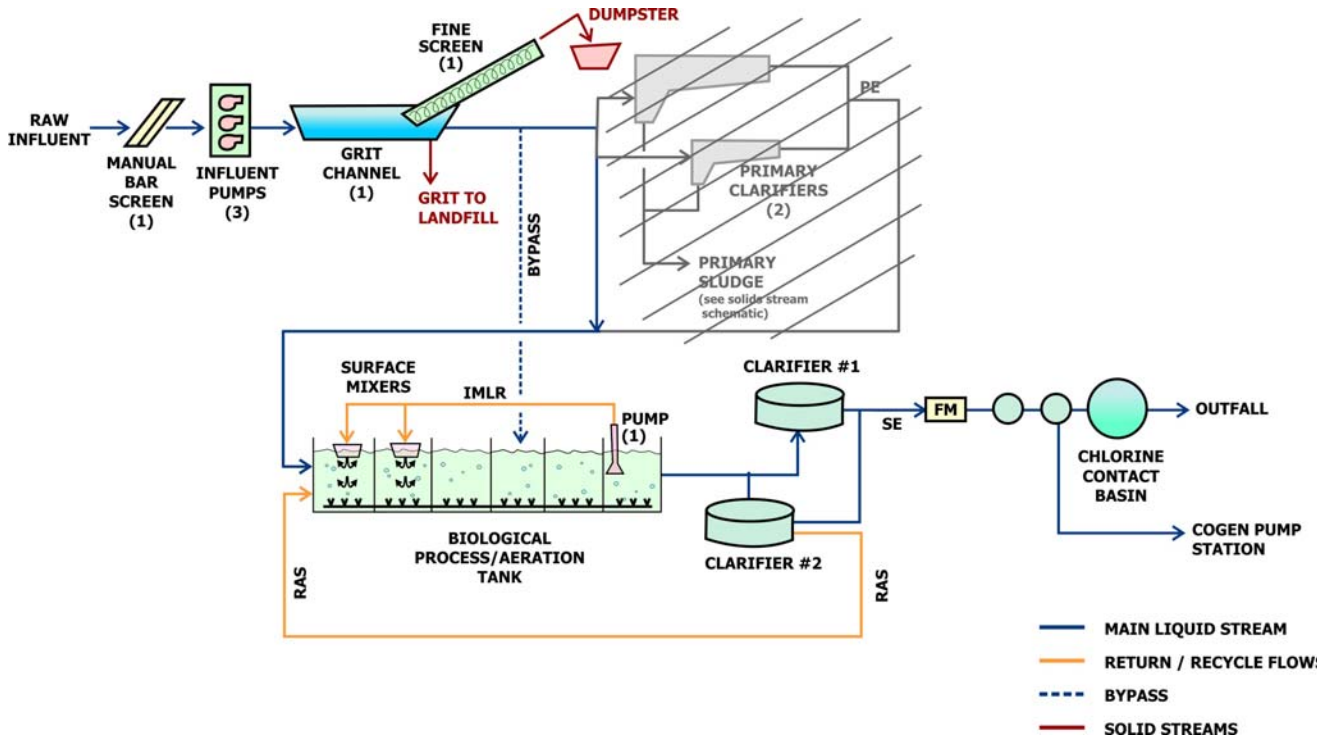


Figure 7.13 Primary Clarifier Option 4 : No Primary Treatment

Table 7.2 Aeration Basin Operational Needs Through Planning Horizon

Parameter	Year			
	2005[a]	**2010**	**2020**	**2030**
Serviced Population	27,700	30,200	35,700	42,000
Peak Month Plant Flow, MGD	5.6	7.5	8.9	10.4
Produced Biosolids (WAS), lb TSS/d (Peak month)				
With Primary Clarifiers (WAS)[b]	3,500	4,300	5,100	6,000
With Primary Clarifiers (Primary)	2,800	4,300	5,100	6,000
With Primary Clarifiers (Total)	6,200	8,600	10,200	12,000
Without Primary Clarifiers (Total)[c]	7,400	9,300	11,000	12,900

Notes:
(a) Peak Month BOD loading in 2005 was atypically high; Peak Month TSS loading in 2005 was atypically low.
(b) WAS production with primary clarifiers assumes a conservative yield of 0.8 lbs TSS/lb BOD removed.
(c) Total sludge production without primary clarifiers is WAS and assumes a conservative yield of 1.2 lbs TSS/lb BOD removed.

Option 5. Chemically Enhanced Primary Treatment (CEPT)

Chemically enhanced primary treatment refers to the use of coagulants in conventional primary clarifiers to achieve normal or higher removals at higher hydraulic loading rates. In other words, the use of chemicals in the primary clarifiers can extend the life of existing facilities by maintaining efficiency as hydraulic loadings increase beyond typical values. Similarly, where footprint area is limited, the use of chemicals can allow installation of smaller tanks for the same removal performance.

Typically, coagulants such as ferric chloride and polyaluminum chloride (PACl) are used at a dosage of 50-75 mg/l and 10 to 20 mg/l, respectively. Anionic polymer at a dose of less than 1 mg/l helps the coagulated floc stabilize and settle. A surface overflow rate (SOR) of 800 to 1,200 gpd/sf at peak month is used in this planning document for setting the clarifier capacity. That loading could be increased to over 3,000 gpd/sf.

At the Spring Street STP, the impact of re-rating the existing clarifiers with CEPT (assuming structural and mechanical deficiencies are addressed) would be that the existing small unit could handle 7.6 mgd instead of its current capacity of 2 to 3 mgd, and that no new primary clarifiers would be needed to address reliability criteria since the small unit could provide 50 percent treatment capacity should the largest unit be out of service.

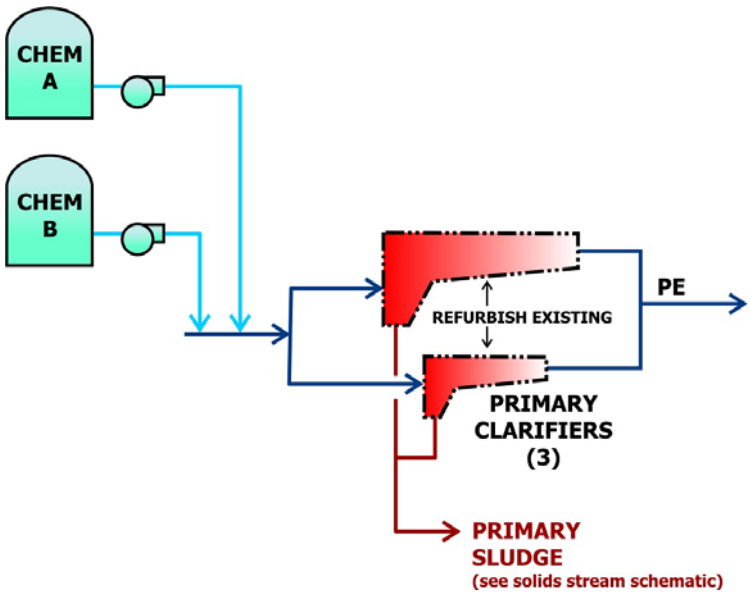


Figure 7.14 Primary Clarifier Option 5: Chemically Enhanced Primary Treatment

Option 6. High Rate Clarification (HRC)

High rate clarification is a water clarification technology that was first applied to wastewater in 1999. The technology provides high suspended solids removal at extremely high SORs. Typical high rate plants operate at SORs of 40,000 gpd/sf, almost 40 times the loading of a conventional primary clarifier while achieving suspended solids and BOD5 removals of greater than 80 percent and 60 percent, respectively. Because of these high loading rates, the units are extremely compact compared to conventional clarifiers.

These high rates are achieved by doing three things:

1. Chemically enhancing the feed to make a strong floc

2. Adding a ballast, either sand or biomass, to that floc to make it heavy

3. Providing a high efficiency clarifier with lamella plates

Typical applications for HRC are where wet weather peaking factors are extreme, and a need exists to relieve pressure on the conventional treatment plant while maintaining plant or system performance. When treating storm flows, effluent turbidities can be as low as 4 NTU, making disinfection using ultraviolet light cost-effective. The chemical addition also achieves low effluent phosphorus and removes some metals. Currently, 3 plants in the Northwest use this technology: Bremerton, WA (15 mgd); Port Orchard, WA (7.5 mgd); and Salem, OR (50 mgd). A summary of plants around the country is found in **Table 7.3**.

The technology is provided by Veolia/Kruger Actiflo and Infilco Degremont Densadeg. In the U.S., this technology is typically applied to intermittent wet weather treatment. For the SSSTP,

the peak month-to-average and peak day-to-average ratio are 2:1 and 3:1, respectively. These peaking factors are not considered extreme; in contrast, Bremerton's peak month-to-average and peak month-to-peak day ratio are 5:1 and 20:1, respectively.

Table 7.3 Summary of HRC in the US

Manufacturer	Number of Installations	First Installed	Smallest Capacity	Largest Plant
Veolia/Kruger Actiflo	8	2001 (Bremerton, WA)	7.5 mgd (Port Orchard, WA)	500+ mgd (Acheres, France)
Infilco Degremont Densadeg	3	2004	10 mgd (Shreveport, LA)	200 mgd (Toledo, OH)

For the SSSTP, using HRC as storm relief during wet weather events would add process complexity while not significantly impacting the required upgrades to the conventional primaries. It is also unneeded to meet design criteria. Further, using this technology year-round for all influent would increase the City's dependence on market variations for chemical and shipping costs.

Comparison of Alternatives

A comparison of the pros and cons for each option is described in **Table 7.4**. The capital and O&M costs are included for each alternative. For direct comparison, annual O&M costs are calculated using 2011 as the base year.

Table 7.4 Business Case Evaluation of Primary Clarifiers Alternatives

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
1.Keep Existing and Add One New	▪ Least expense ▪ Preserves most plant site for future	▪ Does not allow for performance improvement – keeps existing shallow units ▪ Intermediate pumping station for full plant flow would be required to pump to an expanded biological system ▪ Condition of existing timber piles unknown ▪ Tanks may flood at projected 22 mgd peak hour flow in year 2030 unless more flow is routed through the new unit (which would have decreased, short term performance). ▪ Construction near the existing old units and pile driving activity could further damage the existing units ▪ Refurbishing the old units is likely to require new seismic criteria upgrade ▪ The existing influent pump station would interfere with inlet end of the new primary. ▪ The primary effluent channel my have to be upsized to accommodate the additional flow from the third unit ▪ Positive flow splitting to the units using the existing inlet channel will be problematic. ▪ Does not allow raising of the hydraulic grade line, which may require addition of intermediate pumping to achieve an expanded biological treatment ▪ Not compatible with a regional treatment option – leaves little room for easy expansion	4.0	25,000
2. Build New Units in Existing Location	▪ Fits well with keeping existing headworks ▪ Allows construction of state-of-the-art units ▪ Long term solution ▪ Allows raising of the hydraulic grade line and eliminates potential need for intermediate pumping to achieve expanded biological treatment	▪ Requires operation during construction without primary clarifiers ▪ Intermediate pumping station for full plant flow would be required to pump to an expanded biological system ▪ Limits easy expansion of primary clarification in case South Suburban flows are diverted ▪ Does not allow taking advantage of existing structure for other uses (sludge storage, side stream treatment, or biofiltration)	9.2	25,000
3. All New in New Location	▪ Allows construction of state-of-the-art units ▪ Fits well with a new influent pump station and headworks alternative – could be same structure ▪ Eliminates constructability conflicts ▪ Allows for modification to the hydraulic grade line, eliminating potential need for intermediate pumping to expanded aeration basins ▪ Compatible with regional treatment options	▪ Large yard piping over long distance increases costs ▪ Requires raising or replacing existing headworks	11.3	29,000
4. No Primary Treatment	▪ Could reduce carbon needs of potential biological nitrogen removal process, (although DEQ is not indicating tight nitrogen removal limits) ▪ Simplifies the plant by removing one process unit	▪ Reduces effectiveness and efficiency of anaerobic digestion, which in turn reduces biogas production potential, an increasingly valuable resource. ▪ Significantly increases O&M costs for sludge handling and increased aeration demands	Not Costed	Not Costed

Notes:

(a) September 2008 basis. Total project cost estimates reflect planning level and were developed including materials, equipment, and labor, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%). See **Section 6**.

Recommendation

The options for primary clarification summarized in **Table 7.4** show that of the three options considered viable for the plant, Option 3 provides the best opportunity to provide an efficient running plant while keeping the plant open for expansion beyond the 2030 planning horizon or the ability to handle more flow as part of a regional treatment solution. Both Options 1 and 2, which rely on construction in and around the old pile-supported units, expose the City to increased risk of unforeseen conditions during construction. Option 3 has the least impact on plant operations during construction while Options 1 and 2 could only be constructed for summer flow conditions. Finally, a new primaries option allows raising the plant hydraulic profile, enhances flow-splitting options downstream, and provides for an expanded secondary treatment process. Option 4 (No primaries) could be considered as a phasing strategy when a new aeration basin is added before the primaries are demolished and rebuilt.

Based on the pros, cons, and costs, it is recommended to implement Option 3: Build New Primaries in New Location, for best long-term value and compatibility with regional treatment options.

7.2.3 Biological Treatment

Existing System

The Spring Street STP has one aeration basin comprised of a series of six cells connected with manual gates, providing a total (combined) volume of 728,000 gallons, and a side water depth (SWD) of 15 feet. The system is currently operated at an SRT that generally ranges from 3 to 4 days. The plant has two circular secondary clarifiers: Clarifier 1 (1971) is 100 feet in diameter and 12 feet deep, while Clarifier 2 (2001) is 110 feet in diameter and 20 feet deep. Under normal operation, when influent flows are below 9 mgd, mixed liquor flows from the aeration basin to secondary Clarifier 2. Secondary Clarifier 1 is operated when plant influent flow exceeds 9 mgd. Each clarifier has its own set of RAS pumps. Waste activated sludge (WAS) is pumped from the RAS lines to the DAFT thickener.

Biological Process Deficiencies

The Spring Street STP averages 15 mg/L influent ammonia (Section 4). However, DEQ indicates that effluent ammonia limits in the 1 to 2 mg/L range will be required. In other words, full nitrification will be required in the aeration system to meet the proposed effluent limits. In general, as long as a good settling sludge is produced, SRT and temperature have little effect on effluent BOD. However, SRT and temperature have a significant impact on nitrogen removal, and to achieve increased nutrient removal (including both nitrogen and phosphorus), longer SRTs are necessary to allow time for slow-growing, temperature-sensitive nitrifiers. Further, since nitrifiers are sensitive to temperature, the application of year-round nitrogen removal limits (as opposed to seasonal nutrient removal, which is usually imposed during the dry, warm season) will require even longer operating SRTs. Unless the mixed liquor suspended solids (MLSS) concentration can be increased or wasting reduced, an increase in SRT has a direct increase on the amount of aerated (oxic) basin volume necessary for treatment. Keeping this correlation in mind, the impact of increasingly stringent effluent quality goals can be

observed in **Table 7.5**, which shows the required SRT and corresponding aerated volumes required.

For planning, a design MLSS concentration of 2,500 mg/L was assumed, which may be conservative compared to typical design guidelines. However, this value matches existing operational data from the Spring Street STP, and matches the realistic thickening capability of the existing secondary clarification facilities. Note that for planning purposes, the aeration basin volumes indicated in **Table 7.5** are based on use of a typical selector activated sludge process. Other technologies such as step feed activated sludge (SFAS), membrane bioreactors (MBRs), or integrated film activated sludge (IFAS), have enhancements that increase the allowable MLSS and/or sludge inventory within the aerated basins, and would reduce the amount of the aeration basin volume required for the conventional SAS process.

Table 7.5 System SRT and Aerated Volumes Required for Varying Effluent Quality Goals(year 2030)[(a)(b)]

Effluent Quality Goal	Required SRT, days	Aeration Basin Volume Required (MG)		Comments
		Total	New[(g)]	
Status Quo (BOD, TSS removal only) [(c)]	3.7	1.1	0.4	Provides reliable BOD removal year-round, with nitrification limited to 3 or 4 warmest months. Capable of achieving good turbidity removal. This level of treatment would be consistent with a strategy that would involve agricultural or pasture irrigation scenario.
Seasonal Nutrient Removal[(d)]	7.5	2.2	1.4	Provides reliable BOD and first stage phosphorus removal year round. Provides seasonal nitrification (for 4 to 6 warmest months) during the permitted dry weather season.
Conventional Nutrient Removal – Year-round[(e)]	15	3.9	3.2	Provides year-round nitrification and/or biological with good denitrification/phosphorus removal capability.
Stringent Nutrient Removal – Year-round[(f)]	20	4.3	3.6	Provides year-round nitrification and biological denitrification to very low levels, and phosphorus removal capability.

Notes:

(a) Assumes conventional primary clarifiers upstream of biological treatment.
(b) Based on typical suspended growth activated sludge with 2,500 mg/L MLSS.
(c) Status Quo is based on meeting the requirement of OAR 340-041-0026(1)(a) antidegradation policy, which would correspond to meeting BOD and TSS levels of 17 mg/L under the projected maximum month flow of 10.4 mgd in year 2030.
(d) Seasonal Nutrient Removal is defined as meeting at least 10/10/10/1 mg/L cBOD5, TSS, TIN, and TP, respectively, under average dry weather conditions. Under this scenario, effluent concentrations of 15/15/1 mg/L cBOD5, TSS, and TP could be expected year-round. Assumes good settling and/or tertiary filtration.
(e) Conventional Nutrient Removal is defined as meeting at least 10/10/10/1 mg/L cBOD5, TSS, TIN, and TP, respectively, under maximum month conditions (e.g. year-round). Assumes good settling and/or tertiary filtration.
(f) Stringent Nutrient Removal is defined as meeting at least 10/10/3/0.1 mg/L cBOD5, TSS, TIN, and TP, respectively, under maximum month conditions. Assumes tertiary filtration.
(g) Considering existing available volume of 0.7 MG is used. Numbers are rounded.

While the condition assessment showed the existing aeration basins to be in good structural and mechanical condition, and all alternatives considered incorporate use of the existing volume as part of the biological treatment system, several main deficiencies in the biological treatment systems still exist. They include:

- Lack of redundancy – effectively, a single basin does not allow maintenance in one cell without sending mixed liquor to the clarifiers without further treatment
- Lack of available treatment volume to meet conventional nutrient removal limits on a year round basis

Secondary Clarifiers Process Deficiencies

The existing secondary clarifiers provide the hydraulic capacities listed in **Table 7.6**, and show no need for secondary clarifier expansion under the projected conditions. The condition assessment and evaluation of plant record, however, indicate that some improvements to the controls and some mechanisms of the clarifiers could be beneficial. As such, the secondary clarifier deficiencies can be summarized as follows:

- RAS pumps improvements on Clarifier 1
- SRT control capabilities

Other improvements, especially hydraulic upgrades, may be required to fit within the overall recommended plan for the facility.

Table 7.6 Existing Secondary Clarifiers Capacities

	Clarifier 2	Clarifier 1	Notes
Diameter, ft	110	100	
Surface Area, sf	9,500	7,850	
Surface overflow rate, gpd/sf (Largest clarifier out of service)			
@ 50% of PWWF (11 mgd)		1,400	Recommended range: < 1,500 gpd/sf[a]
@ 100% of PWWF (22 mgd)		2,800	< 3.000 gpd/sf[b]
@ 75% of MMADF = 7.8 mgd		990	< 1,000 gpd/sf[b]
@ AWWF = 7.8 mgd		990(	< 1,000 gpd/sf[a]
Solids Loading Rate, lb/sf			
@ 50% of Max Month Loading = 2,250 lbs/d		0.6	Recommended range[a]: < 24 lb/sf/d

Notes:
(a) WA DOE design criteria
(b) Engineering practice

Biological Treatment Alternatives

Sizing of the aeration basins is directly related to the type of microorganisms desired and volume necessary to maintain a solids retention time (SRT) adequate to allow a specific bacterial growth. For a given SRT, the higher the incoming organic load, the higher the amount of biological solids produced and the higher the sludge wasting rate. Capacity for the headworks and primary clarifiers are primarily driven by hydraulics, and are not directly affected by effluent limits established in the TMDL's, or aeration basin sizing and configuration. To meet low levels of nutrient concentrations with a biological process thus requires operation at increased SRTs, and with configuration and operation that focuses on promoting growth conditions for nutrient removal organisms (nitrogen and phosphorus). The operational changes and improvements may also include the use of tertiary or polishing treatment steps.

Design criteria for aeration basin sizing will vary depending upon treatment goals. Later in this section we will discuss specific process modes, but for understanding the capacity and limitations of the existing aeration basin, it is only necessary to consider treatment goals and the SRT to achieve the treatment objectives. A simple definition of SRT is represented as follows:

$$\text{SRT} = \frac{\text{lb MLSS in the aeration basin}}{\text{lb solids wasted from the system per day}}$$

When determining how best to configure additional aeration basin capacity to the Spring Street STP, a number of internal process options can be considered. These configurations will be critical, especially should biological nitrogen removal be required. The latest information from DEQ, however, is to impose phosphorus removal while no total nitrogen limits (e.g., only ammonia limits) would be required. For this reason, information on varying nitrogen removal and combined nitrogen-phosphorus biological removal process internal configurations has been moved to **Appendix D** for future reference, as it appears that nitrogen removal is not driving the choice of treatment alternatives. For this planning effort, we are recommending sizing of the aeration basin to accommodate year round nitrification with an SRT of 15 days.

Unit Process	Biological Treatment
Option 1	SAS
Option 2	SFAS
Option 3	IFAS
Option 4	MBR-SAS
Option 5	COxD

The following five options were investigated for the Spring Street STP's biological treatment process.

Option 1 - Selector Activated Sludge (SAS)

Option 2 - Step Feed Activated Sludge (SFAS)

Option 3 - Integrated Fixed Film Activated Sludge (IFAS)

Option 4 – Membrane Bioreactor with Selector Activated Sludge (MBR-SAS)

Option 5 – Customized Oxidation Ditch (COxD)

Option 1. Selector Activated Sludge (SAS)

This option would build on the City's familiarity with the conventional activated sludge process and on years of demonstrated performance. In a selector activated sludge plant, additional process zones are added upstream of the aerated zones to either preferably select microorganisms (to prevent filamentous growth), to promote denitrification, and/or to favor phosphorus release for later uptake in the oxic (aerated) zone (for overall phosphorus removal) (see **Figure 7.15**).

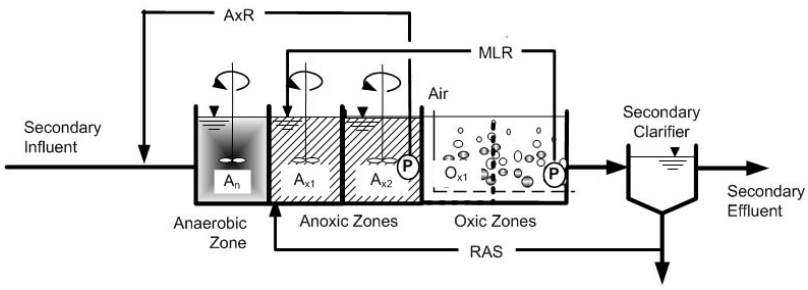


Figure 7.15 Selector Activated Sludge Process Schematic (WEF, MOP 11)

Thousands of activated sludge wastewater reclamation plants (WRP) utilize selector activated sludge (SAS). SAS facilities in Oregon, which are operated for biological nutrient removal,include the following:

- Woodburn WRP
- Winston-Green Regional WWTP
- Durham WRP, Tigard

With the SAS alternative, the existing aeration basin would continue to operate in series with new aeration basins. If necessary, the aeration basins could be further compartmentalized with baffles to achieve varying levels of biological nitrogen removal with internal process variations such as those described in **Appendix D**. The internal dimension of each new basin would be 30 feet wide by 185 feet long, with an 18-foot side water depth (versus the existing 15-foot side water depth).

The specific number of aeration basins and details of the internal compartmentalization will vary depending upon final discharge limits. For conventional nutrient limits, four (4) new basins, or 3.0 additional MG, will be required. If nutrient limits are established that require only seasonal nutrient removal, then only two new basins, or an additional 1.5 MG, would be required.

Basin volumes have been sized based on operation with a mixed liquor concentration of 2,500 mg/L and a 15 day SRT for year round nutrient removal. No new clarifiers are projected to be required. **Figure 7.16** provides a schematic of the upgraded facility with new SAS basins, with the existing aeration basin operating in series with the new ones.

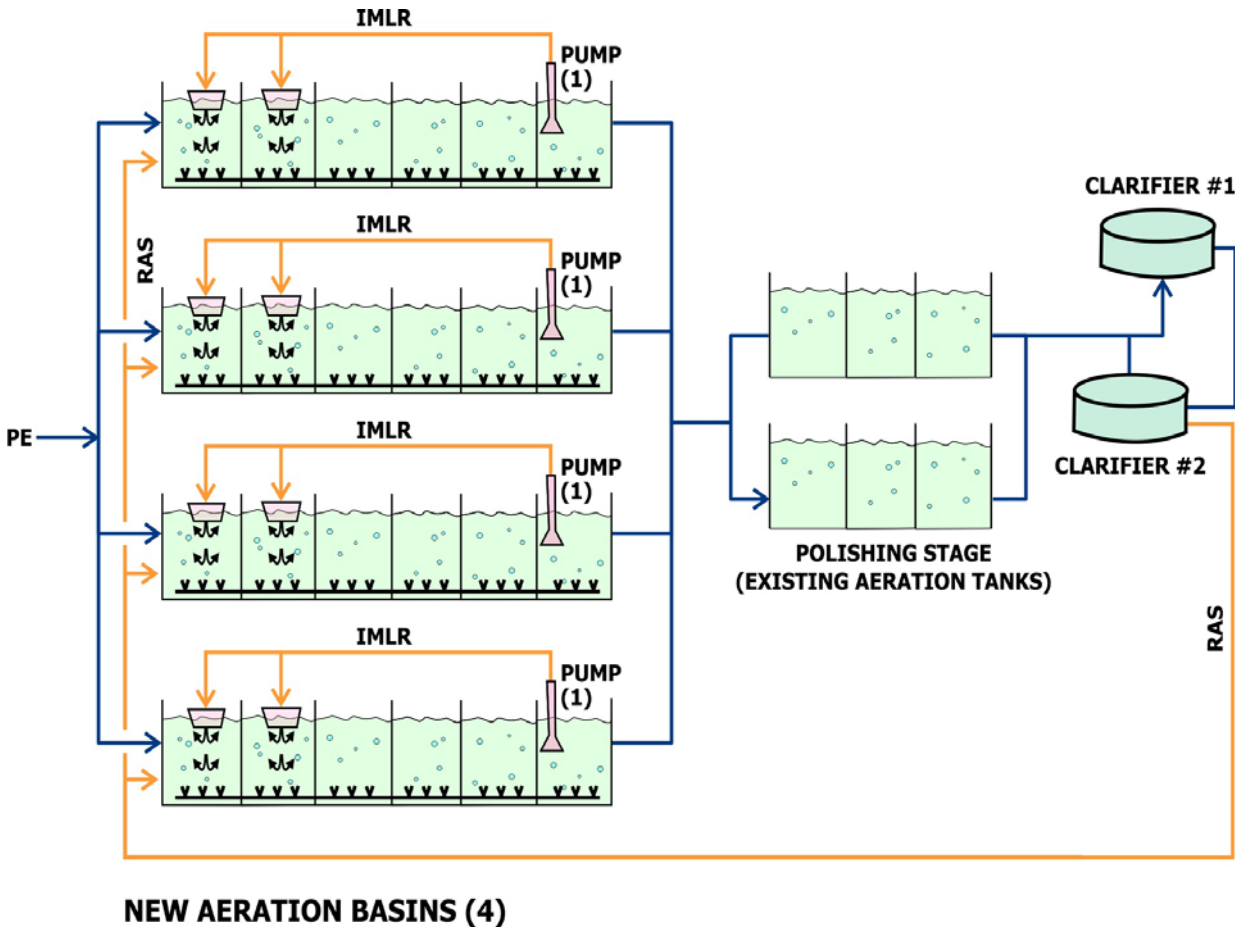


Figure 7.16 Selector Activated Sludge Site Layout

Option 2. Step Feed Selector Activated Sludge (SFAS)

Step feeding of primary effluent into various cells of an aeration basin, rather than only to the front end, is one variation to the conventional activated sludge process that can minimize the overall treatment volume required and offer other advantages. Savings in volume are possible because of a higher concentration of solids maintained in the initial steps of the basin through distribution of influent at various locations. As such, use of the step feed can increase the main aeration tank biomass inventory by about 30% as compared to a conventional plug flow configuration while still maintaining the same solids loading to the secondary clarifiers. (This happens because the MLSS gradient decreases along the length of the reactor). By dividing up the primary effluent feed, step feeding also protects the biomass from both washouts and dramatic temperature drop during storm events. The Rock Creek Advanced Reclamation Plant operated by Clean Water Services in Hillsboro, OR (photo) is an example of an SFAS process.

SFAS tanks at Rock Creek Advanced Reclamation Plant, Hillsboro, OR

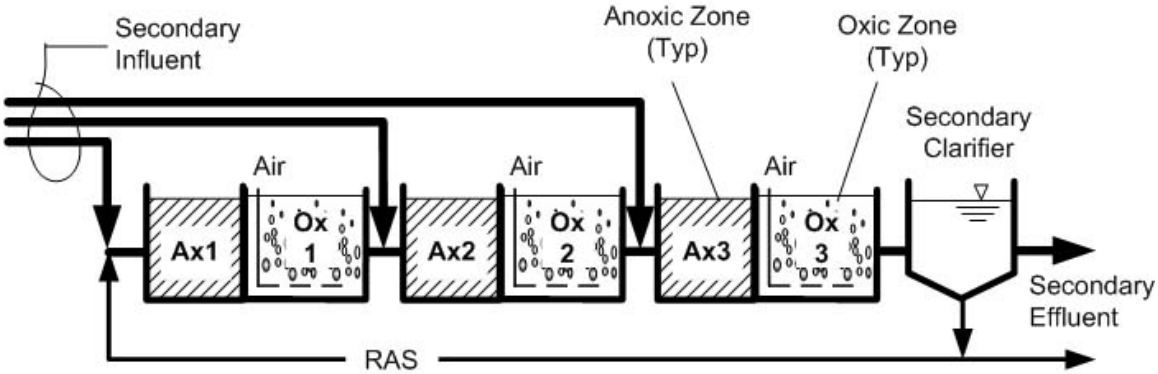


Figure 7.17 Step Feed Activated Sludge Process Schematic (Source: WEF, MOP 11)

The application of SFAS has generally been at large plants, which are space-limited, or when secondary clarifiers are overloaded. While none of these conditions are met at the Spring Street STP now, the technology is common in the Northwest. Some example facilities in the Northwest that have step feed capability built in (not all utilize SFAS, although it is available) include the following:

- Rock Creek WRP, Hillsboro, OR
- Lander Street WRP, Boise, ID
- Marine Park Facility, Vancouver, WA
- Westside Treatment Plant, Vancouver, WA

The drawbacks of SFAS are that more complexity is inherent to the design (multiple gates and piping) while risk of breakthrough of contaminants is increased (because influent is fed in later stages of the basins). Also, sludge settleability may be poorer. Control of the rate at which primary effluent enters various treatment steps is best achieved by low-head pumping of primary effluent; although, good hydraulic design with control gates may allow adequate flow splitting.

Conventional year-round nutrient removal would require construction of two new basins, or 1.9 MG. If nutrient limits are established that require only seasonal nutrient removal, then only one new basin, or an additional 1.0 MG, would be required. In this case, basin volumes are based on operation with mixed liquor concentration averaging 3,800 mg/L and targeting a 15 day SRT. **Figure 7.18** gives a site layout of the upgraded facility with new SFAS basins, with the new aeration basins operating upstream of the existing basins. The SFAS upgrade would reduce the total volume of new biological reactor basin for SAS (Option 1) by 35 percent.

As with Option 1, the aeration basins could be further compartmentalized with baffles to achieve varying levels of biological nutrient removal with internal process variations such as those listed in **Appendix D**. Internal dimensions of each new basin would be 30 feet wide by 235 feet long, with 18-foot side water depth (versus the existing 15 foot side water depth).

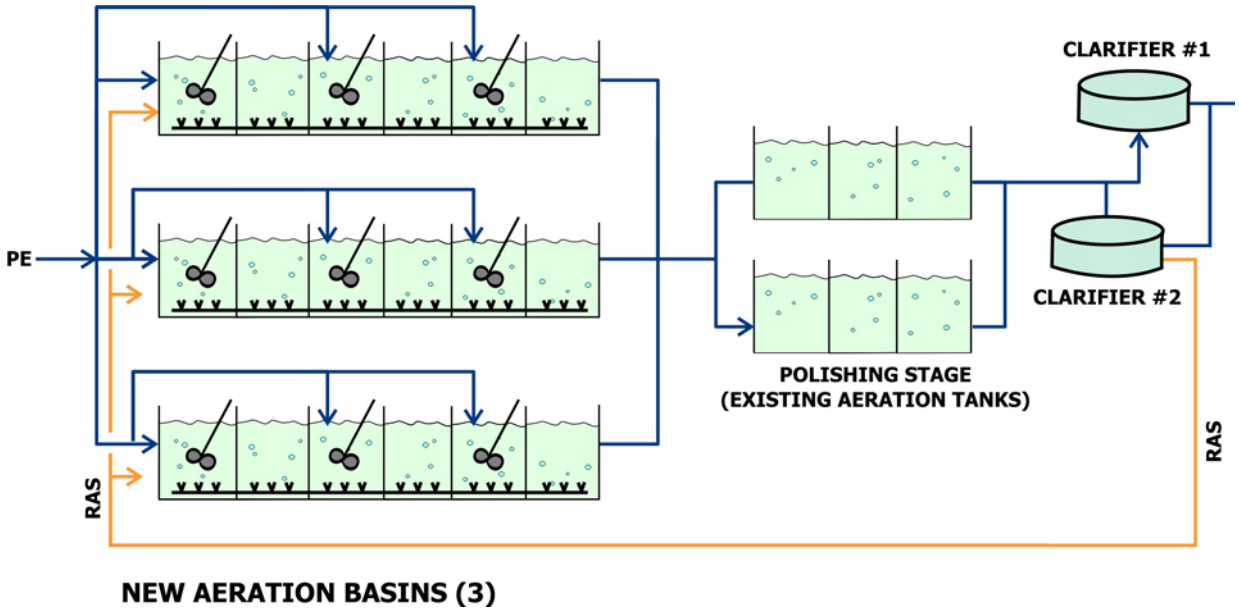


Figure 7.18 Step Feed Activated Sludge (SFAS) Site Layout

Option 3. Integrated Fixed Film Activated Sludge (IFAS)

Option 3 utilizes fixed film to reduce the amount of aeration basin required. This approach is called integrated fixed film activated sludge (IFAS) and involves placing plastic or other types of proprietary media (see **Figure 7.19**) in the aeration basin, which provides surfaces on which bacteria can attach and grow, with the intent of increasing the overall biomass inventory in the aeration tank. Free, floating media is added to the main aeration basins while retaining screens are installed on the downstream end of the tanks to avoid loss of media along with the mixed liquor. A process schematic is shown in **Figure 7.20**.

Figure 7.19 Examples of "wagon wheel" and sponge media used in IFAS technology

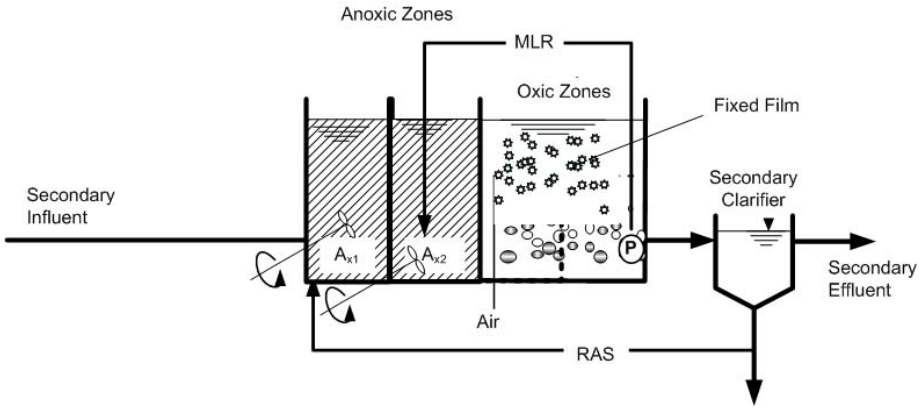


Figure 7.20 Integrated Fixed Film Activated Sludge Process Schematic (WEF, MOP 11)

For conventional year-round nutrient removal, two new basins, or 1.7 MG, will be required. If nutrient limits are established that require only seasonal nutrient removal (NR-S), then only one new basin, or an additional 0.9 MG, would be required. Basin volumes are based on operation with a free mixed liquor concentration of 3,000 mg/L and a 15 day SRT. The internal dimensions of each new basin would be 30 feet wide by 210 feet long, with 18-foot side water depth (versus the existing 15 foot side water depth). With IFAS, the existing secondary clarifiers would continue to be used for separating MLSS from the treated effluent.

With the IFAS alternative, the existing aeration basin would continue to operate in series with new aeration basins (the existing basin would be converted to IFAS). If necessary, the aeration basins could be further compartmentalized with baffles to achieve varying levels of biological nutrient removal with internal process variations.

The IFAS upgrade would reduce the total volume of the new biological reactor basin for SAS (Option 1) by about 43 percent.

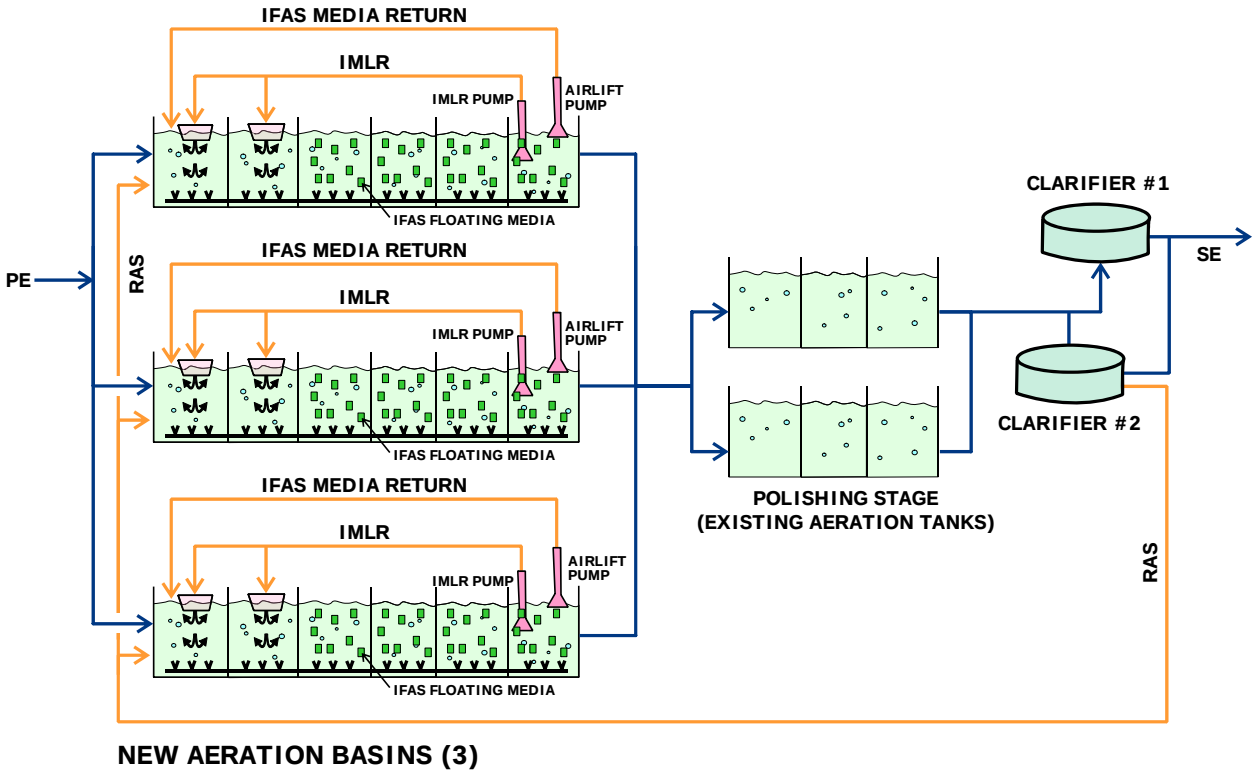


Figure 7.21 IFAS Site Layout (Option 3)

The application of IFAS is relatively new in the United States. There are now less than 24 IFAS activated sludge water reclamation plants (WRP) in the United States treating municipal wastewater. Some example IFAS facilities in the United States of America include:

- Broomfield, CO
- Westerly, RI
- Moorehead, MN
- Annapolis WRF, Anne Arundel County, MD

Option 4. Membrane Bioreactor Combined with SAS (MBR-SAS)

Membrane bioreactors are attractive for many benefits, including minimal land requirements, exceptional effluent quality, and the provision of an additional physical barrier (e.g., filter) to pathogen. Although a relatively new process, there are now likely well over a hundred MBR activated sludge water reclamation plants (WRP) in the United States treating municipal wastewater. Some example nutrient removal MBR facilities currently operating and located in the northwest include:

- Martin Way WRP, Olympia, WA
- Eagle Crest WRP, Redmond, OR
- Bandon Golf Course, Bandon, OR
- Three Rivers Casino, Florence, OR

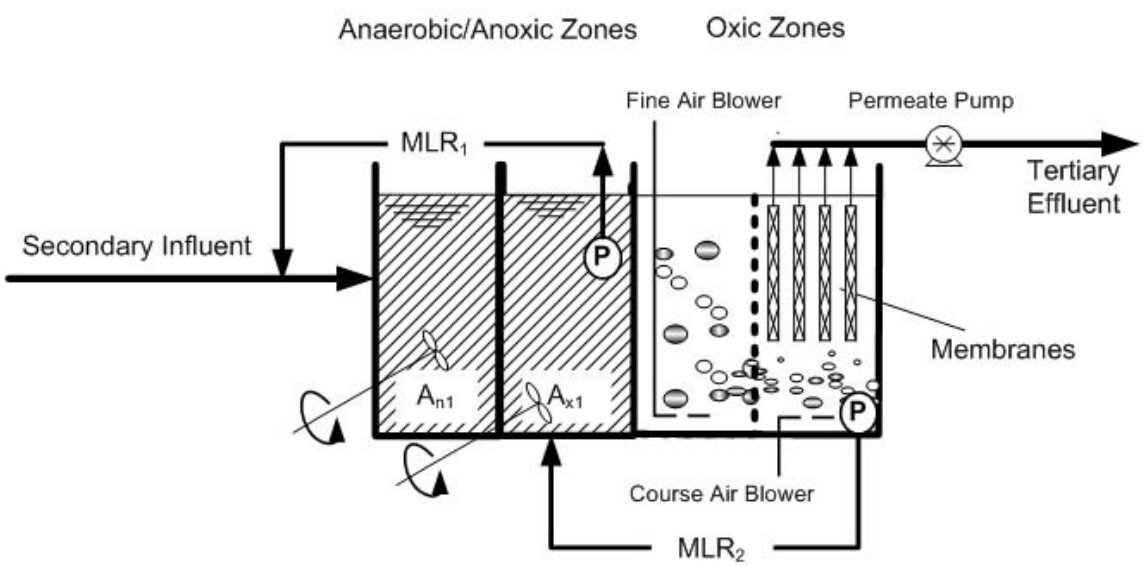


Figure 7.22 MBR Process Schematic (WEF, MOP 11)

However, MBRs also include new challenges, including the need for very fine screens (1 mm opening), increased power consumption, limited ability to pass peak flows, and limited full-scale operation experience at plants larger than 3 to 5 mgd. In addition, membrane bioreactors are effectively replacing secondary clarifiers to remove mixed liquor suspended solids. For these reasons, and because the capacity of the Spring Street STP clarifiers does not warrant full replacement with MBRs based on the projections in this facilities plan, the potential of using membrane bioreactor was investigated for use in combination with existing facilities. As such, an option was developed to use the MBR in a 'scalping' mode, where it would consistently treat up to 3.5 mgd (representing 1/3 of the maximum month flow in year 2030 and representing

current dry weather base flow) while excess flows would be treated in a conventional basin mode and through the secondary clarifiers (see **Figure 7.23**). This option is best described as split treatment consisting of new membrane bioreactors and new selector activated sludge/ (MBR-SAS) reactors.

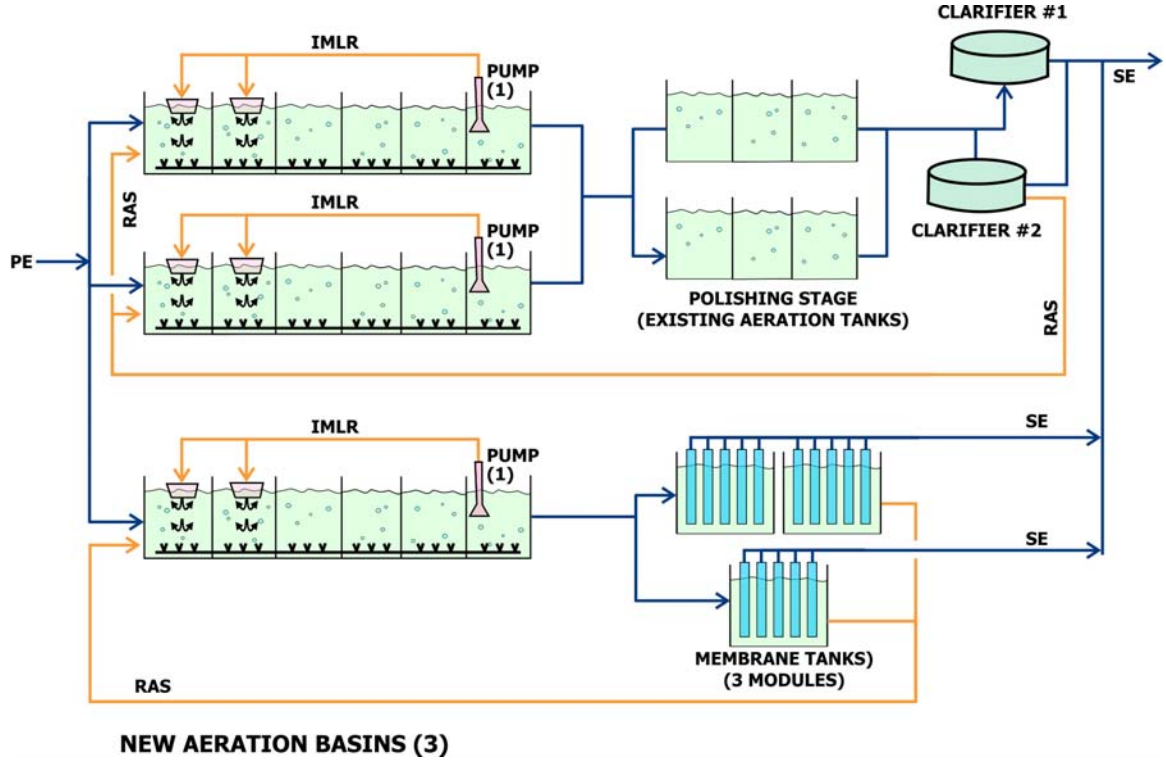


Figure 7.23 Process Flow Schematic of Option 4

The MBR basins would be equipped with coarse bubble diffusers, and no secondary clarifiers would be necessary to follow the MBR units. Since the MLSS concentration in the MBRs is nearly four times greater (9,000 to 10,000 mg/L) than that of selector activated sludge (2,500 mg/L), the MBR basin volumes are roughly one quarter of that required for SAS in Option 1. In Option 4, a balance of conventional treatment with relatively low capital cost and continued use of secondary clarifiers is blended with MBRs, which have higher capital cost but achieve the best effluent quality without the need for effluent filtration.

Meeting year-round, conventional nutrient limits would require the addition of 3 smaller new aeration basins (as opposed to 4 large basins in Option 1 – Conventional SAS) and 3 new MBR tanks or an additional 2.3 MG, of new reactor volume (both SAS and MBR) will be required. If nutrient limits are established that require only seasonal nutrient removal, then only 2 small new aeration basins and 2 MBR tanks, or an additional 1.2 MG of new reactor volume (both SAS and MBR), will be required . Basin volumes are based on operation with a mixed liquor concentration of 2,500 mg/L for SAS and 9,000 mg/L for MBR while targeting 15 day SRTs. MBR tank size is based on flat plate configuration for this planning stage as this is the most space intensive available MBR technology.

With the MBR-SAS alternative, the existing aeration basin would continue to operate in parallel with new SAS and MBR basins. If necessary, the basins could be compartmentalized with baffles to achieve varying levels of biological nutrient removal with internal process variations. The overall dimensions of each new MBR basin would be 25 feet wide by 60 feet long, with an 18-foot side water depth. Dimensions for each new SAS aeration basin would be 30 feet wide by 223 feet long, with 18-foot side water depth (versus the existing 15-foot side water depth). With MBR-SAS, the existing secondary clarifiers will continue to be used for separating MLSS from the treated effluent for the SAS process. No secondary clarifiers are required with the MBR train.

This alternative would reduce the total volume of the new biological reactor basin for SAS (Option 1) by 22 percent.

Option 5. Customized Oxidation Ditch (COxD)

Oxidation Ditches

The oxidation ditch process is a form of suspended growth activated sludge typically characterized by circular or oval channels, along with mechanical surface aeration (photo, this page). Oxidation ditches have long been attractive for their operation at very long solids retention times, which reduces sludge production and associated handling. Moreover, their adaptability to nutrient removal by creating a sequence of aerated and non-aerated zones, their potential for simultaneous nitrification/denitrification and associated low power demand, and their operational simplicity have been sought after, especially in smaller communities. That said, when nitrogen removal is not required, and phosphorus limits are a particular concern, phosphorus release can occur if an excess of anoxic zones is present in the process. Oxidation ditches are a mature technology with thousands in the U.S. Some of the oxidation ditch facilities located in the Northwest which remove nutrients include:

- Silverton WRP, OR
- Cheney WRP, WA
- McMinville WRP, OR
- Ashland WRP, OR

This oxidation ditch alternative is developed assuming continuation of primary clarification. For treatment modes that require biological selectors, the existing aeration basins will be converted to anoxic reactors. Since the existing aeration basin is already compartmentalized and half of the cells have mixers, conversion of the existing basin should require minimal new

construction. Along with mixers, diffused air would remain in the final cells so that the existing basin could serve as a redundant treatment unit should an oxidation unit be removed from service. Low lift pumps would transfer dentrified MLSS from the third cell of the existing aeration basin to the new oxidation ditch system. MLSS for the oxidation ditch will return to the fourth cell of the existing aeration basin for further aeration or post denifrification.

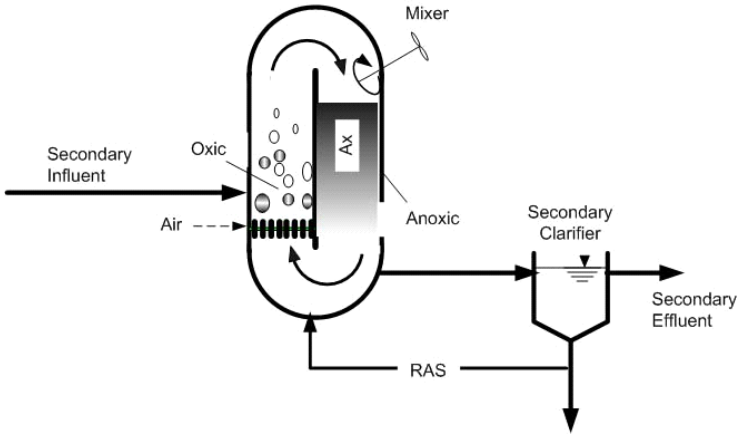


Figure 7.24 Oxidation Ditch Process Schematic (Source: MOP 11)

Continuous year-round conventional nutrient removal would require the construction of two new oxidation ditches, or 3.1 MG. If nutrient limits are established that require only seasonal nutrient removal, then only one new oxidation ditch, or an additional 1.5 MG, will be required. Basin volumes are based on operation with mixed liquor concentration averaging 2,500 mg/L and targeting 15 days SRTs. The COxD upgrade will result in the total volume of a new biological reactor basin being essentially similar to that for the SAS alternative (Option 1).

With the COxD alternative, the existing ditch would continue to operate in parallel with the new aeration basin. If necessary, the separate selectors could be added ahead of the ditch with compartmentalized baffles to achieve internal process variations. Each new customized oxidation ditch would have an internal 56-foot wide and a 160-foot long straight section, with 18-foot side water depth (versus the existing 15-foot side water depth). With COxD, the existing secondary clarifiers would continue to be used for separating MLSS from the treated effluent.

Oxidation ditch units typically treat screened wastewater with no primary clarification. As a result, the oxidation ditch option was first considered along with the "no primaries" option, and was especially attractive within the context of stringent nitrogen removal. However, prescreening of options showed that a "no primary" alternative was not viable, especially because of solids handling and optimization of energy resources (e.g., biogas) while the latest information from DEQ indicates that total nitrogen limits (e.g., denitrification) will not be required. Pros and cons are given in that context in the recommendation section below.

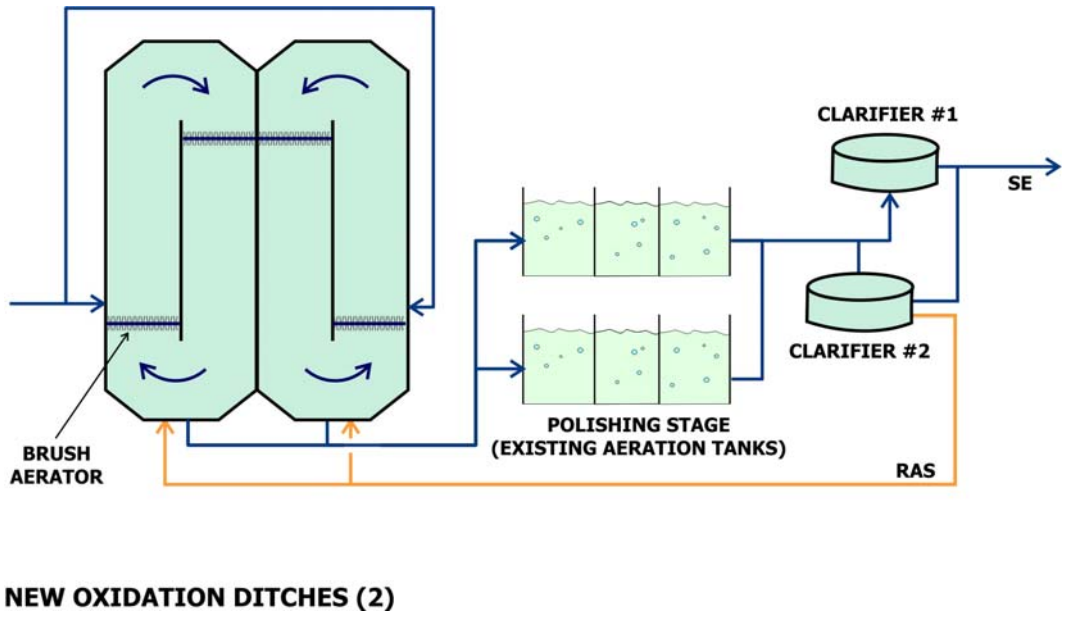


Figure 7.25 COxD Process Schematic for the Spring Street STP

Comparison of Biological Treatment Alternatives

Table 7.7 summarizes the main basin differences for the five alternatives.

Table 7.7 Biological Process Alternatives Reactor Volumes Comparisons

Comparison of Biological Reactor Volume [(a)(b)]	New Aerobic Reactors			Description
	Number Reactors	Volume Each (MG)	Total Volume (MG)	
1 - SAS	4	0.7	2.9	Expand to 10.4 mgd using selector activated sludge
2 - SFAS	3	0.6	1.9	Continue using the existing aeration basin as SAS and add new step feed activated sludge basins resulting in a total 10.4 mgd capacity
3 - IFAS	3	0.6	1.7	Covert the existing aeration basin to integrated fixed film activated sludge (IFAS) and add new IFAS basins resulting in a total 10.4 mgd capacity
4 - MBR-SAS	2 (SAS)	0.9 (SAS)	1.8 (SAS)	Expand with 6.9 mgd using selector activated sludge and add a 3.5 mgd membrane bioreactor
	3 (MBR)	0.17(MBR)	0.5(MBR)	
5 - SOxD	2	1.5	3.1	Continue using the existing aeration basin as SAS and add new oxidation ditches resulting in a total 10.4 mgd capacity

The SAS process is the most adaptable in meeting future effluent standards. Of the biological treatment processes, SAS has the greatest track record as a proven technology while still providing flexibility for future upgrades. This is important since many innovative processes can be reconciled with it. As a result, the SAS process is recommended during the planning stage.

A comparison of the pros and cons for each option is described in **Table 7.8** below. The capital and O&M costs are included for each alternative. For direct comparison, annual O&M costs are calculated using 2011 as the base year.

Table 7.8 Pros, Cons, and Cost of Biological Process Alternatives

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
1. SAS	▪ Process already exists at the Spring Street facility. ▪ Best for flexibility when using compartmentalization to obtain various modes of nutrient removal. ▪ Low capital cost ▪ Adaptable to various process modes ▪ Staff familiarity with process ▪ Compatible with existing secondary clarifiers ▪ Allows use of existing aeration basins ▪ Moderate energy draw ▪ Least limiting option that is adaptable to future, innovative technologies (MBR or IFAS) for expansion or to accommodate very long SRTs	▪ Largest footprint required ▪ Most site construction impact	15.6	74,000
2. SFAS	▪ Reduces the amount of new aeration basin required by 33% from that needed with SAS ▪ High level of process flexibility ▪ Protection of biomass during storm events ▪ Allows extended life of secondary clarifiers should it become limiting (not currently the case)	▪ Requires careful primary effluent flow splitting process to balance flow to individual treatment steps. ▪ Limited number of case histories operating on a routine basis in the Pacific Northwest. ▪ Requires increased operational control to balance loadings. ▪ Difficult to achieve stringent biological nutrient limits without additional mixed liquor return (MLR) pumping at each step. ▪ Measurement and control of SRT is difficult, since there is a gradient across the basins	11.4	79,000
3. IFAS	▪ Reduces the amount of new aeration basin required by 40% from that needed with SAS ▪ Incorporates fixed film biology which is more stable than biology consisting of suspended growth (used in the SAS process) organisms	▪ High capital cost – media is proprietary ▪ Limited number of actual case histories operating within the United States ▪ Effluent turbidity may be higher than with other activated sludge technologies	18.4	77,000

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
	▪ Protects biomass from washout during storm events ▪ Some media might allow operation with simultaneous nitrification/denitrification, which reduces aeration demands and power requirements			
4.MBR-SAS	▪ Reduces the amount of new aeration basin required by 22% from that needed with SAS ▪ High effluent quality achieved without effluent filtration for up to 3.5 mgd ▪ Reuse quality effluent produced without additional tertiary treatment ▪ Excellent public acceptance ▪ Best barrier for suspended solids and associated phosphorus without the need for tertiary filtration	▪ Limited large scale operation ▪ Highest capital cost for biological treatment ▪ High power requirements with little flexibility to reduce them ▪ Requires fine screening at headworks ▪ Essentially running two plants ▪ Reliance on manufacturer for membrane replacement ▪ Chemical storage and handling required for keeping membranes clean ▪ Requires construction of both new MBRs and expansion of SAS ▪ Capacity of existing clarifiers not used ▪ Although cost of membrane bioreactors has continuously decreased over the years, the decrease has slowed down due to stainless steel and plastic/petroleum derivatives- related components and shipping costs	22.2	201,000
5. COxD	▪ Lowest capital cost ▪ Denitrification accomplished by alternating aeration, thereby simplifying operational control ▪ Excellent effluent quality and low turbidity effluent possible ▪ Frequently used at small to moderate sized plants ▪ Low O&M ▪ Simple process	▪ No footprint advantage over SAS option ▪ Oxidation ditches are generally large, making modular expansion difficult ▪ Conversion to advanced biological nutrient removal with selector technology must be done external to ditch ▪ SSSTP size is on the cusp of the target range for COxD and not compatible with regional treatment option ▪ Limited flexibility ▪ Perception of "moving backwards", technology-wise	Not Costed	Not Costed

Notes:
(a) September 2008 basis. Total project cost estimates reflect planning level and were developed including materials, equipment, and labor, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%). See **Appendix A**.

Recommendation

The selector activated sludge process is the most adaptable in meeting future effluent standards. Of the biological treatment processes, SAS has the greatest track record as a proven technology while still providing flexibility for future upgrades. This flexibility is important since many innovative processes examined in this plan can be reconciled with it. As a result, the SAS process is recommended for the facility plan. Selector Oxidation Ditch technology is a variation of SAS, but is most suited to smaller plants, and is not consistent with a larger regional approach. The membrane bioreactor option is very capital- and energy–intensive, and is not needed to meet discharge or reuse requirements at this time. A small MBR could be built at a later date to meet just the reuse demands should the City so choose. MBR technologies are coming on the market that can be retrofitted to an SAS approach.

Based on the pros, cons, and costs, it is recommended to implement Option 1: expand the existing Selector Activated Sludge Process.

7.2.4 Phosphorus Removal

Although some phosphorus removal can be achieved earlier in the process train, a tertiary treatment step is usually required. Tertiary treatment refers to the treatment steps required in addition to secondary treatment, which typically removes conventional levels of BOD, TSS, and some nutrients. A tertiary treatment step is required when stringent effluent limits must be met, particularly on phosphorus and/or turbidity.

Existing System

The Spring Street STP currently operates a conventional activated sludge process under a permit without effluent phosphorus or turbidity limitations. With the sensitive nature of the receiving waters downstream (Lake Ewauna and the Klamath River), effluent phosphorus limitations are likely to be implemented. At a minimum, space needs to be reserved to accommodate phosphorus removal treatment in the future. Two levels of potential phosphorus removal limits can be generically defined, corresponding to a *conventional* level of phosphorus removal (< 1 mg/L) and a *stringent* level of phosphorus removal (<0.1 mg/L). Below is a description of the theory behind the two levels of treatment.

Figure 7.26 illustrates the relationships between effluent total suspended solids and phosphorus content. Conventional activated sludge solids contain between 1.5 and 2 percent phosphorus (blue band in **Figure 7.26**), while phosphorus removal process solids contain between 4 and 5 percent phosphorus (salmon band in **Figure 7.26**).

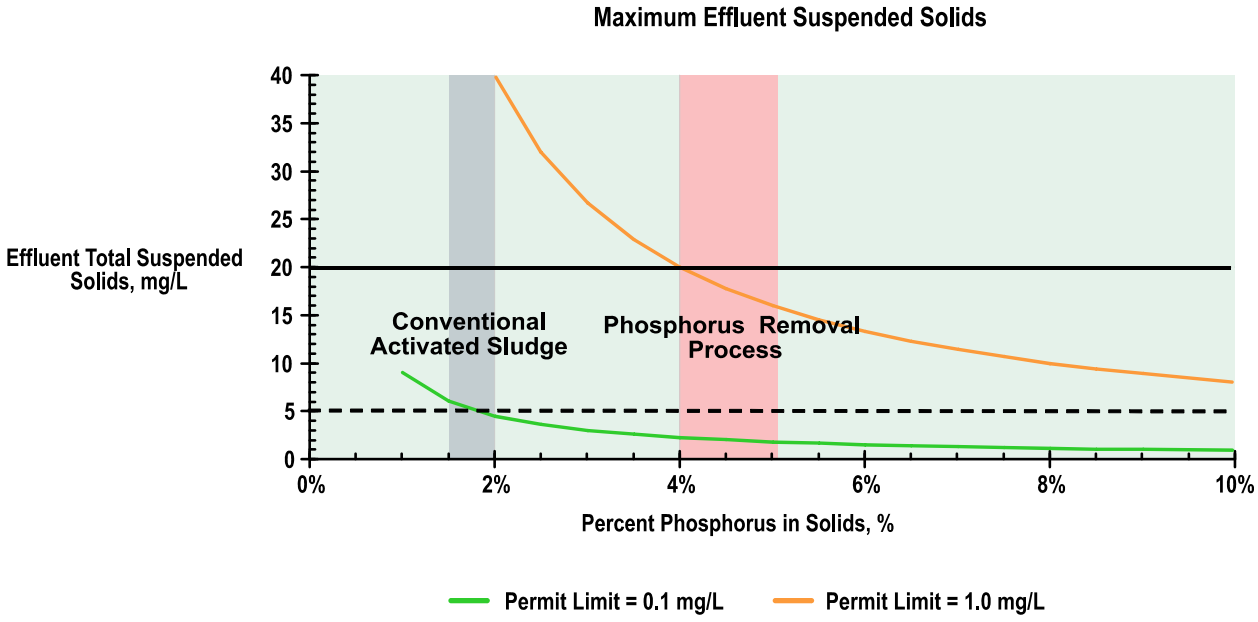


Figure 7.26 Relationship Between Effluent Phosphorus, Efluent TSS, and Permit Limits

Figure 7.26 illustrates that meeting effluent phosphorus limits of 1.0 mg/L may be achievable with conventional activated sludge at effluent TSS concentrations of 20 mg/L while achieving an effluent limit of 0.1 mg/L would require consistently meeting effluent TSS concentrations below 2 or 3 mg/L. Thus, because the concentration of effluent phosphorus is directly related to the concentration of effluent total suspended solids (TSS), very low effluent phosphorus limits require exceptional removal of suspended solids, typically via tertiary filtration. The latest information released by DEQ indicates that the Spring Street STP effluent mass total phosphorus limit will be required to meet 5 kg/day or less. **Figure 7.27** shows the corresponding effluent total phosphorus concentration when applied to the projected flows and loads over the planning period. The red and blue lines in **Figure 7.27** show the impact of applying a seasonal versus a year-round permit limit to the Spring Street STP.

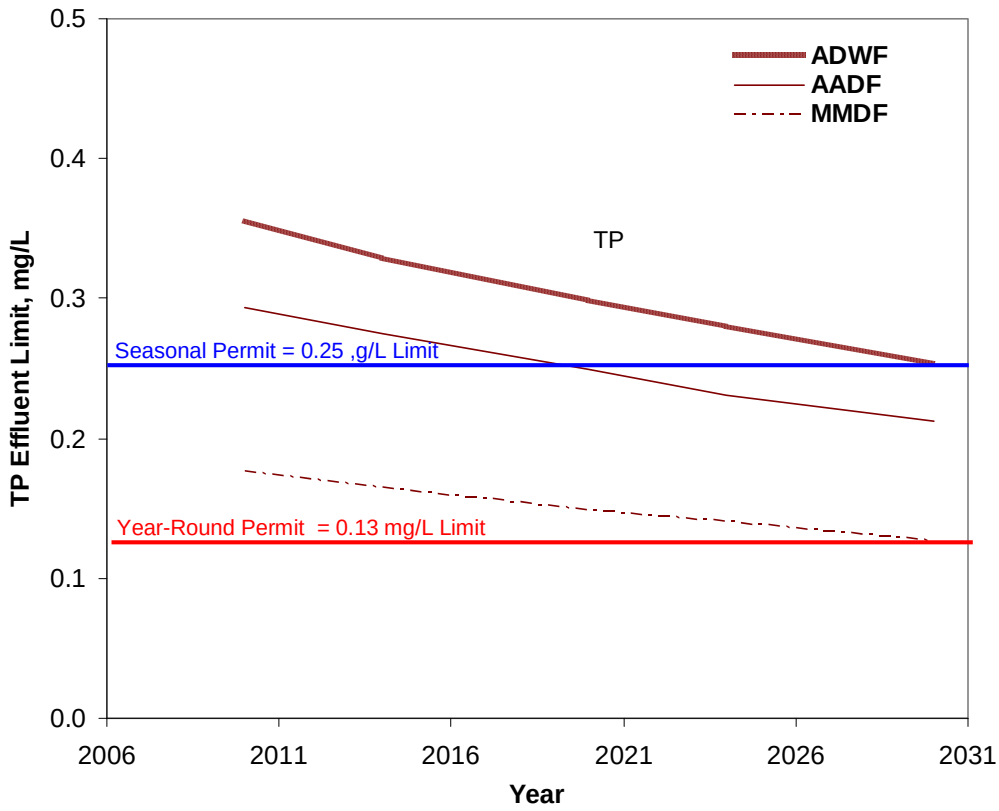


Figure 7.27 Effluent Total Phosphorus Limit (assuming 5 kg/d Total P maximum mass discharge)

Available Technologies

Although there are some examples of enhanced biological phosphorus removal (EBPR) processes meeting effluent phosphorus limits below 1.0 mg/L, the conventional wisdom is that effluent phosphorus limits of 1.0 mg/L or less require the use of chemicals and tertiary filters. Effluent filters lower the effluent phosphorus and provide greater reliability, consistently removing effluent TSS down to 2 mg/L, which in turns removes the phosphorus associated with the effluent TSS, as illustrated in **Figure 7.27**.

Chemical precipitation with tertiary filtration as a stand-alone or a polishing step to EBPR is also the most common treatment technology used in the US, as documented in EPA Region 10's April 2007 document (EPA Region 10 Advanced Wastewater Treatment to Achieve Low Concentration of Phosphorus, EPA 910-R-07-002, April 2007).

Most existing facilities use some type of tertiary chemical precipitation combined with tertiary clarification and/or filtration, the most economical alternatives to meet low levels of effluent phosphorus. Many equipment and configuration variations exist, ranging from sand or cloth filters to ion exchange and reverse osmosis.

Where effluent limits are seasonal, e.g., should phosphorus removal be required only during the dry season based on the receiving water characteristics, the use of high rate clarification (via ballasted flocculation) in a dual purpose fashion may make economical sense. As described in **Section 7.2** of this Plan, ballasted sedimentation is a highly compact clarification process where flocculation and settling is assisted with the use of chemicals. More and more, ballasted sedimentation is used to treat peak wet weather flows where the available footprint is limited, to add conventional clarifiers and/or to prevent biomass washout at high flows. This would normally mean that the units are idle during the dry season. However, when phosphorus removal is required, the ballasted sedimentation tanks can be operated as phosphorus removal tanks since they use the same precipitation chemicals as the high rate primary clarification process. For the Spring Street facility, however, high rate clarification was dismissed because of the low peak to average flow ratios.

Alternatives

Five viable options were considered to address phosphorus removal and/or tertiary treatment at the Spring Street facility:

Option 1 – Provide Anaerobic Influent Zone in Secondary Treatment System

Option 2 - Add Chemical Precipitation and no Tertiary Filtration

Option 3 - Add Chemical Precipitation and Disk Filters

Option 4 – Add Chemical Precipitation and Continuously Backwashed Sand Filters (CBS Filters)

Option 5 – Add Membrane Bioreactors to secondary treatment system

Unit Process	Tertiary Treatment
Option 1	Anaerobic zone
Option 2	Chem Precipitation
Option 3	Chem Precip & Disk Filters
Option 4	Chem Precip &CBS Filters

The options above are all phosphorus removal technologies. While there are emerging phosphorus *recovering* technologies on the market, such as Ostara (Ostara Nutrient Recovery Technologies Inc), there is currently limited information on such technologies and they have not been further evaluated in this plan. As the City progresses in implementing the recommendations, more data may be available to evaluate the benefits, constraints, and costs of such technologies.

Option 1. Provide Anaerobic Influent Zone in Secondary Treatment System

Background. Biological phosphorus removal occurs via phosphorus uptake by bacteria in the mixed liquor. For the uptake to take place, a number of conditions must exist:

- Presence of readily biodegradable BOD or COD, which is rapidly converted to volatile fatty acids (VFAs) through fermentation under anaerobic conditions
- Relatively high BOD/TP ratio (> 20:1)

- Anaerobic conditions, i.e,. absence of dissolved oxygen and nitrates
- Absence of toxins

The uptake of phosphorus by bacteria is a two-step process involving anaerobic and aerobic sequences in the secondary treatment system, each corresponding to phosphorus release (anaerobic stage) and to phosphorus uptake (aerobic stage). Within the sequence, a greater amount of phosphorus is taken up by the bacteria than is released, with a net removal effect from the liquid stream.

The first step towards biological phosphorus removal is thus to provide an additional anaerobic zone within the secondary treatment process. The phosphorus-release process in the anaerobic zone is relatively rapid, and residence time within this zone is typically no more than one hour. Consequently, adding provisions for an anaerobic zone is a relatively minor expense, as it could be made with removable baffles and swing zones (provided with both mixing and aeration that could be independently turned on or off) to maximize process flexibility.

The efficiency of the anaerobic zone, however, is limited and subject to a number of not easily controllable variables, such as sufficient influent VFAs, and the impact of recycle streams. Although anaerobic zones can safely remove phosphorus in the 0.2 to 2.0 mg/L range, their efficiency is limited for more stringent limits. For increased efficiency, enhanced biological process removal (EBPR) processes have been developed, such as the A/O, A^2/O, UCT, VIP, or the 5-stage Bardenpho process, which consist of specific (and proprietary) sequences of anaerobic, anoxic, and aerobic phases to maximize phosphorus release/uptake. Overall, these process variations require significant tank and piping configuration modifications, and are most beneficial when very low levels of phosphorus concentrations are paired with tight nitrogen removal limits. Because the SSSTP will likely face phosphorus limits in the 0.1 to 1.0 mg/L range with no total nitrogen removal limits, it is not deemed appropriate to invest in the more complex biological system configurations and energy requirements of an EBPR process at this point. A simple anaerobic stage addition can achieve a relatively high first-stage phosphorus removal, which could be polished with tertiary filtration as necessary.

Configuration. Based on a maximum hydraulic residence time of one hour at design flow, the addition of an anaerobic zone to the secondary treatment system would require a volume of 433,000 gallons at the most, assuming year-round phosphorus removal (i.e,. designed around peak month flow). Conversely, the same anaerobic zone would require a volume of 217,000 gallons assuming seasonal removal (i.e., designed around average dry weather flow). Removable, submerged baffles should be considered during detailed design of the facility. The zones could be configured as swing zones – either anaerobic or anoxic – requiring mixers and piping provisions for the recycle streams to return to this first cell or to the second cell.

Option 2. Add Chemical Precipitation

Certain chemicals produce insoluble or low-solubility salts when combined with phosphate, which can then be removed from the wastewater with tertiary filtration. Typical precipitation chemicals added to the wastewater are alum, ferric chloride, and lime. Chemicals can be added at various points within the treatment process: upstream of the primary treatment, upstream or downstream of the aeration basins, downstream of secondary clarification, or at a combination of those points (see **Figure 7.28**).

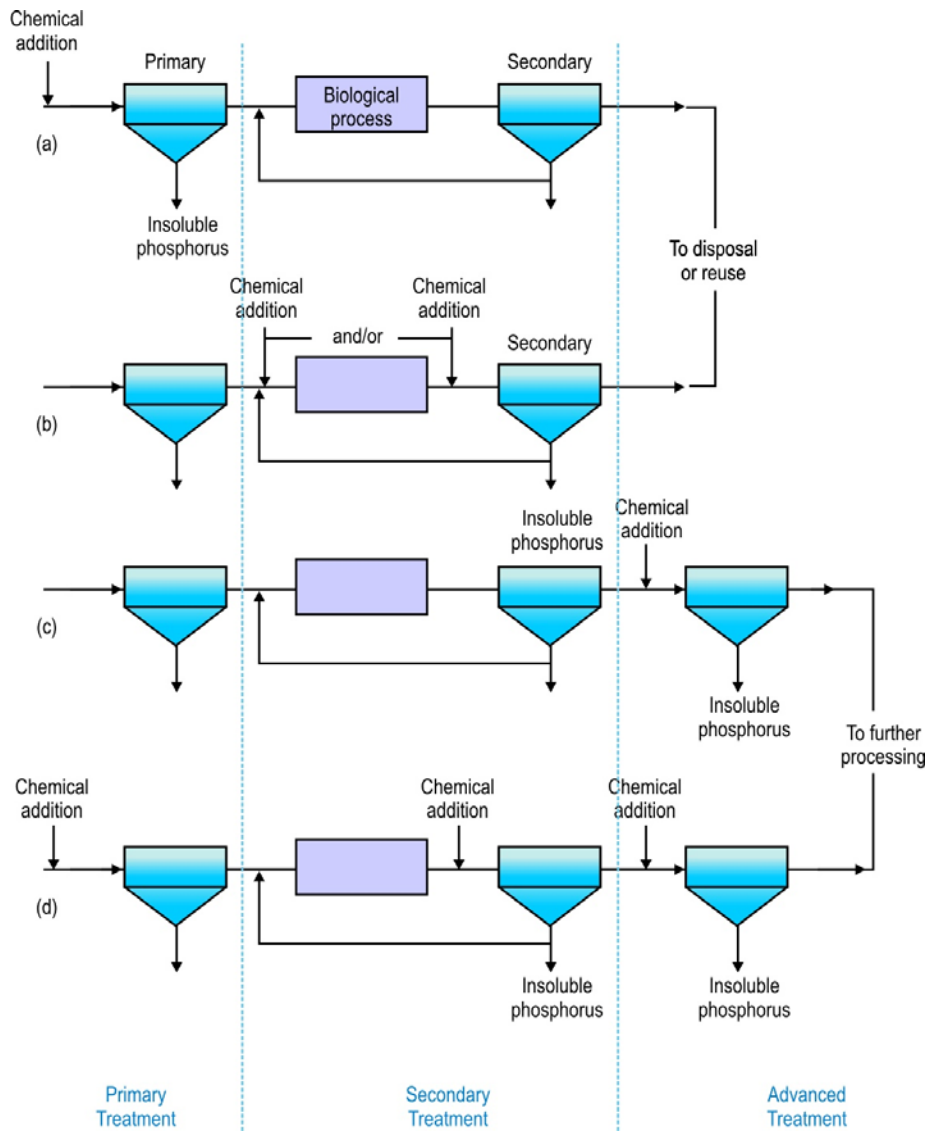


Figure 7.28 Alternative points of chemical addition for phosphorus removal: (a) before primary sedimentation, (b) before and/or following biological treatment, (c) following secondary treatment, and (d) at several locations in a process (known as "split treatment"). (Figure from MetCalf & Eddy, Third Edition)

Iron salts offer the dual advantage of providing phosphorus removal as well as sulfide removal and improved odor control. Because of this, ferric is often added both upstream of primary

treatment and downstream of the secondary clarifiers to deploy its full potential. When there is no biological phosphorus removal, ferric dosages can vary between 5 to 20 mg/L, depending on the level of operations and risk of permit violation.

Ferric chloride needs can be estimated as follows:

Dosage: 5-20 mg/L as iron (Fe). (Note: 0.344 lb Fe per lb of $FeCl_3$).

11.2 lb FeCl3/gal of 30% solution

For 10.4 mgd (peak month flow):

@ 5 mg/L Fe = 1,260 ppd FeCl3 = 112.5 gal/day

@ 20 mg/L Fe = 5,038 ppd FeCl3 = 450 gal/day

For 5.2 mgd (average dry weather flow) :

@ 5 mg/L Fe = 629 ppd FeCl3 = 56 gal/day

@ 20 mg/L Fe = 2,520 ppd FeCl3 = 225 gal/day

A 5,000 gallon feed tank would provide about 3 weeks of storage for a conservative applied dose of 20 mg/L during average dry weather flow. Double-walled, cross linked high density polyethylene (XLHDPE) or fiberglass tanks with double containment are recommended to store ferric chloride, which is corrosive.

The chemical feed pumps for the ferric system will need to provide 2 to 10 gallons of chemical per hour, and should be sized to serve a 5 gallon/hour duty. As ferric chloride is corrosive, any feed pump surface in contact with chemical should be manufactured of a high silica iron (Durimet, Durichlor and Durcon) or titanium. Double mechanical seals should also be provided in the chemical feed pumps to prevent seal leakage over time. These provisions should be carefully evaluated during design for the facilities.

Option 3. Add Disk Filters (Tertiary Filtration)

Tertiary filtration options fit in the plant prior to disinfection, as shown in **Figure 7.29**. Disk filters have become one of the most common tertiary filtration technologies in the past 10 years. A total of 4 units of 3.5 mgd each would be required to meet a year-round effluent phosphorus limit with 1 unit as standby, while 3 units would provide enough capacity to meet a seasonal limit at the projected average dry weather flow of 5.2 mgd. The modular layout of the disk filtration units (see **Figure 7.30**) allows for relatively simple expansion with varying effluent limits. Each unit is small in footprint, with a total estimated footprint of 19 feet by 56 feet for three units. The units have a low profile, with an overall height of about 7 feet. The minimum required hydraulic head is 3.6 feet.

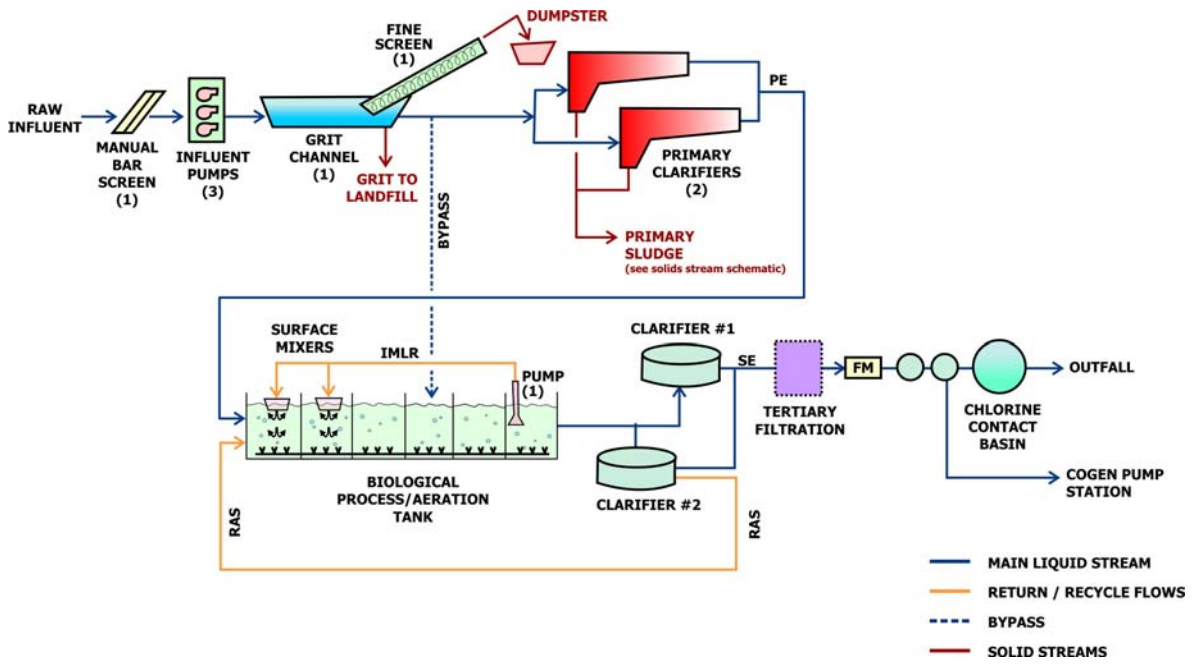


Figure 7.29 Tertiary Treatment Location Within Existing Liquid Stream Treatment Schematic (purple box)

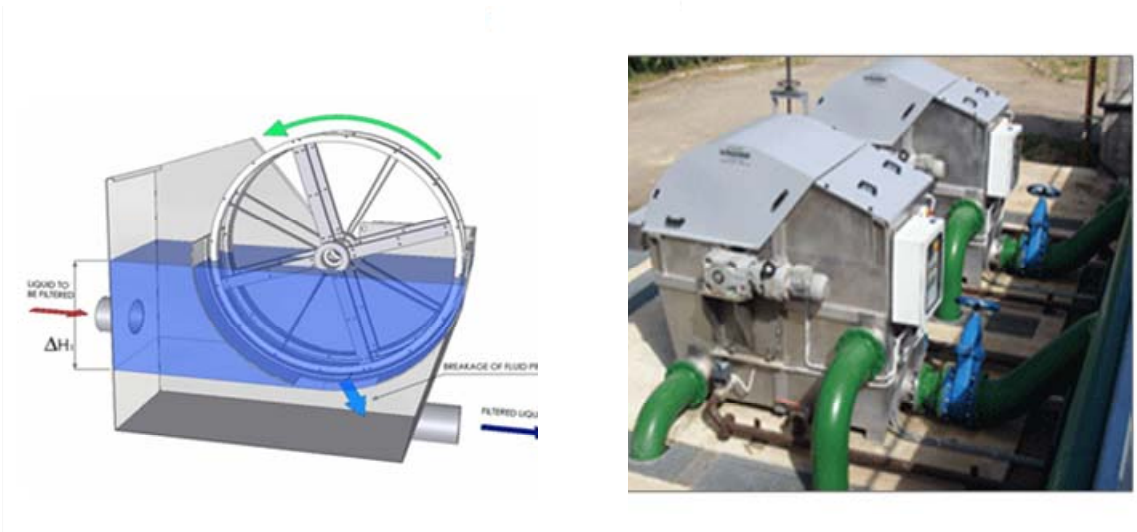


Figure 7.30 Example of Disk Filtration Unit (Ultrascreen® Photo and Schematic Courtesy of Nova Water Technologies)

Site Constraints

The logical site location to add tertiary filtration units would be downstream of the secondary clarifiers, where the existing gravity thickener resides (assuming it would be demolished). However, there are three concerns with siting the filters in that location. First, there are critical pipes and ductbanks in the way (see **Figure 7.31** for site constraints), which would make construction difficult. Second, since very little hydraulic head is available between the clarifiers and Lake Ewauna's high water level, the addition of an effluent booster pump station will be required and take even more space. Lastly, the additional redundancy to the disinfection process required to meet EPA Class I reliability criteria (as presented in **Section 4** and discussed in **Section 7.3** of this Plan) requires modifications that are not compatible with locating the filters in the gravity thickener area. For these reasons, and to fit with long-term planning goals, expansion to the east rather than in place of the existing gravity thickener was considered and developed for this Plan.

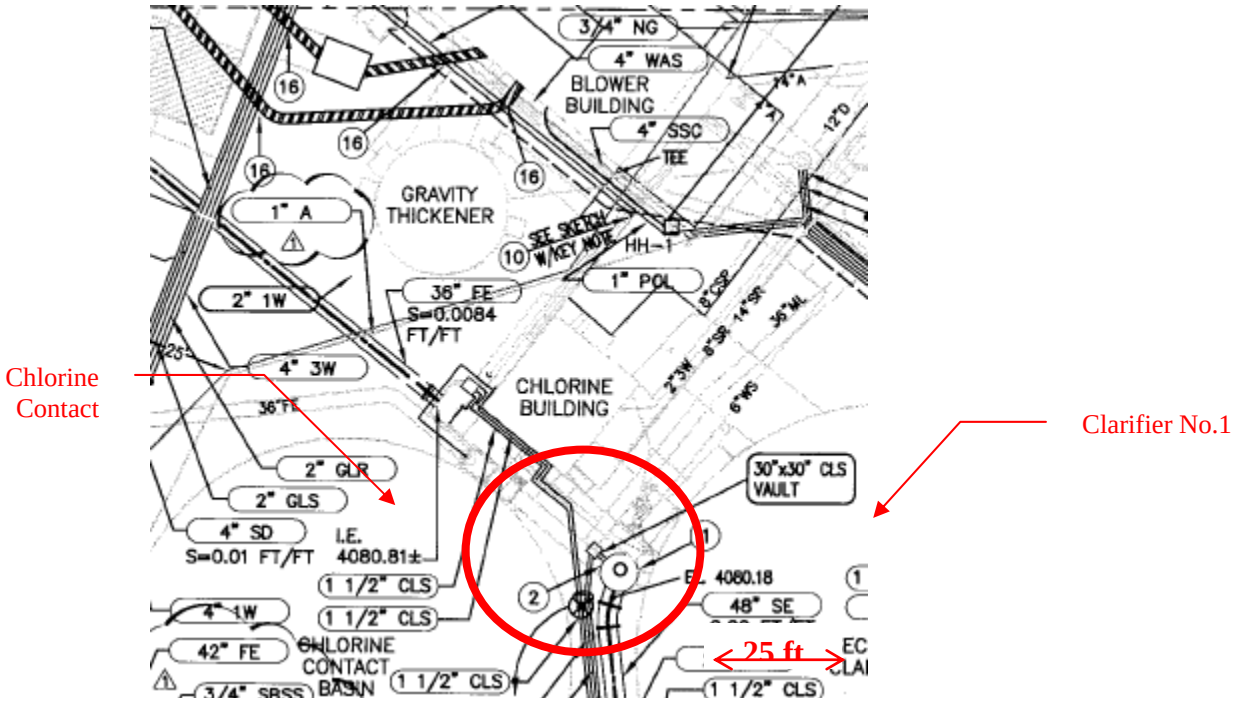


Figure 7.31 Site Constraints for Additional Process Units Between Existing Secondary Clarifiers and Disinfection

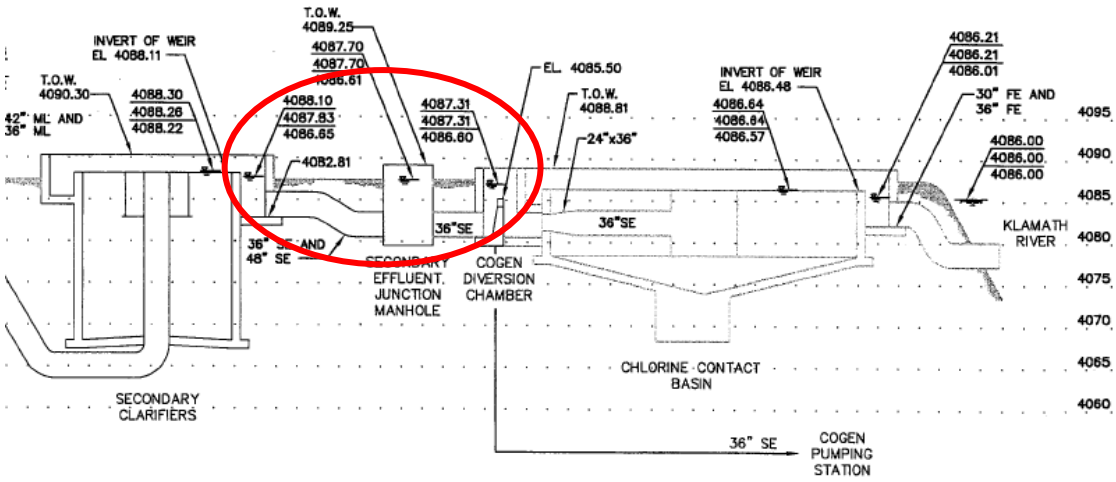


Figure 7.32 Hydraulic Constraints for Additional Process Units Between Existing Secondary Clarifiers and Disinfection

The disk filters require a minimum of 3.6 feet of hydraulic head; however there is less than a foot of hydraulic head available between the secondary clarifiers and effluent disinfection. The available head between the secondary clarifiers and Lake Ewauna's high water level (see **Figure 7.32**) is also less than 3 feet. Because of this, a low head effluent booster pump station would be required prior to the disk filters.

Option 4. Add Continuously Backwashed Sand Filtration

Continuously backwashed, moving bed sand filters are increasingly used to achieve very low phosphorus levels. The moving bed terminology refers to the fluid-like movement of the sand within the unit, which continuously grinds the media and effectively eliminates backwashing needs. This fluid movement of the filtering media is maintained via airlift pumps. **Figure 7.33** depicts the technology. The clarified secondary effluent is conditioned with chemicals before entering the filtering unit via distribution arms at the bottom. Wastewater flows upwards through the bed, where phosphorus precipitates and other particulates are captured and sent to solids handling.

One advantage of this technology is that it could be expanded from a single pass system that could meet total phosphorus limits down to 0.5 mg/L, to a two-pass system that could achieve effluent limits down to 0.1 mg/L or even less. Some manufacturers provide proprietary reactive sand, which is coated with iron oxide. The reactive sand can potentially be recycled to the head of the plant, reportedly assisting in secondary clarifier settling while providing odor control (because of the iron).

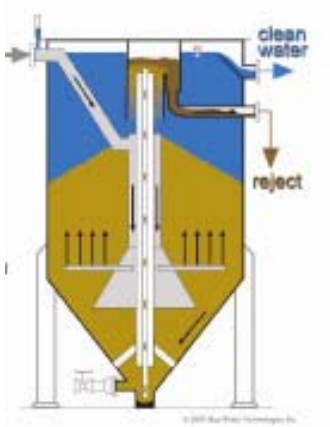
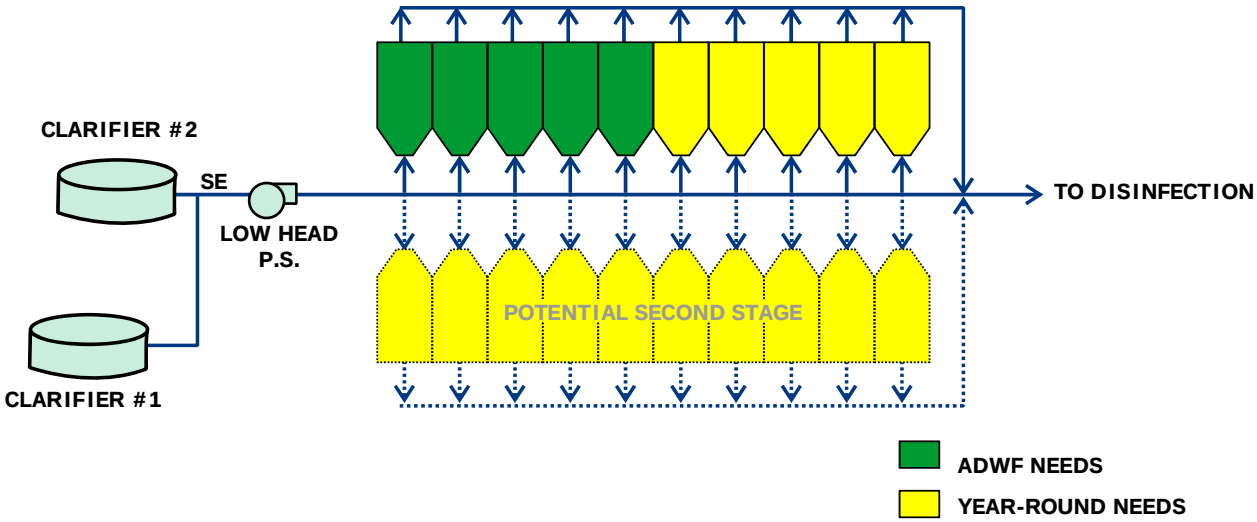


Figure 7.33 Schematic of Continuously backwashed Sand Filter (Picture courtesy of Blue Pro®)

Should seasonal limits be imposed, the system would need to be sized to treat 5.2 mgd (average dry weather flow in 2030) and meet 0.25 mg/L total P, which is achievable with a single pass. This would translate into a system of five quads (sets of four units, each sized at 5 gpm/sf loading rate), occupying a total footprint of approximately 24 feet by 75 feet. However, meeting a year-round total P limit of 5 kg/d would require both doubling the hydraulic capacity and likely going to a dual pass system to maintain effluent concentrations below 0.13 mg/L at peak month flow (10.4 mgd). In year 2030, this means that as much as twenty quads (sets of four) may be required should a dual pass be required, depending on pilot testing (see **Figure 7.34**).

A plan view of a single pass installation is shown in **Figure 7.35.**



TERTIARY FILTRATION UNITS (10 QUADS)

Figure 7.34 Continuously Backwashed Sand Filtration Schematic

For this evaluation, a total of ten units in a single pass configuration was assumed, considering that first stage biological P removal and/or chemical precipitation in the secondary clarifiers would be implemented. When reserving footprint, accommodation should be discussed with plant staff for room for an appropriate loading method for supplying fresh media into the units.

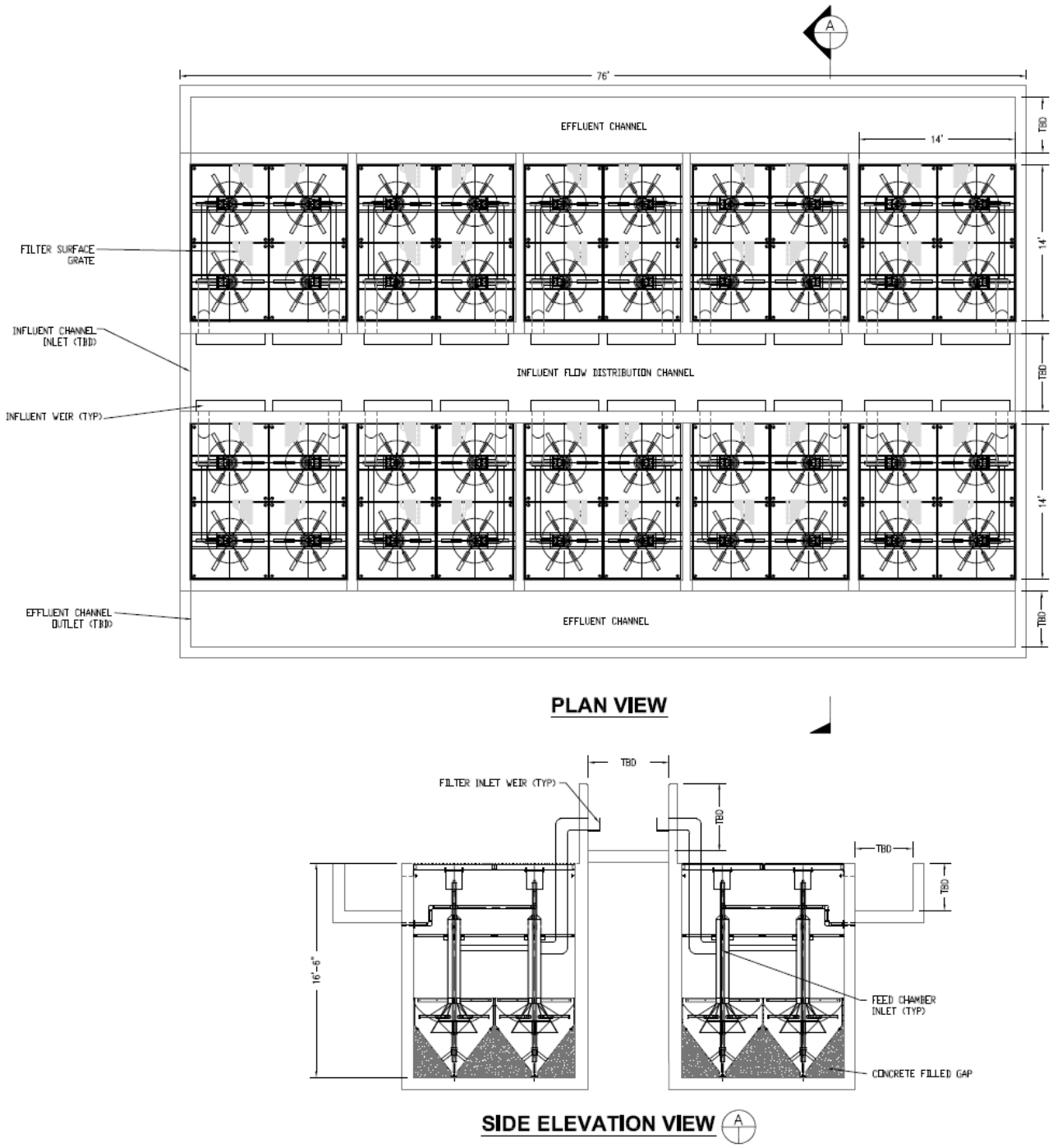


Figure 7.35 Plan and Section Views of Continuously Backwashed Filtration Units Installation (10 quads of 4 in single stage mode). Drawing Provided by Blue Water Technologies (Hayden, ID).

Option 5. Add Membrane Bioreactors to secondary treatment system

In this option, the benefits of using membranes for secondary treatment system are included under the tertiary filtration portion. Because of the very fine mixed liquor filtration that would be achieved with membranes (in lieu of secondary clarifiers), there would be no need to add tertiary filtration for particulate and particulate-associated phosphorus removal. Combined with biological soluble phosphorus removal via the addition of an anaerobic zone, a high level of phosphorus removal could be achieved, as very low effluent NTU and TSS concentrations. It is generally recognized that MBR filtration can achieve total phosphorus effluent concentrations ranging from 0.01 to 0.04 mg/L. This performance is beyond the requirements for the City: assuming permitted mass discharge limits of 5 kg/day total phosphorus, the Spring Street facility would be required to be able to meet discharge limits down to 0.13 mg/L total phosphorus, based on a projected peak month flow of 10.4 mgd.

With this consideration, the existing secondary clarifiers at the Spring Street facility are one of the few facilities not requiring an upgrade based on capacity, reliability, or structural integrity, and replacing the entire secondary treatment process with an MBR one may not serve the best interests of the City. Therefore, this analysis examined a potential blending scenario, where the smallest MBR plant would be installed in parallel with a conventional plant to achieve the desired blended effluent quality. This scenario would be particularly attractive should low phosphorus limits be required on a seasonal basis rather than year-round (which is not the direction that DEQ is indicating).

For an evaluation of the blended scenario, it was assumed that the MBR effluent would meet a total phosphorus (TP) concentration of 0.04 mg/L while the conventional plant (assuming biological phosphorus removal) would reliably achieve between 1 and 2 mg/L TP. **Figure 7.36** illustrates the result of the analysis. The blended scenario was run for both average dry weather flow (ADWF) and maximum month average daily flow (MMADF). For each of these conditions, a pair of lines illustrates the expected range of the blended effluent TP at a given MBR size (the conventional plant being sized for the balance of the flow for each condition). The analysis shows that to achieve the phosphorus levels below 2 mg/L, the MBR plant would essentially have to be sized for the entire flow.

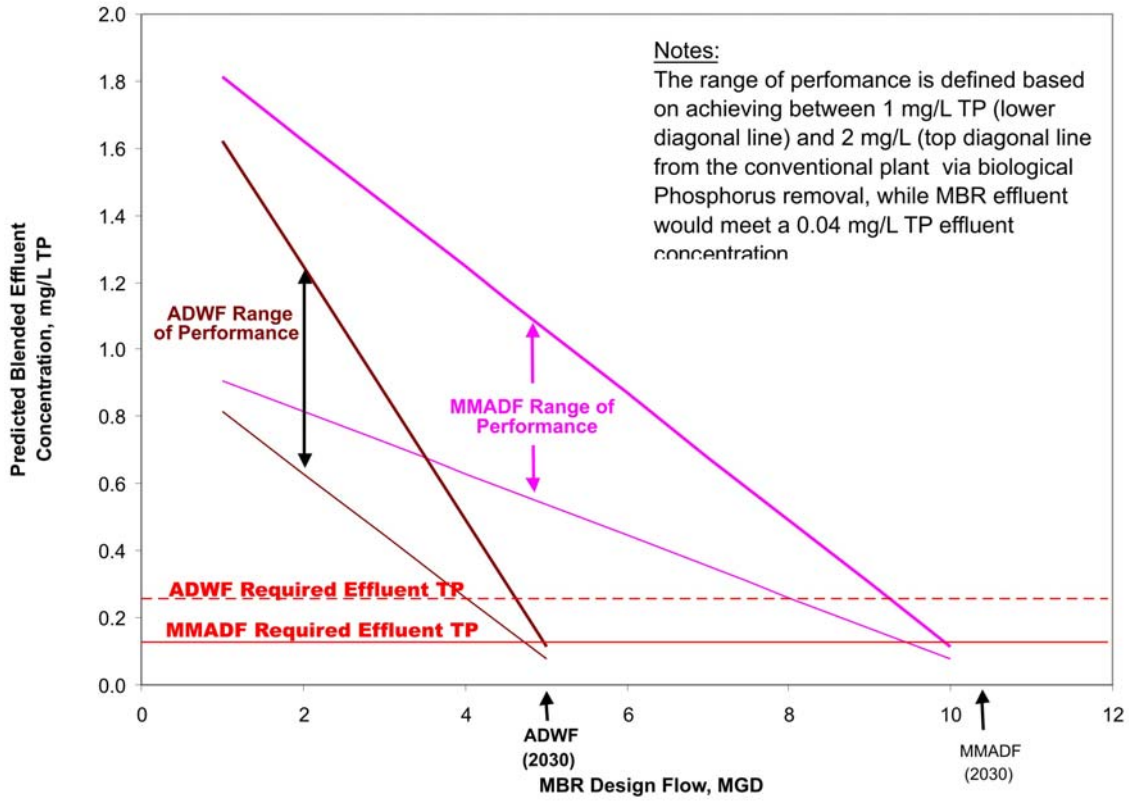


Figure 7.36 Range of Performance for a Blended MBR-Conventional Activated Sludge Effluent, assuming effluent quality of 0.04 mg/L TP from the MBR and between 1 and 2 mg/L TP from the conventional plant.

Comparison of Alternatives

A comparison of the pros and cons for each option is described in **Table 7.9**. The capital and O&M costs are included for each alternative. For direct comparison, annual O&M costs are calculated should the unit be operating in year 2011.

Table 7.9 Pros, Cons and Cost of Phosphorus Removal Alternatives

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
1. Anaerobic Influent Zone	▪ Low capital ▪ Low O&M ▪ Flexible (by turning zones on/off) ▪ Allows conventional phosphorus removal levels (1-2 mg/L) ▪ Low Risk ▪ Relative small modifications to coordinate with biological system ▪ Relative low cost ▪ Easy to include at this point ▪ Swing zones maximize the flexibility ▪ Biggest "bang for the buck"	▪ Limit of technology is about 1 mg/L Phosphorus; effluent quality typically varies from 0.2 to 2.0 mg/L[1] ▪ Efficiency of P removal decreases with increasing SRT which is required for very low effluent nitrogen limits ▪ Requires good overall process understanding, including recycle streams and sludge processing ▪ Efficiency of Anaerobic Influent zone in secondary treatment system is limited; Bio-P bacteria can be out-competed ▪ Biological system – risk of failure ▪ Risk of foam trapping ▪ Cannot meet TMDL limit of 0.2 mg/l annual average	Inherent to biological tank costs	Not determined
2. Chemical Precipitation – No Filtration	▪ Achieves conventional phosphorus removal levels (1-2 mg/L) relatively consistently ▪ Optimized when biological P removal is done in previous stage ▪ Very low capital investment ▪ Small footprint ▪ May be able to use existing chemical feed facilities ▪ Common and proven technology	▪ Requires handling of chemicals ▪ New chemical feed system may be required if existing facilities cannot be used ▪ Subject to chemical costs ▪ Can be expensive if no bio-P removal upstream ▪ Cannot meet TMDL limit of 0.2 mg/l annual average	0.3	188,000
3. Chemical Precipitation and Disc Filters	▪ Allows ability to consistently achieve conventional phosphorus removal levels (1-2 mg/L) ▪ Low to modest capital investment ▪ Relative low energy consumption ▪ Small footprint ▪ Common and proven technology ▪ Modular – easily expandable	▪ Hydraulic requirements require effluent booster station, which increases overall costs unless booster station is required for other purposes	15.6	193,000

[1] *Factors Influencing the Reliability of Enhanced Biological Phosphorus Removal*, WERF Final Report, 2005

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
4. Chemical precipitation and Continuously Backwashed Sand Filters	▪ Only technology available to meet TMDL limit of 0.2 mg/l annual average ▪ One of the best P-removal technology available ▪ Modular - Compatible with phased expansion ▪ Effluent is compatible with reuse standards (meets NTU requirements) ▪ Compatible with simultaneous arsenic removal ▪ Relative low energy consumption ▪ Pilot units available	▪ Highest-cost technology ▪ Hydraulic requirements require effluent booster station, which increases overall costs unless booster station is required for other purposes ▪ Largest footprint and highest profile ▪ Ferric dose is independent of TP concentration (hydraulically-based), although first stage biological P removal may allow to achieve removal with single pass only	8.7 (single Stage)	199,000
5. Add Membrane Bioreactor to Secondary Treatment	▪ Best filtration technology ▪ Avoid tertiary treatment step	▪ Complex mechanical equipment ▪ Requires larger chemical systems at this size (10 mgd) ▪ Energy intense ▪ Relies on proprietary supplies (membranes) ▪ Not required to meet tight footprint requirements or inadequate secondary clarifier capacity ▪ Expensive ▪ Implies running two biological systems in parallel	33.3 (includes secondary treatment)	Not estimated

Notes:

(a) September 2008 basis. Total project cost estimates reflect planning level and were developed including materials, equipment, and labor, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%). See Section 6.

Recommendation

The summary of the strengths and weaknesses of the phosphorus removal options shown in **Table 7.9** shows that of the four viable options, only chemical precipitation and filters can meet the draft limit of 0.2 mg/l total phosphorus. The selection of the actual filter technology and configuration should be refined in design and perhaps through the use of pilot studies. The recommendation and costs here are based on continuous backwash sand filters. This alternative does not exclude chemical addition to the primary clarifiers as a way to remove additional phosphorus as part of a program to reduce odors and digester gas hydrogen sulfide and struvite control.

Based on the pros, cons, and costs, it is recommended to add continuously backwashed sandfilters, combined with provisions for biological phosphorus removal in the biological process and chemical addition in the mixed liquor channel as ways to optimize the removals and minimize operation costs.

7.2.5 Effluent Disinfection

Existing System

The Spring Street STP currently disinfects with liquid sodium hypochlorite (12.5%) injected via perforated pipe diffusers in the disinfection manhole downstream of clarifiers 1 and 2. Additional hypochlorite is added to the cogen effluent bypass weir box. Currently only one chlorine contact tank exists, which consists of a converted clarifier, and provides 30 minutes of contact time at 20 mgd. Meeting EPA reliability Class I standards will require the Spring Street facility to have a standby disinfection system. Deficiencies identified for the existing disinfection facilities are:

- Lack of redundancy to meet EPA reliability Class I requirements
- As part of long-term planning, it was also apparent that continued use of the chlorine contact basin - should it be baffled in two sections to provide redundancy and be capable of treating 50 percent of the flow – was physically incompatible (because of hydraulics and site constraints) with planned expansions to add tertiary filtration.

Alternatives

Two viable options were evaluated to address the lack of redundancy:

Option 1 – Add Chlorine Contact Basin

Option 2 - Add In-line Ultraviolet Disinfection

Unit Process	Disinfection
Option 1	New Chlorine Contact Basin
Option 2	In-Line UV

Option 1. Add Chlorine Contact Basins

In Option 1, new, rectangular chlorine contact basins would be added to treat up to 22 mgd peak hour flows and maintain at least 60 minutes of contact time at annual average flow. In this option, two serpentine channels, each 12 feet wide (3 passes) and 60 feet in length, would be required. The overall footprint, including feed and collection channels, would be about 80 feet

by 80 feet. In this option, no new chemical feed facility would be required, as liquid sodium hypochlorite is already in use. **Figure 7.37** illustrates the layout of Option 1 when combined with the requirements for leaving provisions for tertiary treatment and an associated effluent booster pump station. When this alternative was developed, it was assumed that the effluent would still be discharged to Lake Ewauna. Should final effluent be sent to a new, remote outfall or for reuse, effluent pumping would be required downstream of the contact basin. The layout in **Figure 7.37** also shows a new effluent splitter box to the cogeneration pumps.

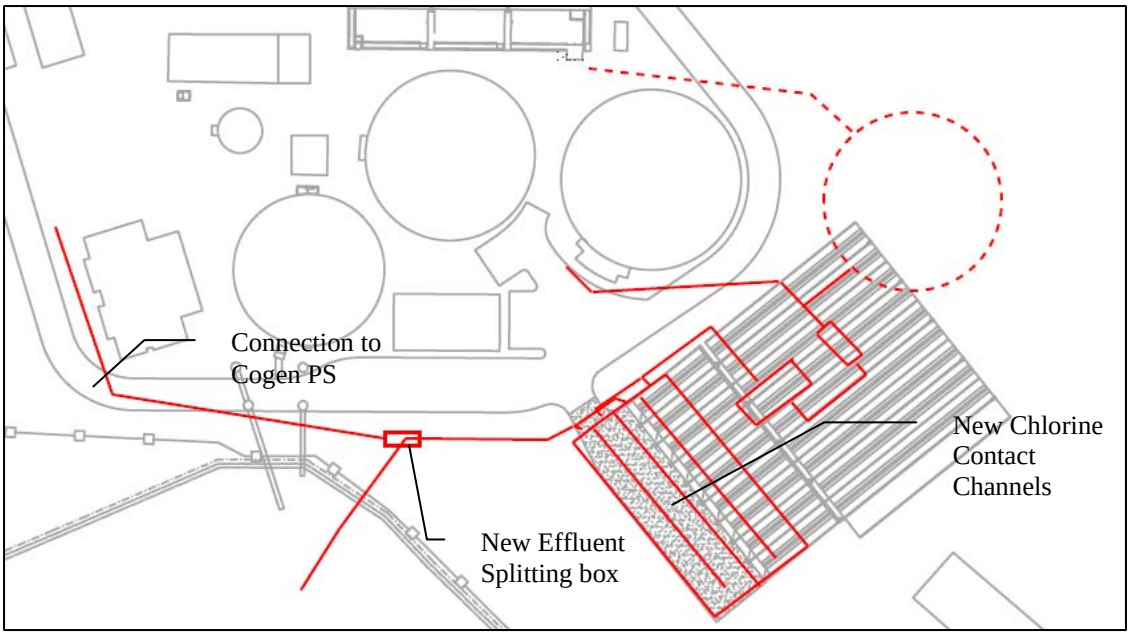


Figure 7.37 Early Conceptual Layout for the Addition of Effluent Booster Station, Tertiary Filtration, and Open Channel Chlorine Disinfection

Option 2. Add In-line Ultraviolet Disinfection

In Option 2, in-line UV reactors were considered. In-line reactors refer to a closed-channel configuration, as opposed to an open channel configuration. For planning purposes, a lamp transmittance of 55 percent was assumed to account for the potential implementation of tertiary filtration, which would improve the transmittance and reduce power consumption for the UV system. To treat the peak hour flow, a total of four units would be required. A vault of 26 feet by 20 feet would include the units, while a 20 x 20 feet electrical building would provide enough room for future equipment should meeting effluent reuse requirements with UV be imposed.

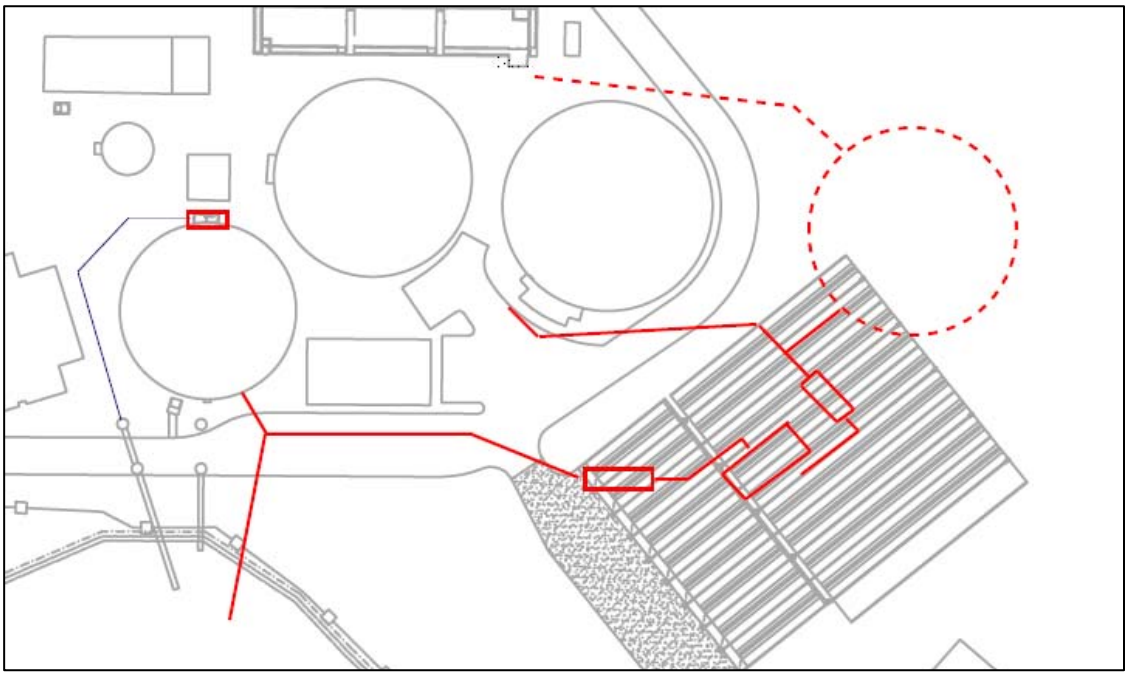


Figure 7.38 Conceptual Layout for the Addition of Effluent Booster Station, Tertiary Filtration, and In-Line UV Disinfection Followed by Chlorine Disinfection

Comparison of Alternatives

Table 7.10 compares the pros, cons, and cost of the two disinfection options evaluated.

Table 7.10 Pros, Cons, and Costs of Disinfection Alternatives

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
1.Add Chlorine Contact Basins	▪ Uses existing chemical feed facilities, which were just upgraded ▪ Compatible with reuse chlorine residual requirements, if required ▪ Common technology ▪ Familiarity of staff with technology	▪ Relies on delivered chemicals ▪ Requires dechlorination facilities ▪ Large land requirement ▪ Open surface3 – requires effluent PS should remote outfall or reuse application be implemented ▪ Large construction impact ▪ Requires handling of chemicals ▪ Does not free up chemical feed facilities for other chemical use ▪ Incompatible with low nitrogen limits; may need to add ammonia for efficient disinfection ▪ May contribute to formation of THMs and other organic toxins	3.4	19,000
2. Add In-Line Ultraviolet Disinfection	▪ Smallest footprint ▪ Reduces or eliminates chemical use ▪ Common and proven technology ▪ Little hydraulic head loss ▪ Flexible for future upgrades ▪ Relatively low capital costs ▪ Reduces need for sodium hypochlorite should residual be needed for potentially long outfall ▪ Frees up chemical storage space in chemical building ▪ City has more control on power use than on chemical use, via on-site production	▪ Power intense ▪ More complex ▪ Regrowth might be problematic in downstream conveyance system ▪ Tied to manufacturer's UV lamps, although more generic bulbs are available	3.3	48,000

Notes:
(a) September 2008 basis. Total project cost estimates reflect planning level and were developed including materials, equipment, and labor, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%). See **Section 6**.

Recommendation

In-line UV was selected for implementation because the higher operating cost is offset by the simplicity of operation and the environmental benefits of not using sodium hypochlorite and sodium bisulfite to the effluent. Ultraviolet disinfection is also adaptable to meet stringent standards on organic toxins such as N-nitrosodimethylamine (NDMA) that may work their way into future discharge permits.

7.3 Effluent Disposal Alternatives

During this planning effort, a number of effluent disposal alternatives were described and evaluated in a series of memoranda. Eight effluent disposal alternatives were initially identified:

- Effluent discharge in the river, but with advanced treatment and a new diffuser
- Effluent discharge into the river, but with additional, more stringent treatment (to background quality) and new a diffuser
- Agricultural land application with winter storage
- Constructed wetlands with indirect discharge to surface waters
- State wildlife refuge for land application
- Indirect subsurface discharge – hyporheic zone
- « A » Canal discharge for land application
- Pollutant load offset trading

On May 22, 2008, the Oregon Department of Environmental Quality (ODEQ) met with representatives of the City of Klamath Falls and South Suburban Sanitary District to present tentative Klamath River TMDL waste load allocations. The tentative allocations for the City are found in **Table 7.11**.

Table 7.11 Waste Load Allocations (proposed by ODEQ May 22, 2008)

Minimum Effluent Dissolved Oxygen Concentration	**cBOD**		**Total Phosphorus**		**Ammonia Nitrogen**	
mg/L	mg/L	kg/day	mg/L	kg/day	mg/L	kg/day
5.7	24	266	0.41	5	3.3	37

The concentrations listed in **Table 7.11** are based on effluent flow rates that are at or below the current dry levels. **Table 7.12** lists the concentrations based on the projected flows, while Table **7.13** lists the waste load allocations for heat by month.

Table 7.12 Effluent Concentrations Required by Proposed TMDL When Applied to Projected Design Flows

Year	Flow Condition	cBOD[(a)] mg/L	Total Phosphorus[(b)] mg/L	Ammonia Nitrogen[(c)] mg/L
2020	Average Dry Weather Flow = 4.4 mgd	16	0.30	2.2
	Average Wet Weather Flow = 6.6 mgd	11	0.20	1.5
	Maximum Month Flow =8.9 mgd	7.9	0.15	1.1
2030	Average Dry Weather Flow = 5.2 mgd	14	0.25	1.9
	Average Wet Weather Flow = 7.8 mgd	9.0	0.17	1.3
	Maximum Month Flow = 10.4 mgd	6.7	0.13	0.9

Notes:

(a) 266 kg/d or 585 lb/d maximum allowable mass discharge, per draft TMDL
(b) 5 kg/d or 11 lb/d maximum allowable mass discharge, per draft TMDL
(c) 37 kg/d or 82 lb/d maximum allowable mass discharge, per draft TMDL

Table 7.13 Waste load allocations for heat by month

	June	July	August	September
Effluent Temperature, ^{o}C	32.0	32.0	32.0	21.3
Discharge Flow, MGD	3.0	3.0	2.6	2.7
Allocation, kilocalories/day	367,147,008	362,857,703	344,761,641	220,889,641

After considering these proposed TMDLs, all but two of the eight disposal alternatives have been discarded for consideration, with the two remaining alternatives being:

A. Effluent Discharge into the River, but with Advanced Treatment and a New Diffuser to meet TMDL waste load allocations and In-stream Water Quality Standards.

B. Summer Agricultural Land Application with Winter Storage (No surface water discharge).

The other six alternatives were discarded for the following reasons:

- *Effluent Discharge to the River, but with Additional, more Stringent Treatment (to background quality) and a New Diffuser.* The concept behind this option was to treat background nutrient concentrations in the Klamath River, thereby making the requirements of the nutrient TMDL irrelevant. At the time this concept was developed, the City feared that an expanded treatment plant would be needed before DEQ finalized the TMDL. DEQ has released its tentative TMDL waste load allocations for the City and, therefore, there is no need to pursue this concept.

- *Constructed Wetland(s) with Indirect Discharge to Surface Waters.* This option would still require an NPDES permit, and anticipated pollutant attenuation via the wetlands would unlikely provide sufficient treatment to meet the TMDL and other water quality standards. Additional, advanced treatment would be required by a treatment plant prior to discharge into the constructed wetlands. So it provides no real benefits over that provided by a direct discharge via a new outfall diffuser.

- *State Wildlife Refuge for Land Application.* Contacts with the Oregon Department of Fish and Wildlife that owns the nearby refuge has indicated that it would not be interested in pursuing this option.

- *Indirect Subsurface Discharge – Hyporheic Zone.* This option has similar problems and issues as are encountered with a constructed wetland with indirect discharge and, therefore, has no real benefit over that provided by a direct discharge via a new outfall diffuser.

- *"A" Canal Discharge for Land Application.* The water in "A" canal is distributed to farmers by various irrigation districts. Discharge of effluent into the "A" canal could eliminate the irrigation district's NPDES permit exemption for the discharge of irrigation return flows. Based upon this, it is highly likely that this option would be aggressively opposed by the U. S. Bureau of Reclamation and the irrigation districts that obtain water via the "A" canal.

- *Pollutant Load Offset Trading.* At this time, there is no known source of pollutant loads that the City could obtain that would significantly increase the pollutant discharges required by DEQ to meet the TMDL. If the City selects to eliminate its discharge by summer irrigation and winter storage, it may have discharge credits that it could sell to other pollutant sources that have been assigned restrictive load allocations under the TMDL for the Klamath River.

- Injection into the geothermal aquifer beneath the City of Klamath Falls. This option was not one of the original options under consideration, but was added because it seemed like a possible low cost option for effluent disposal. This option, however, has been discarded because direct injection is prohibited by ODEQ administrative rules and indirect injection is not feasible because the aquifer is confined and under pressure.

The two shortlisted alternatives were evaluated further as summarized below.

Option 1. Effluent Discharge in the River with Advanced Treatment and A New Diffuser

Under this alternative, sufficient treatment would be provided to reduce specific pollutants to levels that meet waste load allocations specified in the Klamath River TMDL, and to meet other in-stream water standards prescribed for the Klamath River. These pollutant levels will ultimately be established as Pollutant Discharge Elimination System (NPDES) permit effluent discharge limitation. As described in **Section 7.2**, the modifications needed at the Spring Street facilities to meet the requirements of this alternative would include expansion of the biological system to accommodate full nitrification and the addition of tertiary filtration for phosphorus removal.

Because of the insufficient or non-existent mixing in Lake Ewauna, it is anticipated that a new outfall or off-site disposal of most, if not all effluent will be required. As described in the effluent disposal alternatives technical memorandum, a new outfall near Highway 97 or using winter storage ponds for summer land application are alternatives that would require off-site pumping. For this plan, it was assumed that the existing 24-inch and 12-inch cogeneration and blowdown lines would be used to pump and discharge off-site, with no cogeneration blowdown return. The existing on-site effluent (cogeneration) pump station would be expanded with dry weather pumps in the two open slots within the well, while a new wet weather pump station would be added adjacent to it (see **Figure 7.39**).

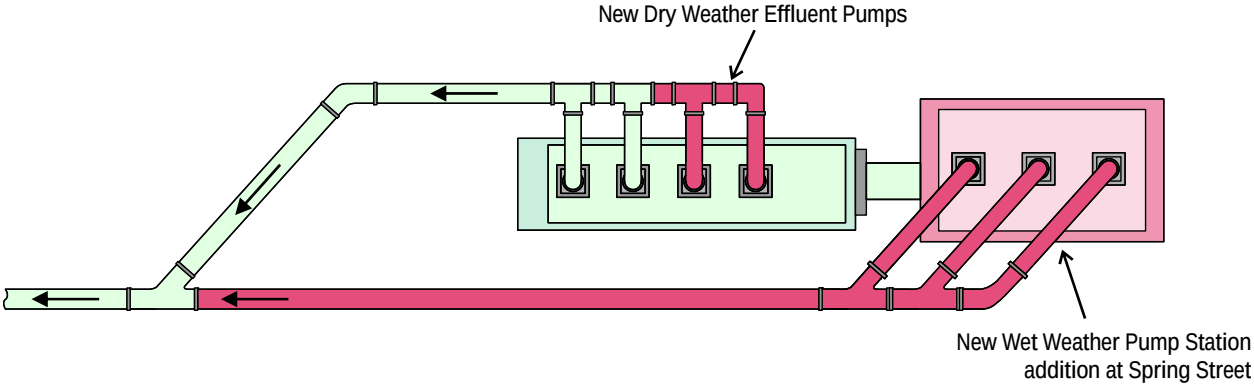


Figure 7.39 Effluent Cogen Pump Station Modifications for Remote Outfall Pumping

Final effluent pumping via the existing 24-inch and 12-inch pipelines to the cogeneration plant requires high pressure pumping, especially at peak wet weather flows. At the same time, these pipelines are assumed to be capable of sustaining 100 psi of pressure. To maintain the integrity of the existing pipelines, an intermediate booster pump station is required to deliver final effluent to the proposed Highway 97 outfall area or storage pond. Although high head pumps would be required because of the relative small diameter of the existing pipes, the higher flows

are not expected to be sustained. The possibility of allowing the infrequent use of the existing outfalls in Lake Ewauna as peak wet weather flow discharge points should be discussed during design activities. This would avoid power surges and minimize the size of the pumps and motors. Impacts on water quality of such a mode of wet weather operation should be discussed with DEQ.

Option 2. Agricultural Land Application with Winter Storage

Under this alternative, Spring Street's effluent would be stored during the non-irrigation season and would be irrigated at agronomic rates during the irrigation season. STP would not discharge to surface waters. Based upon current projected design flows, the storage basins would require 380 acres, assuming a depth of 10 feet. Agronomic irrigation at 3 feet per year would require an irrigation area of 2000 acres. Wastewater quality requirements set forth in ODEQ's rules for using recycled water depend upon the actual use. Irrigation of non-food crops such as forage would require a 7-day median total coliform limit of 23 CFU/100 mls with no two consecutive samples exceeding 240 CFU/100mls. Virtually any mechanical, biological sewage treatment process with disinfection should be able to achieve these levels. If food crops destined for human consumption were to be irrigated with recycled water, higher levels of treatment and disinfection would be required to achieve a Class A recycled water treated to reuse standards and disposed off-site. Although there would be no nutrient removal requirements to meet, the NTU and disinfection requirements are such that tertiary filtration may still be required. This alternative would then require:

- Two additional, smaller selector activated sludge aeration basins (additional 1 million gallons of tankage, or one third of advanced treatment option above) to provide a total system SRT of 5 days for carbonaceous BOD removal only. Existing aeration basins would be used in series with the new basins.
- New Chlorine contact channels – the efficiency of liquid hypochlorite is not impaired because of the need for full nitrification
- Liquid sodium hypochlorite injection at intermediate pumping station for chlorine residual
- A lined storage pond (380 acres by 10 feet deep)
- Irrigation facilities

Figure 7.40 illustrates the main effluent pumping and disposal elements of this alternative.

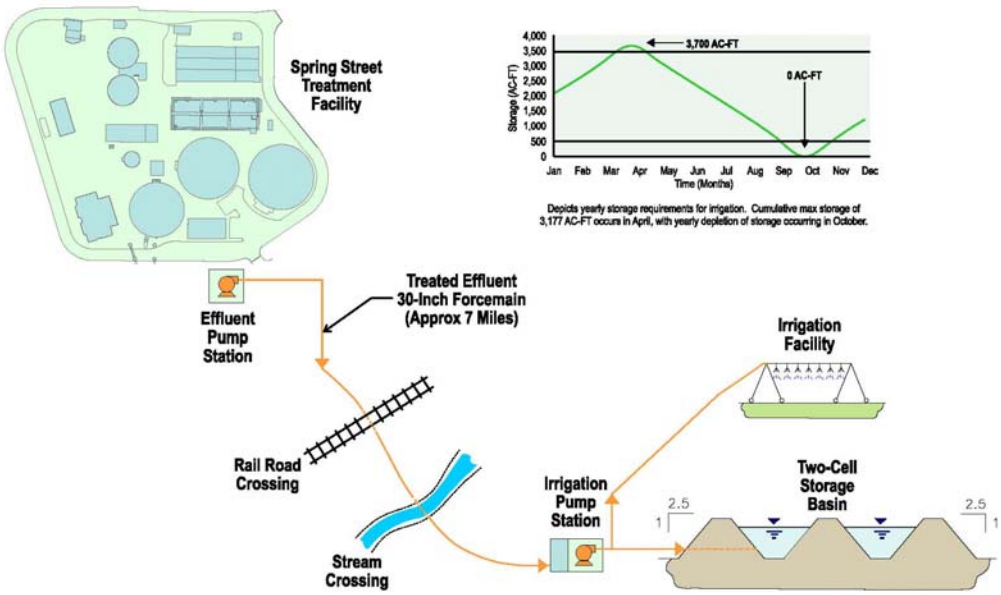


Figure 7.40 Schematic of Summer Agricultural Irrigation/Winter Storage Alternative Effluent Pumping and Discharge Elements

Effluent Disposal Alternatives Evaluation

These alternatives are better detailed through the series of Technical Memoranda provided to the City. However, first order planning level estimates for these alternatives showed over 90 million dollars required for the construction of the storage basin in the winter storage alternative while it would only yield a 20 million dollars credit from the reduced treatment needs at the plant.

An integrated evaluation of the two alternatives is presented in **Section 7.7** of this Plan.

7.4 Biosolids Management

Biosolids management involves the treatment of sludge collected and generated during primary and secondary treatment to create a usable or amenable product called biosolids. The physical characteristics of sludge, including an active biological mass that can attract disease carrying vectors, a high pathogenic content, and an abrasive and odorous nature, require an extensive

biosolids management program, and can pose one of the greatest maintenance and regulatory problems to the wastewater treatment facility. That said, biosolids are increasingly considered a useful resource because of their organic content, as recognized by the City of Klamath Falls, which currently produces compost from biosolids.

The biosolids management process configuration typically involves thickening (bringing the sludge to approximately 5 percent solids content), stabilization (reducing biological activity and inactivating pathogenic bacteria), dewatering (bringing the sludge to a cake-like or dryer consistency), and distribution or disposal (the actual disbursement of the newly classified biosolids). Variations to these steps are allowed, provided that the treated biosolids meet the local and federal standards for distribution (OARS 340-50 and 40 CFR 503). Further, additional processes relevant to the biosolids treatment are often considered to be part of a biosolids management system, including sludge storage and biogas utilization. **Figure 7.41** illustrates the existing Spring Street STP Solid Stream Flow Schematic and will be referenced throughout the section.

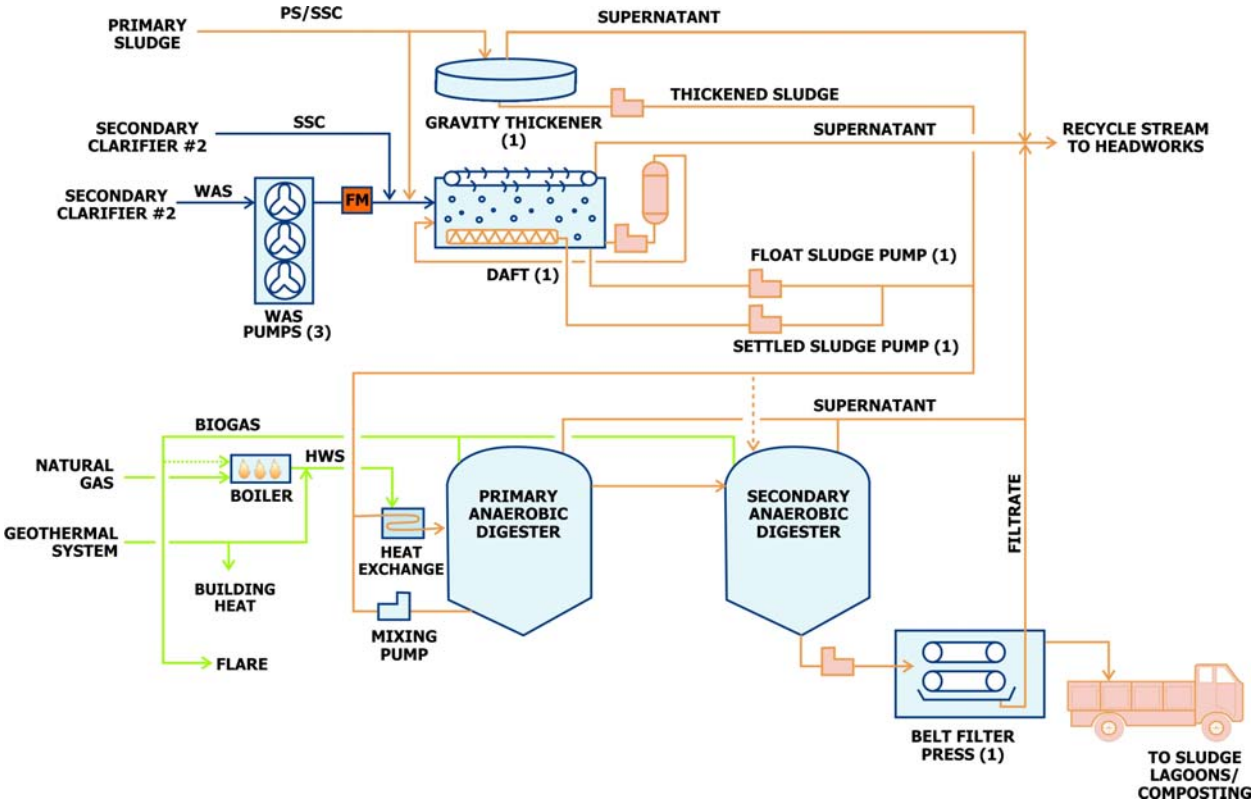


Figure 7.41 Existing Spring Street STP Solid Stream Flow Schematic

In this section, the following major biosolids management unit processes are considered:

- Thickening
- Stabilization/Digestion
- Storage

- Solids Dewatering
- Ultimate Use and Disposal

A separate section, **Section 8**, was specifically developed to address Biogas Use and Management options.

A well-functioning biosolids management program is capable of reducing the solids volume while producing a desirable product during average and adverse conditions. Biosolids processes do not have federally mandated levels of reliability, like liquid stream processes; although, most facilities aim to have a certain level of redundancy within their solids handling system to address peak events, equipment maintenance, and equipment failure. To that end, the existing solids handling system was evaluated based on the projected solids loads out to the year 2030, as listed in **Table 7.14**. This table was developed based on operations data from 2001 to 2006, population/solids projections (section 5) and standard design guidelines. It should be noted that the solids loads in 2005 were uncharacteristically low. This low year makes it appear as though a sharp increase occurs between 2005 and 2010.

Table 7.14 Raw Sludge Production Data

Design Year	**2005[e]**	**2010**	**2020**	**2030**
Sewered Population	27,700	30,200	35,700	42,000
Total Sludge (dry lb./day)				
Peak Week[a]	9,300	12,000	14,100	16,600
Max Month[b]	6,200	8,600	10,200	12,000
Annual Average Day	5,400	6,600	7,700	9,100

Notes:

(a) Sludge production based off a 7 day SRT under peak week flow conditions (shorter SRTs produce more sludge). Does not assume chemically enhanced phosphorus removal.

(b) Sludge production based off a 15 day total SRT with max month flow conditions. Does not assume chemically enhanced phosphorus removal and associated increased sludge production. Note that for planning level, maximum month projections are based on the 1 in 5 peaking ratio of the 5 years of record, which makes for relatively higher solids production numbers than the population projection increase.

(c) Note that 2005 was a unusually low solids loading year.

Table 7.14 contains projected data for the peak week, the maximum month, and annual average conditions. The table indicates that the peak week condition is a little less than twice the annual average, with a peaking ratio of 1.8. Because of the impact of solids retention time in the liquid stream processes and digesters, solids side peak conditions are typically sustained over longer periods of time. For this Facilities Plan, unit processes and equipment on the solids handling system have been sized based on the greatest loads individual units can be expected to handle. Upstream of the digesters, the peak load corresponds to the solids production after a peak week

in the liquid stream process. The peak load for the digesters and all unit process downstream corresponds to the solids production after a maximum month, due to the combined equilibration provided by the liquid stream processes and the long detention time within the digesters themselves.

Finally, if chemically enhanced phosphorus removal was employed on a routine and sustained basis, the values could increase by 15 percent.

Alternatives in this plan were considered based on the following:

- Load projections as presented in **Table 7.14** above
- Local and federal standards for biosolids distribution (OARS 340-50 and 40 CFR 503)
- Full unit process redundancy or the inclusion of at least on "wide spot" in the treatment process (extra capacity)

A range of options was developed as shown in the matrix in **Figure 7.42**, with each option described in the following section with pros, cons, and estimates of probable costs for screening and planning purposes. Cost estimates were developed with the cost factors and multipliers listed in Section 6.

Figure 7.42 Matrix of Biosolids Operations Evaluated

Thickening	Stabilization	Storage	Dewatering	Ultimate Use / Disposal	Biogas Utilization
Refurbish Gravity Thickener	Refurbish Existing Digesters	Refurbish Existing Digester	Existing BFP	Enhanced Windrow Composting	Flare
Add one DAFT	Add One 500,000 gal M-Digester	Expand Digester Upgrade	Relocate/ Add BFP	Aerated Static Piles	Boiler – Digester Heating
Add One GBT	Add One 300,000 gal T-Digester	Replace Sludge Lagoon	Relocate/ Add Screw Press	Aerated Static Piles - Pull out Pipes	Biosolids Drying
Add One Centrifuge	Add Two 55,000 gal Acid Phased Digesters	Add Dewatered Cake Storage	Relocate/ Add Centrifuge	Sludge Dryer	Cogeneration – Heat and Power
					Scrub and Sell – Vehicle Fuel / Pipeline

7.4.1 Thickening

Existing System

Primary sludge, WAS, and a small amount of scum are currently co-thickened with polymer addition to about 4.5 percent solids in the single, 250 ft² dissolved air flotation thickener (DAFT), shown in top picture to the right. A rehabilitated 24 ft diameter gravity thickener is also available on-site (bottom picture on the right); however, it is not the preferred method of thickening, due to the poor condition of its pumps and valves and the exceptional performance of the DAFT.

Existing 250 ft² DAF

Existing 24 ft Gravity Thickener

While operator experience has indicated surplus capacity within the DAFT, the DAFT unit, including the polymer addition system, has not been pushed and intentionally stressed to determine its actual installed loading capacity. Standard design guidelines suggest the DAFT is of sufficient size to handle the anticipated peak week solids loads up to an equivalent service population of 30,200, which could be realized as early as 2010. Further, the DAFT lacks equipment redundancy. The gravity thickener provides some systematic redundancy, but is not considered viable due to its inability to handle the full solids loads even under current conditions. **Table 7.15** and **Table 7.16** present the potential thickening capacity of the existing system depending on the sludge feed, whether co-thickening primary sludge and waste activated sludge, or thickening each sludge separately. Sizing guidelines were developed from WEF MOP 8 and CDM's industry experience in similar installation settings.

Table 7.15 Existing DAFT Capacity in Function of Sludge Feed (1)

Co-Thickening		Primary		WAS	
w/ Chemicals(2) (lb/d)	w/o Chemicals(3) (lb/d)	w/ Chemicals(4) (lb/d)	w/o Chemicals(5) (lb/d)	w/ Chemicals(6) (lb/d)	w/o Chemicals(7) (lb/d)
< 12,000	3,600 to 7,500	< 12,000	5,000 to 7,500	< 9,000	3,000 to 4,800

Notes:

(1) Sizing criteria based on sizing criteria Metcalf & Eddy (2003, pp 1492) and engineering experience
(2) Assuming solids loading rate of 48 lbs/sf/day
(3) Assuming solids loading rate of 15 - 30 lbs/sf/day
(4) Assuming solids loading rate of 48 lbs/sf/day
(5) Assuming solids loading rate of 20 - 30 lbs/sf/day
(6) Assuming solids loading rate of 36 lbs/sf/day
(7) Assuming solids loading rate of 12 - 20 lbs/sf/day

Table 7.16 Existing Gravity Thickener Capacity in Function of Sludge Feed (1)

Co-Thickening (2) (lb/d)	Primary (3) (lb/d)	WAS (3) (lb/d)
2,250 to 6,300	9,000 to 13,500	1,800 to 3,600

Notes:

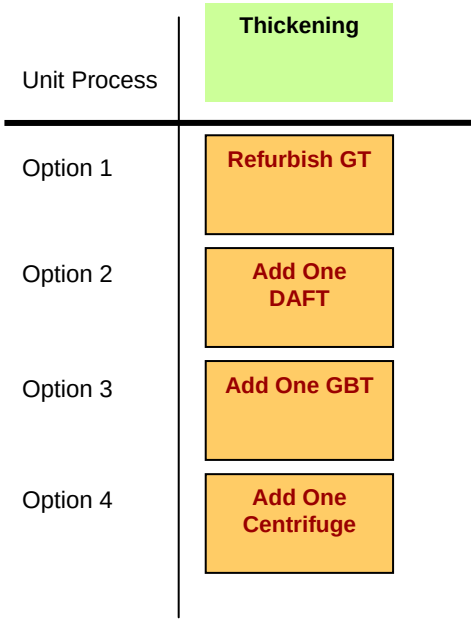
(1) Sizing criteria taken from WEF MOP 8 (20-10)
(2) Assuming solids loading rate of 5-14 lbs/sf/day
(3) Assuming solids loading rate of 20 - 30 lbs/sf/day
(4) Assuming solids loading rate of 4-8 lbs/sf/day

Based on the information in **Table 7.15** and **Table 7.16**, operating the DAFT and gravity thickener together could provide the full thickening capacity during peak week conditions through 2030. However, should the DAFT fail during a peak week event, Spring Street would be left with just the thickener operating, which even if refurbished would only provide 40 percent capacity in 2010 down to 25 percent capacity in 2030. That said, the DAFT is expected to have surplus capacity through 2030 during annual average loads. Therefore, the main sludge thickening deficiencies that need to be addressed in this plan include:

- Capacity Needs
- Redundancy Needs

Thickening Alternatives

Various thickening alternatives to address capacity and redundancy needs were investigated for implementation. Some of these alternatives were dismissed after preliminary investigations due to assorted infeasibilities. Among these early discarded options were rotary drum thickeners, which were eliminated because of their difficulty thickening WAS and their inconsistent performance. Four options, considered more practical, were developed for consideration in the final plant-wide alternatives. The four options are described below:



Option 1 - Refurbish Gravity Thickener

Option 2 - Add One DAFT

Option 3 – Add One GBT

Option 4 – Add One Centrifuge

These options are discussed and compared below.

Option 1. Refurbish Gravity Thickener

In this option, the plant would continue to co-thicken with the existing DAFT and refurbish the gravity thickener's mechanical and structural components to provide full capacity and put it back in routine service. A minor piping modification would be incorporated on the DAFT to enable the thickened bottom sludge pump to serve as a backup to the thickened sludge pump. Currently, the DAFT has no back up pumping. This alternative would not provide full systematic redundancy in itself, but would rely on other sludge processing units (sludge storage upstream of thickening) or operational changes (temporarily reducing wasting volumes) to take on the additional loads in case of failure of one of the thickening process. A failure to the DAFT in this alternative would leave the Spring Street STP with a thickening capacity of just 4,500 lbs/day.[2] This amount, 4,500 lbs, is insufficient for handling annual average loads under current conditions; further, it represents just 40 percent of the 2010 peak week capacity and just 25 percent of peak week capacity for 2030. Selection of this alternative alone could severely limit operations and pose a risk. This option is mainly included to serve as added capacity for the other thickening alternatives. **Figure 7.43** shows a process schematic of this alternative.

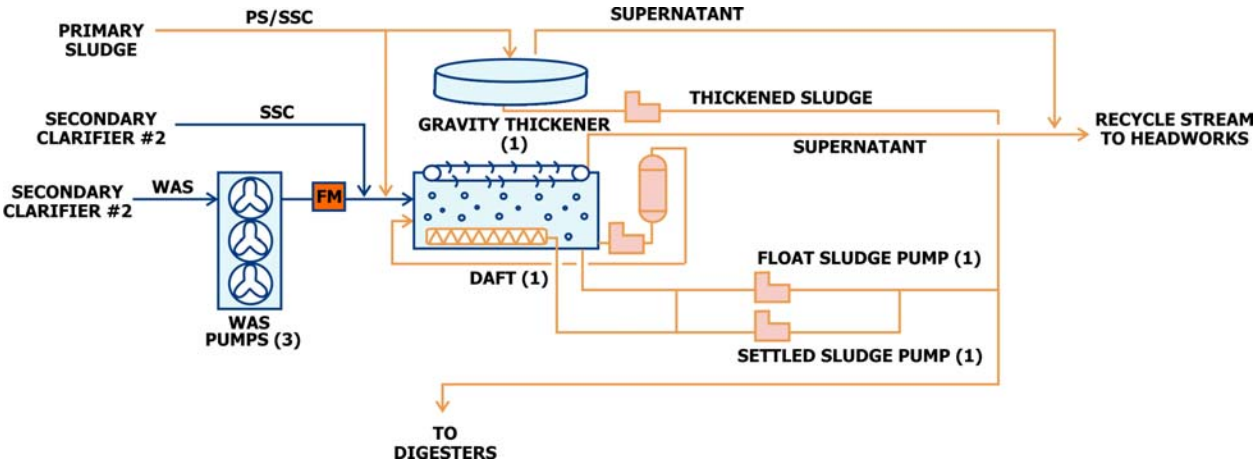


Figure 7.43 Thickening Process Schematic : Upgrade Gravity Thickener

[2] 4,500 lbs/day is based on a loading rate of 10 lbs/sf/day. This is a conservative estimate for a co-thickening on the 450 sf gravity thickener. 4,500 lbs represents roughly 1/4 of the anticipated load in 2030.

Option 2. Add One DAFT

In this option, the thickening capacity would be expanded by installing an additional 250 ft² DAFT. The additional DAFT would handle the anticipated peak week 2030 loads while providing system surplus capacity approaching 50 percent under peak week conditions and over 150 percent under annual average conditions. **Figure 7.44** shows a process schematic of this alternative. For additional redundancy, the gravity thickener could also be refurbished to be fully functional (Option 1).

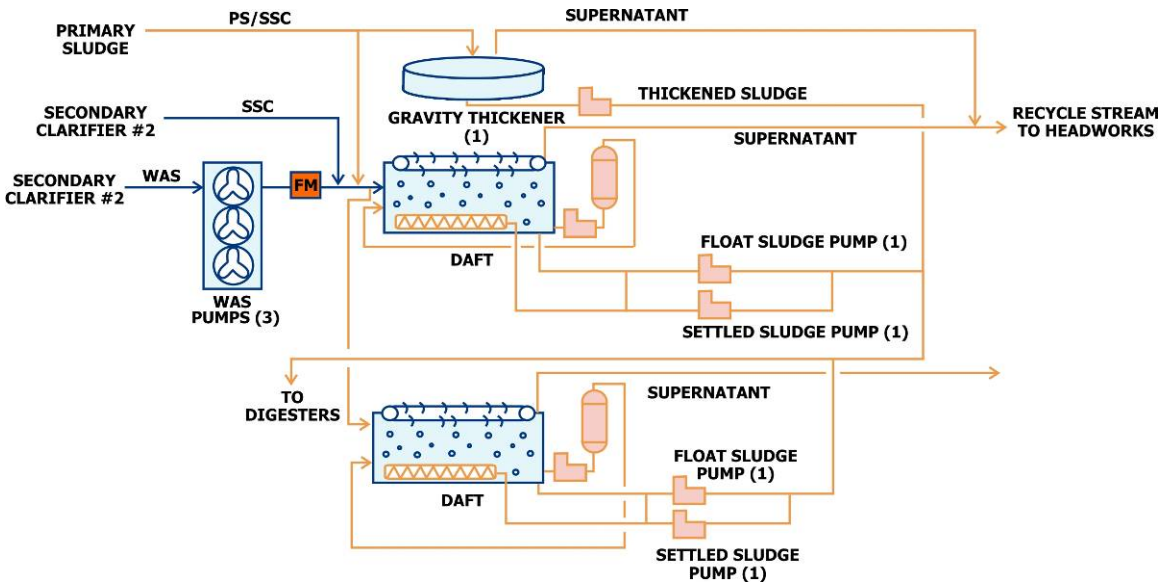


Figure 7.44 Thickening Process Schematic : Add one DAFT (Option 2)

Option 3. Add One GBT

In this alternative, the thickening capacity would be expanded with a new, 2-m gravity belt thickener, as shown in the picture to the right, in a building adjacent to the existing DAFT. A 2-m gravity belt thickener operated 5 days/week, 8 hours/day would provide the same thickening capacity as an additional 250 ft² DAFT at 12,000 lbs/day. The capacity of this alternative could be augmented by extending the operating schedule during peak events. For additional redundancy, the gravity thickener could also be refurbished to be fully functional (Option 1). **Figure 7.45** shows a process schematic of this alternative.

Gravity Belt Thickener

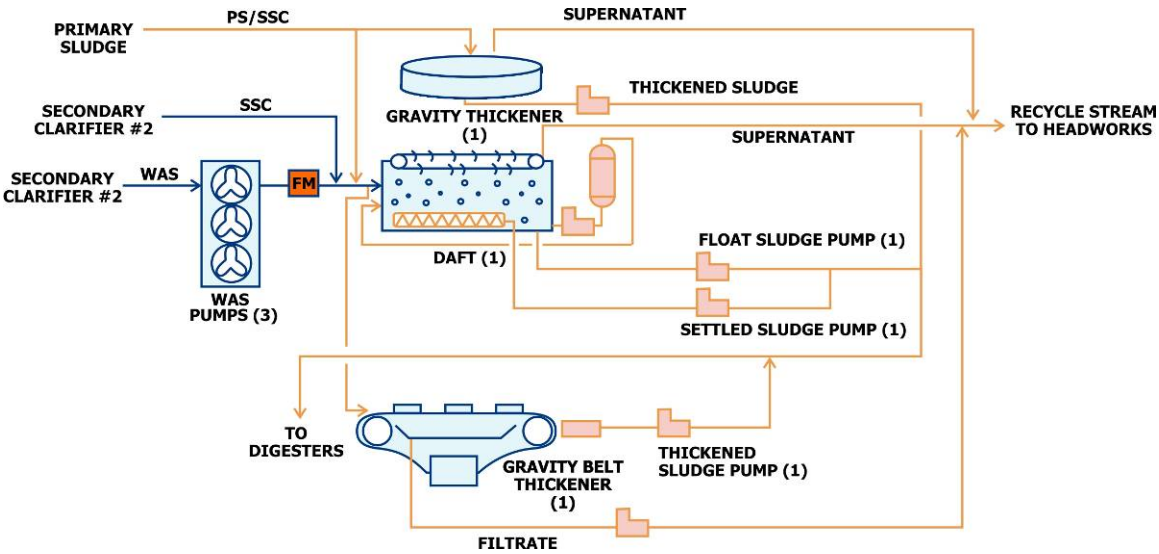


Figure 7.45 Thickening Process Schematic : Add one GBT (Option 3)

Option 4. Add One Centrifuge

In this option, the thickening facility would be expanded by adding a thickening centrifuge to handle the anticipated 2030 peak week loads with 35 percent surplus capacity. An example Centrifuge is shown in the picture to the right. The centrifuge would be located in a new building adjacent to the existing DAFT and would provide 10,600 lbs/day of capacity, assuming a 5 days/week, 8 hours/day operation. The capacity of this system could be augmented during peak events by extending the operation schedule. For additional redundancy, the gravity thickener could also be refurbished to be fully functional (Option 1). **Figure 7.46** shows a process schematic of this alternative.

Centrifuge

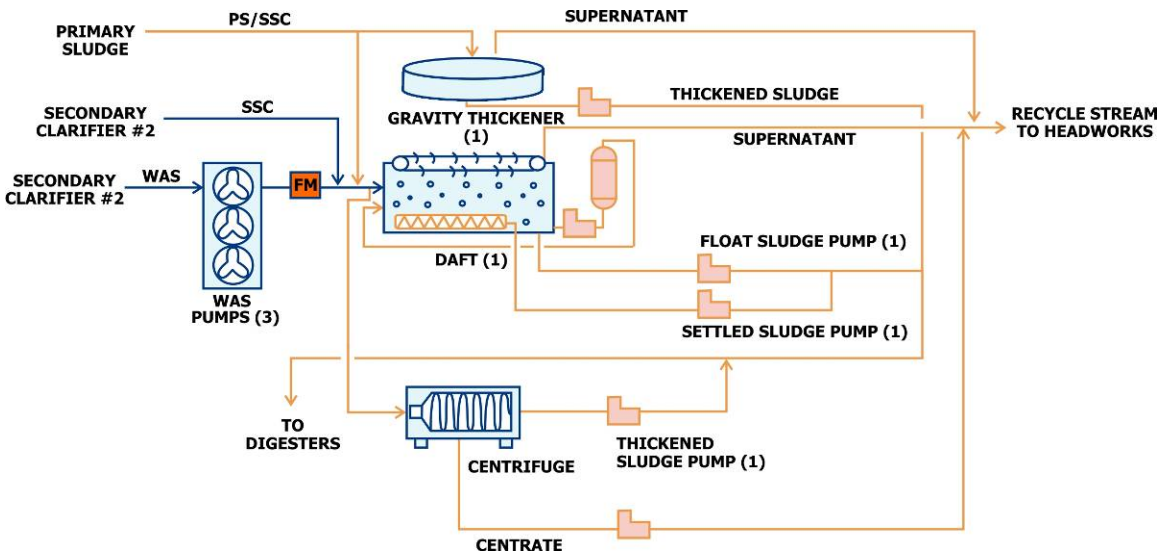


Figure 7.46 Thickening Process Schematic : Add One Centrifuges (Option 4)

Comparison of Alternatives

The four thickening alternatives are compared in **Table 7.17**

Table 7.17 Pros, Cons, and Costs of Thickening Alternatives

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
1. Refurbish Gravity Thickener	▪ Low cost option providing full capacity ▪ Low cost option providing full capacity ▪ Familiarity with processes ▪ Increases reliability of DAFT	▪ No inherent redundancy ▪ Two different sludge thickening processes ▪ The gravity thickener incorporates grit into the sludge going to the digesters ▪ Pipe upgrades required ▪ Uncontained odor source ▪ Potential for gas flotation and poor thickening ▪ Inconsistent performance of gravity thickener, especially at longer SRTs	0.7	45,000
2. Add one DAFT	▪ Provides full capacity and at least 50% surplus under all conditions in 2030 ▪ Mirror copy of existing unit ▪ Familiarity with process ▪ Known performance ▪ Streamlines thickening process ▪ Contained odor sources ▪ Allows grit to settle out so that it does not pass on to the digester	▪ Largest footprint required ▪ Relatively high mechanical complexity ▪ Very high power consumption	3.3	43,000
3. Add One GBT	▪ Provides full capacity and at least 50% surplus under all conditions in 2030 ▪ Simple operation similar to existing belt filter press ▪ Can provide thicker sludge, potentially expanding capacity of the digesters ▪ Contained odor sources (building) ▪ Low power draw	▪ Grit is incorporated with sludge and is passed on to the digesters ▪ High wash water volumes required, impacting recycle streams and nutrient removal process ▪ Highest odor potential	2.7	46,000
4. Add One Centrifuge	▪ Provides full capacity and partial redundancy under all conditions in 2030 ▪ Can provide thicker sludge, potentially expanding the capacity of the digesters ▪ Could be used to dewater ▪ Contained odor sources (building)	▪ Large capital costs ▪ Large power demands ▪ Unfamiliar process ▪ High mechanical complexity ▪ Grit is incorporated with sludge and goes to the digesters ▪ High wash water volumes required, impacting recycle streams and nutrient removal process ▪ Highest odor potential	4.0	46,000

Notes:
(a) September 2008 basis. Total project cost estimates reflect planning level and were developed including materials, equipment, and labor, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%). See Section 6 A.

From a capacity standpoint, the existing DAFT and gravity thickener have almost 7,200 lbs/day of surplus capacity under current peak week conditions, and 11,100 lbs/day under annual average conditions. The combined capacity of the two units, assuming a fully refurbished gravity thickener, is 16,500 lbs/day, which essentially matches the expected 16,600 lbs/day peak week solids production in 2030. To realize this capacity, minor piping and mechanical modifications would be required on the DAFT and GT. These modifications include new gravity thickener pumps, valves, and a piping modification on the DAFT that will enable the thickened bottom sludge pump to serve as a backup to the thickened sludge pump. However, it is not recommended that Spring Street pursue this thickening configuration by itself due to limited redundant capacity: a failure of the DAFT in this configuration would render Spring Street with insufficient capacity for day to day and peak condition operations. It is recommended that Spring Street further augment their thickening capacity through the addition of another unit.

The most elegant and comprehensive solution would be best addressed by the addition of either a DAFT or a GBT. However, for process familiarity and uniformity, it is recommended to add a mirror copy of the existing DAFT in an adjacent building. Considerations for a larger DAFT unit should be made during preliminary design to evaluate the impact of installing a larger DAFT for additional redundancy.

7.4.2 Solids Stabilization

Sludge stabilization, or treatment, is a key step during solids handling, and several techniques exist: anaerobic digestion, aerobic digestion, alkaline treatment, and composting. The primary purpose of stabilization is to reduce the biological activity of organic matter in raw sludge. Active organic matter can attract disease-carrying vectors such as flies. The secondary purpose of stabilization is to reduce the mass of organic solids and the concentration of pathogenic bacteria. The stabilization of sludge is important because it determines the methods of sludge disposal options that can be employed. The more stable sludge is classified as Class A and has less stringent disposal requirements than lower Class B sludge. The classifications and disposal alternatives are regulated by the federal and local government agencies.

Existing System

Existing Anaerobic Digesters

While the Spring Street facility is equipped with two anaerobic digesters in series for the treatment and stabilization of their waste sludge, the windrow composting process on the back end of the process is ultimately what treats the sludge to Class A biosolids standard as defined by 40 CFR Section 503.13. The Spring Street primary digester is 299,000 gallons and the secondary digester is 289,000 gallons. By convention 10 percent of the volume is reserved for gas and grit, yielding effective volumes of 269,000 and 260,000 gallons, respectively. Despite the relatively large available volume, the digesters at Spring Street are insufficient for meeting even the Class B stabilization requirements. The 503 regulation requires that each particle of sludge achieve a 15 day solids residence time (SRT) maintained at 98 degrees Fahrenheit to achieve a Class B product. In order to meet this requirement, a batch or complete mix system must be maintained within the digesters. The secondary digester at Spring Street lacks dedicated heating and mixing equipment, effectively

relegating its function to storage rather than digestion, and precluding its volume from being included in the working volume calculations. Further, the mixing equipment of the primary digester is inadequate to provide sufficient mixing. A completely mixed digester should be turned over every 30 minutes. The 269,000 gallon digester would require a 9,000 gpm pump to accomplish this. Further, the condition assessment revealed that both digesters are in poor structural and mechanical condition, particularly the internal piping and valves. The City removed the gas mixing system, eliminating mixing redundancy. All gas produced is flared off, with none recaptured to heat the digesters. The primary heating of the digesters comes from the Klamath Falls geothermal system. A natural gas boiler is used to heat the digesters when the geothermal system is unavailable; however, it too is in poor condition due to corrosion from hydrogen sulfide condensate.

In order to investigate the digestive operations at Spring Street, the effective capacities of the existing digesters were evaluated against projected flows and loads. **Table 7.18** shows the capacity of existing digestion facilities.

Table 7.18 Existing Digesters Mesophilic SRT Capacity through 2030(1)

Design Year	2005	2010	2020	2030
Sewered Population	27,700	30,200	35,700	42,000
Thickened Sludge Flow (MGD)(2)	0.017	0.023	0.027	0.032
TSS loading (lbs/d)	5,900	8,200	9,700	11,400
SRT – Primary Digester Only (days)	15.8	11.7	10.0	8.4
SRT – Both Digesters (days)(3)	31.1	23.0	19.6	16.5

Notes:

(1) Under peak month conditions
(2) Assumes 4.3% thickened sludge concentration and solids capture of 95% in the thickeners
(3) Secondary digester not currently included in working volume and effective SRT due to mixing and heating deficiencies.

Thus, the existing digestion process faces the following deficiencies:

- Poor mechanical and piping conditions, including internal piping and valves
- Insufficient heating and mixing of secondary digester to meet Class B requirements
- Insufficient mixing equipment for primary digester
- Inefficient heating of the primary digester
- The structural integrity of digesters is questioned (see Condition Assessment)
- Lack of redundancy for digester maintenance or potential failure

- Insufficient effective capacity for future loads

Solids Stabilization Alternatives

Unit Process	Stabilization
Option 1	Refurbish Existing Digesters
Option 2	Add 500,000 Gallon Digester
Option 3	Add 300,000 Gallon Digester
Option 4	Acid/Gas – Add 50,000 Gallon Digester

Biosolids stabilization options were considered within the context of the overall end product and systematic reliability. The windrow composting of the sludge (post dewatering) has been an effective and very popular means of stabilization and disposal, despite operational difficulties incurred by staff during cold weather and due to poor equipment. The composting process is expected to be a viable form of stabilization for the foreseeable future, which has reduced pressure on the Spring Street facility to develop additional stabilization alternatives and has allowed the facility to operate with inefficient and ineffective digesters. However, the City has expressed a desire to have a system with a high level of reliability and has interest in the potential benefits, such as process flexibility, storage capabilities and the beneficial use of biogas, provided by the anaerobic digestion process. Four stabilization alternatives were developed to provide biosolids stabilization operational flexibility and systematic redundancy at the Spring Street facility. These four alternatives are as follows:

Option 1 – Refurbish Existing Digestion Facilities

Option 2 – Add One 500,000 Gallon Thermophilic/Mesophilic Digester

Option 3 - Add One 300,000 Gallon Thermophilic/Mesophilic Digester

Option 4 – Add One 50,000 Gallon Digester and Switch to Acid Gas Phased Digestion

Option 1. Refurbish Existing Digestion Facilities

In this option, Spring Street would continue to stabilize solids entirely through windrow composting. Digesters 1 and 2 would be upgraded to provide full digestive capabilities under mesophilic conditions and the ability to meet Class B sludge requirements. Although this option can be evaluated by itself, it will likely represent a part of all other options. This option will require a thorough structural and mechanical evaluation to determine the necessary upgrades and costs. The anticipated upgrades include structural reinforcement to the digester walls and covers, insulation repair, and replacement of the heating and mixing equipment including the interior piping and valves. **Figure 7.47** shows a process schematic of this alternative.

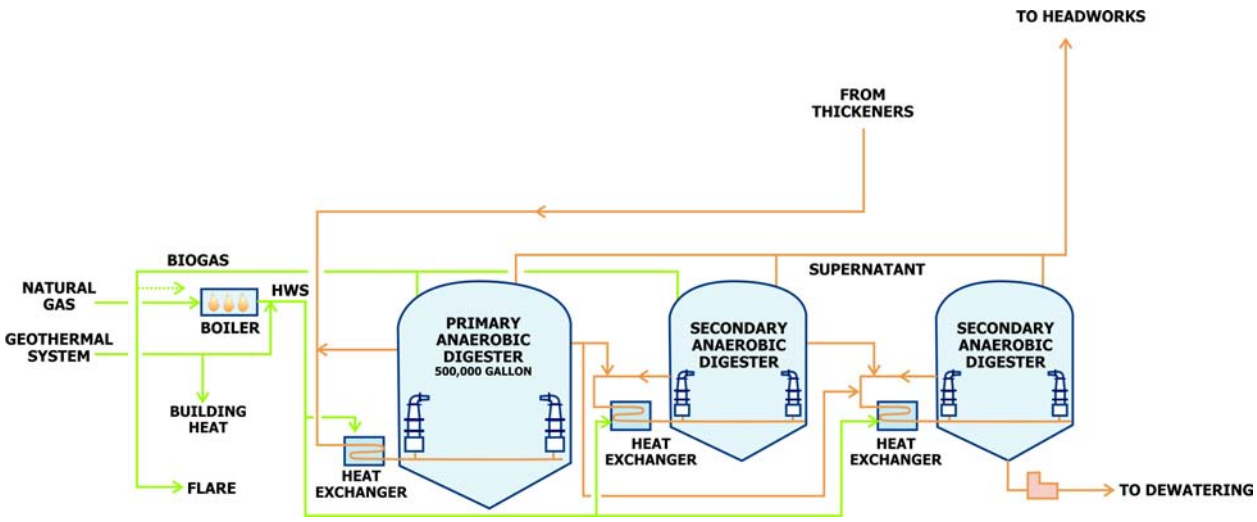


Figure 7.47 Solids Stabilization Option 1 : Refurbish Existing Digestion Facilities

Option 2. Add One 500,000 Gallon Thermophilic/Mesophilic Digester

In this option, a new 500,000 gallon digester would be constructed with the provisions necessary to operate under thermophilic (122 to 135ºF SRT≥10 days) or mesophilic conditions (95 to 105ºF SRT≥15 days). These provisions would include heat exchangers, insulation, and gas handling equipment of sufficient size and quality to meet the increased thermophilic demands. A 500,000 gallon digester would provide Spring Street with 15 days of capacity to approximately the year 2030. Under mesophilic operations, this would be sufficient to attain Class B product; under thermophilic operations, this would be sufficient for Class A product. Under this option, the existing digesters could be upgraded to serve as secondary digesters or as used as storage. The most elegant layout would utilize the 500,000 gallon digester as a primary digester, with the existing digesters operated as secondary digesters parallel to one another. This operation would provide Spring Street with 43 days of detention time in 2010 and 31 days in 2030. **Figure 7.48** shows a process schematic of this alternative.

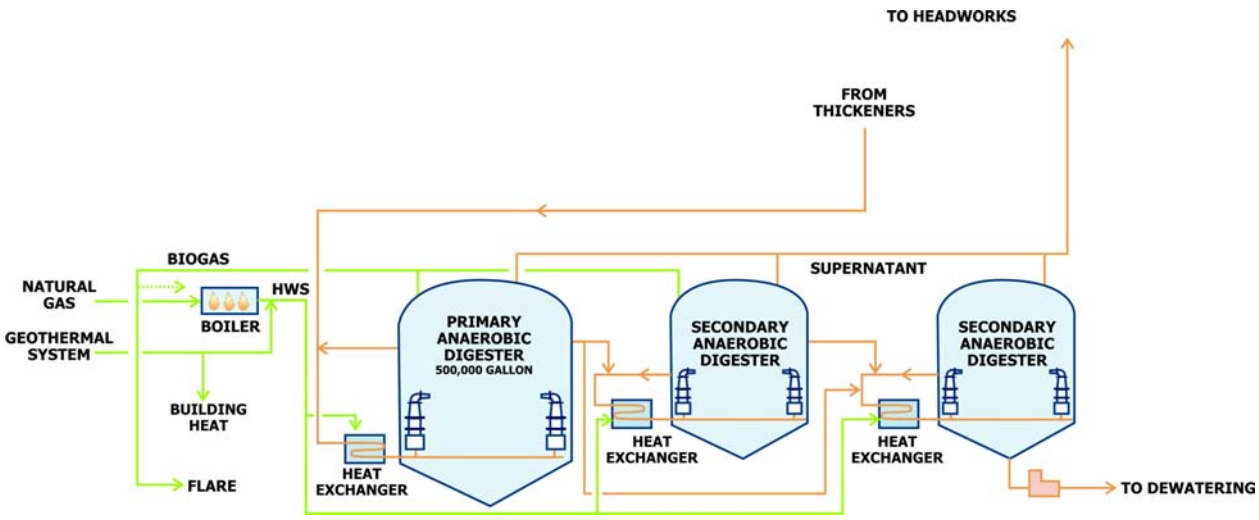


Figure 7.48 Solids Stabilization Option 2 : Add One 500,000 Gallon Thermophilic/Mesophilic Digester

Option 3. Add 300,000 Gallon Thermophilic/Mesophilic Digester

As in Option 2, this option utilizes the construction of a new digester to handle the anticipated solids loads. A new 300,000 gallon digester would be constructed with the same provisions to operate under thermonphilic or mesophilic conditions. A 300,000 gallon digester would provide Spring Street with an additional 12 days of capacity in 2010 and 8.5 days of capacity under 2030 loads. The construction of a new, third digester would increase operational flexibility and enable Spring Street to delay upgrades to the existing digesters. The new digester would serve as the primary digester, and the existing digesters would serve as secondary digesters operated in parallel to one another. The three digesters would have a combined retention volume equivalent to 35 days in 2010 and 25 days in 2030. **Figure 7.49** shows a process schematic of this alternative.

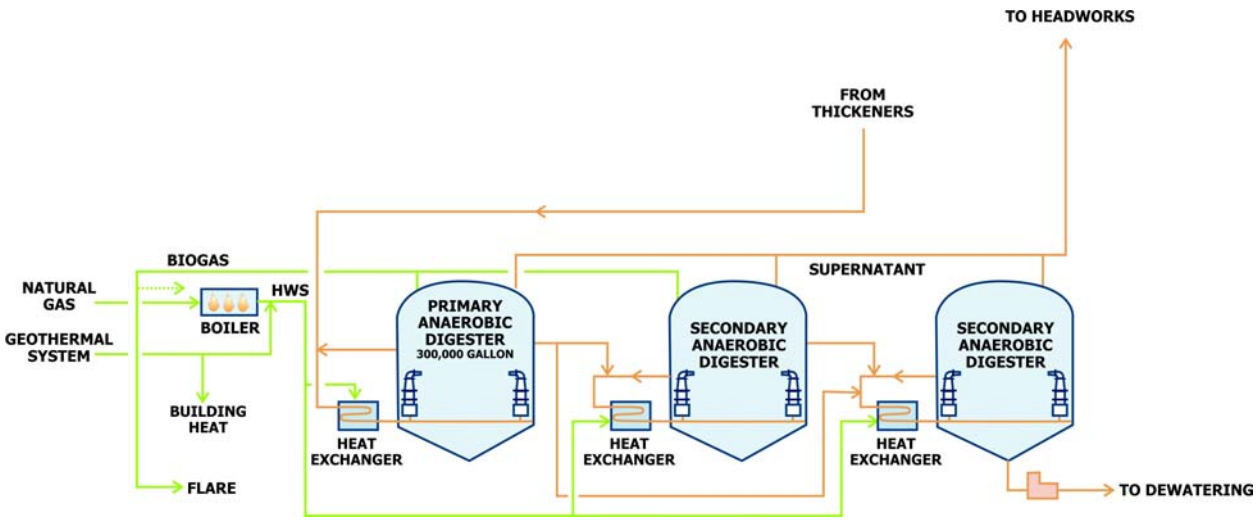


Figure 7.49 Solids Stabilization Option 3 : Add One 300,000 Gallon Thermophilic/Mesophilic Digester

Option 4. Add 50,000 Gallon Digester and Switch to Acid-Gas Phased Digestion

In this option, Spring Street would continue to stabilize solids entirely through windrow composting. Digesters 1 and 2 would be upgraded to be fully functional, and a new 50,000 gallon digester would be constructed to operate in Acid-Gas phased digestion. Acid-Gas digestion separates the digestion processes (hydrolysis, acidogenesis, and methanogenesis) into separate tanks, allowing a facility to optimize the individual process conditions within individual tanks. The smaller acid phase tanks are operated at a low pH (approximately 5.5) and with a short retention time (1 to 2 days) to maximize volatile acid formation. The larger existing tanks operate at a neutral pH with a longer retention time (10 to 12 days) to maximize methanogenesis. The acid-gas digestion process can be operated under mesophilic, thermophilic, or a combined process of conditions. Switching to Acid-Gas phased digestion would provide Spring Street with systematic redundancy and standby capacity through 2030, even with the largest tank out of service. The acid digester could also be used to provide the Spring Street facility with a low nitrogen carbon source for possible use in nitrogen removal, should it be required in the future. **Figure 7.50** shows a process schematic of this alternative.

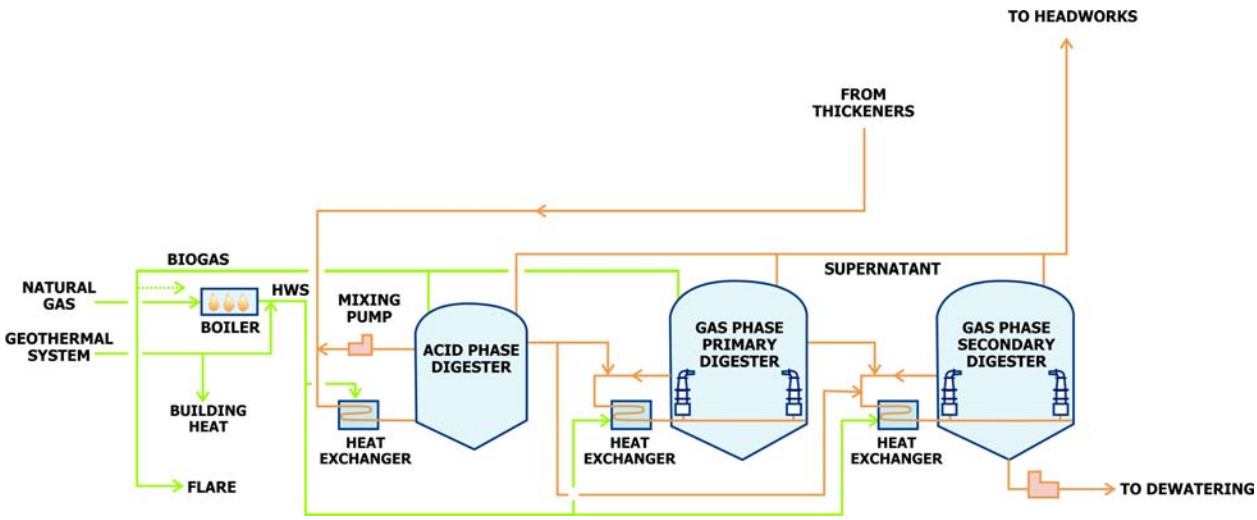


Figure 7.50 Solids Stabilization Option 4 : Add Two 50,000 Gallon Digesters and Switching to Acid-Gas Phased Digestion

The costs represented in **Table 7.19** are for the construction and operation of the new acid digester only. This alternative requires additional digesters to be constructed or rehabilitated.

Solids Stabilization Comparison

The stabilization options are compared in **Table 7.19**.

Table 7.19 Pros, Cons, and Costs of Stabilization Alternatives

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
1. Refurbish Existing Digestion Facilities	▪ Potential for low cost ; preserves capital for other upgrades ▪ Footprint remains mostly unchanged ▪ Fits well into a phased approach, while there is no imminent indication that the composting amendment will be lost ▪ Takes advantage of existing facilities ▪ Provides operational flexibility to stabilization process ▪ Provides systematic redundancy to stabilization process ▪ Amenable to further optimization with implementation of co-digestion to increase volatile solids reduction and biogas production	▪ Relies on windrow composting to achieve Class A product ▪ May require open contract agreement to Class B sludge hauler in case composting is aborted ▪ Digestion process is not inherently redundant ▪ Capital cost uncertain; requires thorough structural and mechanical evaluation of existing digesters ▪ Provides little operational flexibility	4.8	48,000
2. Add One 500,000 Gallon Thermophilic/Mesophilic Digester	▪ Allows capability to achieve Class A product with one unit out of service, i.e., adds flexibility ▪ Is not reliant on composting process to achieve Class A product ▪ Adds storage capacity in case dewatering is down ▪ Provides the greatest capacity of the alternatives ▪ Fits well into a phased approach, while there is no imminent indication that the composting amendment will be lost ▪ Familiar process ▪ Thermophilic operation has potential for increased biogas production and decreased solids production ▪ Takes advantage of existing facilities ▪ Provides operational flexibility to stabilization process ▪ Provides systematic redundancy to stabilization process ▪ Amenable to further optimization with implementation of co-digestion to increase volatile solids reduction and biogas production	▪ Has highest capital cost ▪ May require open contract agreement to class B sludge hauler in case composting is aborted ▪ Has the largest footprint	6.3	38,000
3. Add One 300,000 Gallon	▪ Allows capability to achieve Class B product with one	▪ Has relatively high capital cost	3.9	30,000

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
Thermophilic/Mesophilic Digester	unit out of service, i.e., adds flexibility ▪ Adds storage capacity in case dewatering is down ▪ Provides substantial capacity ▪ Fits well into a phased approach, while there is no imminent indication that the composting amendment will be lost ▪ Familiar process ▪ Thermophilic operation has potential for increased biogas production and decreased solids production ▪ Takes advantage of existing facilities ▪ Provides operational flexibility to stabilization process ▪ Provides systematic redundancy to stabilization process ▪ Amenable to further optimization with implementation of co-digestion to increase volatile solids reduction and biogas production	▪ May require open contract agreement to class B sludge hauler in case composting is aborted ▪ Has large footprint		
4. Add 50,000 Gallon Digester and Switch to Acid-Gas Phased Digestion	▪ Achieves Class B biosolids with one digester out of service, i.e. adds flexibility ▪ Adds storage capacity in case dewatering is down ▪ Expandable to thermophilic operation to achieve Class A product ▪ Relatively low capital cost	▪ May require open contract agreement to Class B sludge hauler in case composting is aborted ▪ Digestion process is not inherently redundant ▪ Capital cost uncertain; requires thorough structural and mechanical evaluation of existing digesters ▪ Provides little operational flexibility ▪ Novel and unfamiliar process ▪ Requires robust construction materials ▪ Can require increased level of operator attention	7.1	65,000

Notes:
(a) September 2008 basis. Total project cost estimates reflect planning level and were developed including materials, equipment, and labor, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%). See **Section 6 A**.

Solids Stabilization Recommendation

To give the City full control of the biosolids product, Options 1 and 2 are recommended as the long term stabilization alternatives. Construction of the new 500,000 gallon digester should precede the rehabilitation of the existing digesters, to provide the requisite volume and equipment during the rehabilitation. The new digester will provide the necessary capacity and redundancy to handle year 2030 loads while also providing the Spring Street facility with a second method of producing Class A biosolids. Further, the new digester will reduce the existing pressure to upgrade and rehabilitate the existing digesters, which will provide the City with the time and flexibility to address this capital improvement project.

A full structural and mechanical evaluation of the existing digesters is recommended during the planning period in order to more accurately estimate the costs of upgrading the existing units and to compare this with the capital cost of new digesters. Further, considerations for a larger digester should be made during preliminary design to evaluate the impact of installing a larger digester for additional capacity.

7.4.3 Sludge Storage

Although not required, sludge storage is generally recommended to provide a "wide spot" in the sludge processing line to accommodate varying and staggered sludge processing schedules, cleaning and maintenance programs, or as a way to add redundancy without duplicating other processes. As an example, the Ten State Standards suggest a minimum storage capacity of one month to provide adequate time to address maintenance and operational issues. Much smaller storage times can be adequate given the entire process configuration and operating schedule, with the smallest storage capacity typically around 72 hours to accommodate weekends and unanticipated repairs on equipment. Sludge storage can be provided through dedicated storage points like sludge lagoons, or through "wide spots" in the line such as surplus capacity within the digesters.

Existing System

Sludge storage at the Spring Street facility is currently limited to the surplus capacity provided by digesters. While an unlined sludge lagoon and a sand drying bed are in place at the facility, they are generally not utilized except during emergency situations. The irregular shape of the lagoon and the lack of a liner have more or less rendered it inoperable. This point was underscored by DEQ in its latest permit revision which cited the lack of a liner in the lagoon as a point of concern that would need to be addressed. City utility staff plan to officially decommission use of the drying beds.

Table 7.20 and **Table 7.21** show the holding capacity of the existing lagoon and digesters. This option assumes that the lining issue of the lagoon is addressed and that the City continues operation of the two digesters at the Spring Street facility.

Table 7.20 Existing Lagoon Sludge Holding Capacity(1)

Design Year	2005	2010	2020	2030
Sewered Population	27,700	30,200	35,700	42,000
Thickened Solids Storage (days capacity)(2)	39.4	28.4	24.0	20.4

Notes:

(1) Unlined lagoon of 650,000 gallon holding capacity. Lack of liner has been outlined by DEQ in its latest permit revision. To be usable, sludge lagoon would need to be lined.

(2) Assuming 4.3% total solids concentration and based on maximum month sludge production.

Table 7.21 Existing Digesters Sludge Holding Capacity(1)

Design Year	2005	2010	2020	2030
Sewered Population	27,700	30,200	35,700	42,000
Thickened Solids Storage (days capacity)(2)	31.1	23.0	19.6	16.5

Notes:

(1) Assumes both digesters are maintained and provide a total available volume of 529000 gallons.

(2) Assumes a Assuming maximum month conditions and a thickened solids concentration of 4.3% which is commensurate with current practice at the Spring Street facility.

The storage provided by the digesters at the Spring Street STP exceeds the minimum storage requirements well beyond the year 2030, but falls short of the suggested one month storage capabilities in 2010. One month storage capacity is suggested in order to provide the City with a comfortable amount of time to address major repairs and failures, which can require long lead times for replacement parts and can often require specialty knowledge and input. The sludge storage deficiencies that need to be addressed for the long term plan are:

- Inadequate liner within the sludge which the DEQ has outlined as an item of concern
- Shrinking long term capacity, insufficient for long term maintenance and operational adjustments.

Sludge Storage Alternatives

Neither of the existing sludge storage locations are fully realized or available, due to the structural, mixing, and heating deficiencies of the digesters and the lack of a liner in the lagoon. As a result, four other storage options were investigated for implementation at the Spring Street STP, including:

Option 1 – Surplus Digester Volume

Option 2 – Replace Existing Lagoon

Option 3 – Add Dewatered Cake Storage

Option 1. Surplus Digester Volume

Unit Process	Storage
Option 1	Surplus Digester Volume
Option 2	Replace Existing Lagoon
Option 3	Add Dewatered Cake Storage

This option would continue to store thickened/digested sludge in the surplus digester volume as long as capacity allows for it. This option assumes that a new 500,000 gallon digester will be built for the solids stabilization and that the existing digesters will be upgraded to be fully functional as discussed in **Section 7.4.2**. The combined storage volume of this alternative is 43 days in 2030.

Option 2. Replace Existing Sludge Lagoon

In this option, the current sludge lagoon would be replaced with a deeper, more regularly shaped, lined lagoon with surface aerators. A lagoon 15 to 20 feet deep with surface aerators is typically quiescent and odor free, as there is enough depth to provide an anaerobic layer at the bottom, an intermediate layer, and develop an aerobic layer on the surface of the pond to limit odor generation. A deep lagoon could also provide a large storage capacity for digested and even unthickened sludge during prolonged maintenance events. The thickened sludge from the bottom of the lagoon will be accessed via a dredge. An 18 feet deep lagoon capable of storing the maximum month sludge production in 2030 would be 60 x 130′, assuming a 2 foot freeboard is maintained for wave action and to prevent overspills. A lagoon capable of storing six month's sludge under annual average conditions would be 150 x 240′.

Option 3. Expand Dewatering and Add Dewatered Cake Storage

This sludge storage option is inherent to the dewatering options discussed in **Section 7.4.4**. In this option, the dewatering equipment would be relocated to the composting area, with space reserved for dewatered cake storage. The dewatering equipment would be expanded to provide redundancy and increased processing capacity to handle thickened or digested sludge.

Dewatered cake storage requires the smallest area per pound sludge stored. Further, upgraded dewatering equipment would address the current dewatering deficiencies (inconsistent performance and high water content) and would help to improve the composting process by producing a drier cake that could be stored through the winter long enough to take advantage of higher summer temperatures that encourage the composting process and reduce the bulking agent demand.

Comparison of Alternatives

The pros, cons, and cost of storage options are shown in **Table 7.22**.

Table 7.22 Pros, Cons, and Costs of Sludge Storage Alternatives

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
1. Surplus Digester Volume	▪ Inherent to digestion process upgrade ▪ Utilizes existing infrastructure ▪ Operational familiarity ▪ Contained odor source ▪ Stores and treats sludge simultaneously	▪ Limits flexibility of digester operation ▪ Cannot store unthickened sludge ▪ Speeds up the existing digester upgrade planning period	Inherent to digester upgrade costs	5,000
2. Replace Existing Sludge Lagoon	▪ Provides stable sludge storage ▪ Provides the largest storage capacity ▪ Used as a wide spot for any type of sludge ▪ Has passive treatment within lagoon ▪ Could be used for long term storage/stabilization	▪ Long storage times may impair composting process by reducing organic content and activity of incoming biosolids ▪ Requires large footprint that could be reserved for other expansion, especially regional treatment expansion ▪ Difficult construction due to high groundwater table ▪ Uncertain permitting conditions ▪ Requires groundwater table monitoring ▪ Loses beneficial by-products of sludge stabilization (e.g., biogas) ▪ High capital costs for excavation, dewatering, liner ▪ Low public acceptance for new facilities	Not costed	Not costed
3. Expand Dewatering and Add Dewatered Cake Storage	▪ Smallest footprint ▪ Allows capability to match compost generation with highest product demand ▪ Builds upon upgrades to dewatering and composting facility ▪ Small capital cost	▪ Limited impact: provides storage only at the end of the sludge processing train ▪ Relies upon composting for sludge stabilization	Inherent to composting area upgrades	10,000

Notes:

(a) September 2008 basis. Total project cost estimates reflect planning level and were developed including materials, equipment, and labor, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%). See Section 6 A

Sludge Storage Recommendation

The use of surplus digester volume and the expansion of the dewatering equipment with dewatered cake storage are recommended as the sludge storage alternatives for the Spring Street facility. Both alternatives represent modest capital and O&M expenditures, as they are part of other process upgrades previously identified as areas of concern at the Spring Street facility. While the selection of these alternatives could speed up the timeframe for the process expansions, they will provide the facility with extensive digestive, dewatering, composting, and storage capabilities.

7.4.4 Solids Dewatering

Biosolids are dewatered to reduce disposal costs, increase disposal options, and to prepare the biosolids for further processing. Dewatering of digested biosolids at the Spring Street STP is accomplished via a 1.5 meter belt filter press located in a carport approximately 200 yards northwest of the composting facility.

Existing System

A single trailer-mounted belt filter press (BFP) aided by polymer addition is used to dewater the digested solids produced by the Spring Street facility. The BFP is currently adjacent to the blower building and dewatered solids cake is trucked to the composting area. BFP operation is currently limited to 5 days/week, 8 hours/day, according to the current staffing structure. While the 1.5 meter Alrick BFP is in good condition, the BFP building is in poor structural condition. Additionally, the wood planking on the BFP trailer is showing signs of deterioration and warping. The composting evaluation revealed that the dewatering equipment currently achieves just 14 percent solids content. This low solids content is more difficult to store and requires a great amendment volume during the composting process. While it may be possible to improve the dewatering capabilities of the existing BFP through operational changes, including differing the polymer quantity and quality, this has not been explored by Spring Street.

From a capacity standpoint, the existing BFP has a 825 lbs/hour throughput capacity[3] (550 lb/hr/meter x 1.5 meter belt). Assuming that active dewatering operation of the press is no more than 6 hours a day, the existing daily dewatering capacity is just about 5,000 lbs/day (dry solids). If operating under the current schedule of 5 days a week, this translates into a weekly dewatering capacity of 25,000 lbs/week. While this capacity could be augmented by extending the operation schedule either to seven days a week or by extending the daily operating hours (see **Table 7.23**), the BFP capacity is limited.

[3] This assumes the belt is loaded at 550 lbs/hr/meter. This is in the middle of the typical range: 400 – 700 lbs/hr/meter

Table 7.23 Solids Loading and Dewatering Constraints

Design Year	2005	2010	2020	2030
Sewered Population	27,700	30,200	35,700	42,000
lbs/day (dry basis)(1)				
Max Month	22,400	31,500	37,100	44,100
Annual Average	19,600	24,500	28,000	32,900
Existing Belt Capacity, lbs/week(2)				
5 day/week, 6 hr/day active operation(3)	25,000	25,000	25,000	25,000
5 day/week, 8 hr/day active operation	33,000	33,000	33,000	33,000
5 day/week, 11 hr/day active operation	45,400	45,400	45,400	45,400

Notes:

(1) Based on 95% solids capture within the thickening process, 55% volatile solids reduction through digesters with 82% initial volatile solids concentration.

(2) Current belt width is 1.5 meters. Start up and shut down of unit estimated at 2 hours/day. This assumes the belt is loaded at 550 lbs/hr/meter. This is in the middle of the typical range: 400 – 700 lbs/hr/meter. Sizing is based on maximum month loading rate. Under these conditions, the existing belt loading capacity is 825 lbs/hour.

(3) Existing operating schedule

Current dewatering deficiencies include:

- Lack of long-term capacity under current operating constraints
- Lack of redundancy provided by operation of single unit
- Operational deficiencies due to the remote location of the dewatering process from the composting facilities
- Ancillary facilities (building) deficiencies
- Low solids content of dewatered cake

Unit Process	Dewatering
Option 1	Existing BFP
Option 2	Relocate/ Add BFP
Option 3	Relocate/ Add Screw Press
Option 4	Relocate/ Add Centrifuge

Solids Dewatering Alternatives

Sludge dewatering usually involves bringing sludge from a concentration of approximately 3 percent to a cake-like concentration of 15 percent to 20 percent. A number of dewatering technologies exist including belt filter presses (BFP), pressure plate filter presses, screw presses, and centrifuges.

Four dewatering alternatives were developed to increase the capacity of the dewatering system. These alternatives were also selected to address the other known deficiencies of the dewatering system: truck transport demands, a

deteriorating trailer, low solids content, and poor structural condition of the dewatering building.

Option 1 – Existing BFP

Option 2 – Relocation and BFP Expansion

Option 3 – Relocation and Screw Press Expansion

Option 4 – Relocation and Centrifuge Expansion

Option 1. Existing BFP

This option would continue to operate the BFP in the same location, with no process expansion. Truck transport would continue to bring the dewatered cake to the composting facility. Peak events would be addressed by extending the operating schedule of the BFP. In the year 2030, the current unit would need to be operated on 9.5 hour shifts, 7 days a week, to meet the anticipated load. **Figure 7.51** shows a process schematic of this alternative.

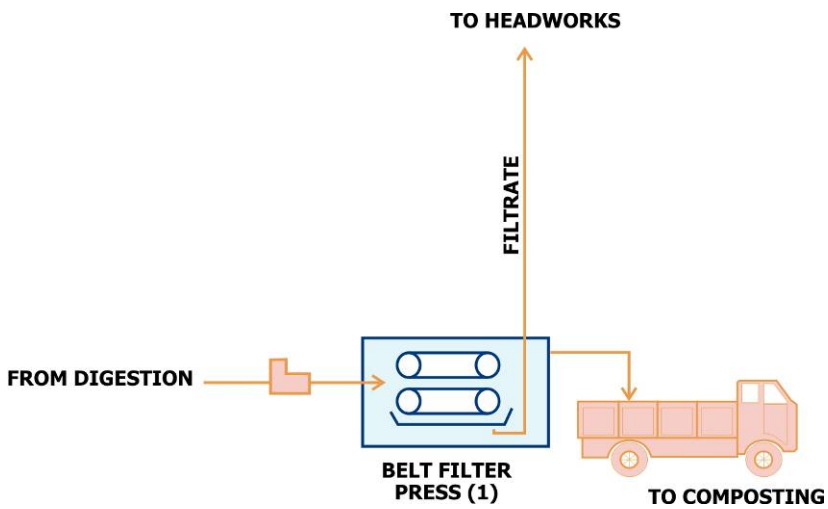


Figure 7.51 Solids Dewatering Option 1 : Status Quo – Existing BFP in Existing Location

Option 2. Relocation and BFP Expansion

Under this option, the dewatering facility would be moved adjacent to the composting facility to eliminate truck transport. An additional 1.5m BFP would be installed for system redundancy and capacity through 2030. This alternative would require pumping the digested sludge to the composting facility and the filtrate back to the headworks. A receiving area would need to be constructed within the composting area. This expansion would enable the Spring Street facility to handle 2030 loads with an operating schedule of 6 hour shifts, 5 days a week. Further, it

would provide the surplus capacity to handle peak events and address equipment failures. **Figure 7.52** shows a process schematic of this alternative.

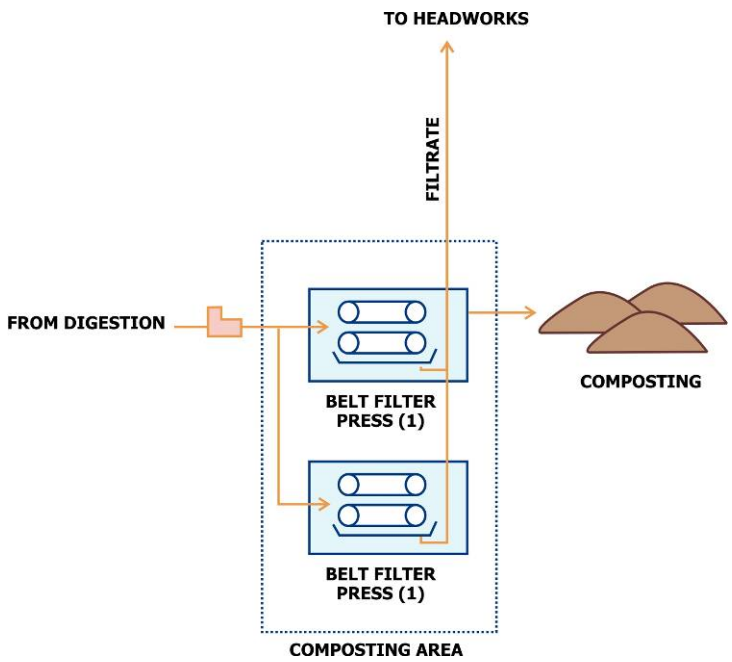


Figure 7.52 Solids Dewatering Option 2 : Relocation and BFP Expansion

Option 3. Relocation and Screw Press Expansion

Like Option 2, this option would move the dewatering facility adjacent to the composting facility to eliminate truck transport. A new FKC screw press would be installed for system redundancy and capacity through 2030. This alternative would require pumping the digested sludge to the composting facility and the filtrate back to the headworks. A receiving area would need to be constructed within the composting area. The combined capacity of the screw press and the existing belt filter press would enable Spring Street to handle 2030 loads with 8 hour shifts, 5 days a week. **Figure 7.53** shows a process schematic of this alternative.

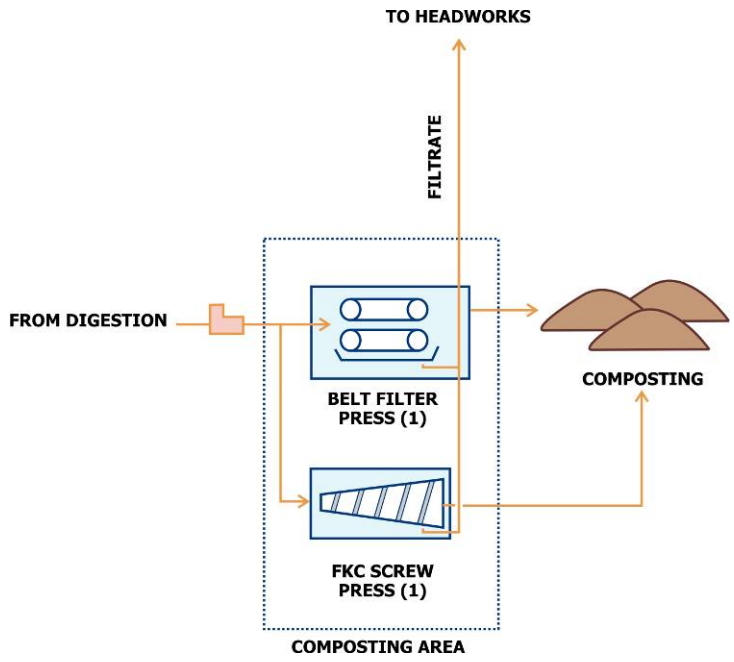


Figure 7.53 Solids Dewatering Option 3 : Relocation and Screw Press Expansion

Option 4. Relocation and Centrifuge Expansion

Like Options 2 and 3, this option involves moving the dewatering facility adjacent to the composting facility to eliminate truck transport. A 55-hp dewatering centrifuge would be installed to provide system redundancy and capacity through 2030. This alternative would also require pumping the digested sludge to the composting facility and the filtrate back to the headworks. A receiving area would need to be constructed within the composting area. **Figure 7.54** shows a schematic of this option.

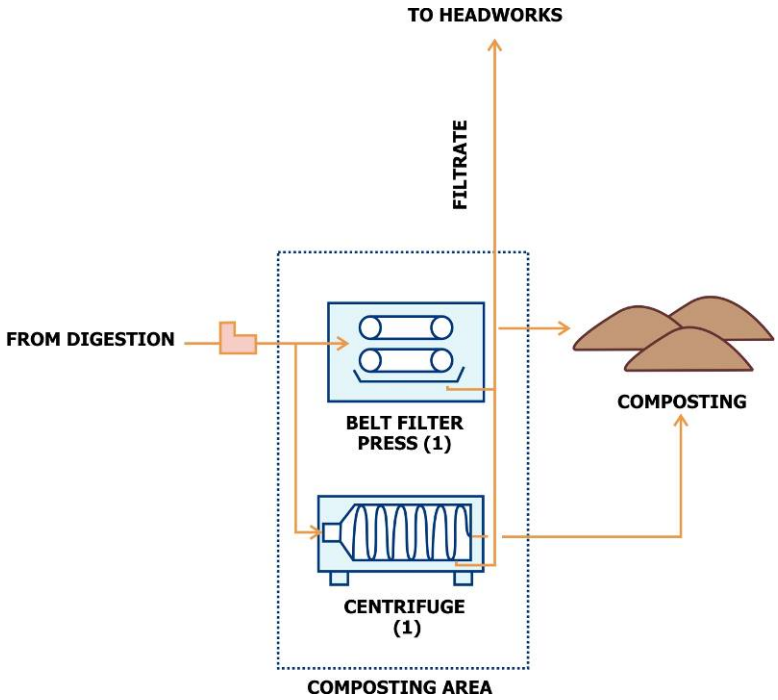


Figure 7.54 Solids Dewatering Option 4 : Relocation and Centrifuge Expansion

While centrifuges are known to produce a very dry solid, recent results found that anaerobically digested solids contained higher concentrations of fecal coliforms and a higher odor potential after centrifuge dewatering when compared with other dewatering technologies.[4] This is potentially due to the high shear exerted on the solids during the centrifuge process. This odor release potential is critical to consider, as the City plans on continuing its composting operation and residential expansion is anticipated in the surrounding area.

Comparison of Sludge Dewatering Alternatives

The dewatering options are compared in **Table 7.24** with pros, cons, and costs.

[4] Richard K Tsang (CDM), *Low-Shear Dewatering*, WE&T, July 2008.

Table 7.24 Pros, Cons, and Costs of Dewatering Alternatives

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
1. Existing BFP	▪ Least expensive	▪ Requires staffing changes for longer operational hours during peak events ▪ No redundancy ▪ Risky if combined with a "no sludge storage" option ▪ Still requires trucking of dewatered cake ▪ Odor generation source close to potential development to the north	1.1	65,000
2. Relocation and BFP Expansion	▪ Process familiarity ▪ Reliable operation ▪ Addresses operational deficiencies (trucking, building) ▪ Provides systematic redundancy ▪ Increases reliability of sludge handling process ▪ Known efficiency ▪ Moves odor generation source away from potential residential development; consolidates with composting area ▪ Provides surplus capacity to be coupled with dewatered cake storage	▪ Requires digested sludge pumping to the composting area ▪ Requires filtrate pumping back to the headworks from composting area ▪ Still requires high polymer and washwater volumes ▪	2.0	70,000
3. Relocation and Screw Press Expansion	▪ Low cost ▪ Reliable ▪ Addresses operational deficiencies (trucking, building) ▪ Provides full redundancy ▪ Increases reliability of sludge handling process ▪ Moves odor generation source away from potential residential development; consolidates with composting area ▪ Has the ability to produce a drier cake which can increase composting efficiency and reduce storage area	▪ Requires digested sludge pumping to the composting area ▪ Requires filtrate pumping back to the headworks ▪ Unknown efficiency ▪ Unfamiliar process ▪ Need to maintain and operate two types of mechanical equipment (increases process complexity)	2.2	72,000
4. Relocation and Centrifuge Expansion	▪ Reliable ▪ Addresses operational deficiencies (trucking, building) ▪ Provides full redundancy ▪ Increases reliability of sludge handling process ▪ Moves odor generation source away from potential residential development; consolidates with composting area ▪ Can produce the driest product which can increase composting efficiency and reduce storage area	▪ Higher odor potential due to high shear ▪ Requires digested sludge pumping to the composting area ▪ Requires filtrate pumping back to the headworks ▪ Unknown efficiency ▪ Unfamiliar process ▪ Need to maintain and operate two types of mechanical equipment (increases process complexity) ▪ High energy demand ▪ High capital cost ▪ High noise potential	2.0	73,000

Notes:
(a) September 2008 basis. Total project cost estimates reflect planning level and were developed including materials, equipment, and labor, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%). See **Section 6 A**.

Sludge Dewatering Recommendation

Due to the operational familiarity and flexibility provided by the BFP expansion, it is recommended that the Spring Street dewatering operation be relocated and expanded with an additional 1.5 m BFP. This option will streamline the dewatering process while increasing capacity and operational reliability. This upgrade should be considered a top priority given the minimal capacity available on the existing BFP during peak month conditions and the extra labor that is currently expended on truck transport of the dewatered cake. Further, an efficient and reliable dewatering process will facilitate the other process upgrades and expansions by providing the necessary processing capacity during construction.

Prior to initiating design on this upgrade, it is recommended that the dewatering capabilities of both the existing BFP and the proposed BFP be evaluated to ensure they can produce a dry enough cake for the composting operations. The advantages of improved dewatering capabilities as they pertain to composting are discussed in the following section and in the composting technical memorandum provided in **Appendix E**.

7.4.5 Ultimate Use and Disposal Alternatives

The final step in the solids handling train is the disposal or beneficial use of the biosolids. This can be the most costly step in the solids handling process due to permitting requirements and public skepticism over the safety of biosolids. Disposal/distribution alternatives include composting for distribution, incineration, land application, land-filling, and drying.

Existing System

Currently, all biosolids produced at the Spring Street STP are distributed through its very popular and successful composting program. Spring Street has a composting facility that it utilizes for a windrow composting process. Composting produces a Class A biosolids product that is freely distributed to the community for incorporation into gardens, parks, and yards.

The composting facility consists of a 100 ft x 200 ft. open-front building that currently houses a screen and a stockpile of finished compost. There is a paved area in front of the building and an extensive area of unimproved land. The unimproved land is wet during times of precipitation and snowmelt and is not useable at those times. The building was originally intended for aerated static pile composting and included an aeration system. The aeration system had disposable aeration pipes on the concrete surface and was difficult to operate.

The current composting operation consists of forming windrows and turning them periodically using a front end loader. Since the paved area is limited, most of the windrow composting takes place on the unimproved land. During the winter, some of the dewatered sludge is stacked on the paved surface using dikes of woodchips until space is available for windrowing. This constraint is due to the lack of availability of usable land during wet conditions. The sludge is well-digested and does not generate significant odor in the winter. One other disadvantage of composting on an unpaved surface is that rocks are picked up with the windrows.

The 2007 Annual Biosolids Report submitted to the Oregon Department of Environmental Quality indicates that the windrow process meets US EPA 40 CFR Part 503 requirements for Class A pathogen reduction using the turned windrow criteria.

As with most operations in which dewatered biosolids are composted, it is necessary to mix the biosolids with an amendment consisting of ground or chipped wood. The amendment is needed to increase the solids content, provide porosity and structure for aeration, and provide supplemental carbon. The amendment used at Klamath Falls is chipped wood and brush from the clearing of electrical utility rights of way. The material is abundant, and the City receives some revenue for taking it. It is an entirely suitable amendment material, except that it can contain some large chunks of wood. After composting in windrows, the compost is screened. The screen is an old and unreliable unit with conveyors salvaged from other facilities. It is not capable of handling the rocks that are picked up from the unpaved surface or the large chunks of wood that come in with the amendment.

Deficiencies identified by the Wastewater Division Staff for the composting process are summarized as follows:

- The screen is old and unreliable and should be replaced
- The-front end loader is old
- Not enough paved surface exists to allow all-weather windrow composting throughout the year
- Mixing biosolids and amendment is time-consuming
- Composting operation is a full-time job in the summer when plant staff catch up with the winter backlog
- Full descriptions of these alternatives are found in **Appendix E**.

Unit Process	Ultimate Use / Disposal
Option 1	Enhanced Windrow
Option 2	Aerated Static Piles
Option 3	Aerated Static Piles –Pull out pipes
Option 4	Sludge Dryer

Ultimate Use and Beneficial Use of Alternatives

Four options were developed and evaluated in this plan:

Option 1 – Enhanced Windrow Composting

Option 2 – Aerated Static Piles – Trenched Pipes

Option 3 – Aerated Static Piles – Pull out Pipes

Option 4 – Sludge Dryer

Option 1. Enhanced Windrow Composting

Because the City is generally satisfied with the windrow composting operation, the baseline alternative consists of providing the equipment and site improvements needed to optimize the windrow process. Improvements are summarized as follows:

a) New Screen
b) Windrow turner
c) Site improvements to provide sufficient all-weather surface to meet biosolids processing demand throughout the year

Option 2. Aerated Static Pile Composting – Trenched Pipe Construction

Aerated static pile composting requires less space and loader time than windrow composting; although, it is a more complex process due to the construction of piles and the operator-intensive blower and aeration control. This option will look at the most operator-friendly approach in which the aeration system will be installed with a trenched pipe construction. A new concrete floor approximately 12 inches thick would be poured over the existing floor with aeration trenches. During composting, a layer of amendment would be placed over the aeration trenches and covered with an 8-foot deep stack of mix with a 12-inch layer of unscreened compost as an insulating cover.

Aeration would be designed to provide both positive aeration (blowing up through the piles) and negative aeration (drawing down through the piles). This provides optimal distribution of air. Air extracted during negative aeration would be treated in a biofilter.

Improvements necessary under this alternative are summarized as follows:

a) New Screen
b) New batch mixer
c) New aeration and control system
d) New concrete floor overlay with aeration trenches
e) Site improvements to provide additional sufficient all-weather surface, but not as much area as for windrow composting

Option 3. Aerated Static Pile Composting – Pull-Out Pipes

Aerated static pile composting can be designed to utilize removable pipes that are pulled out of the piles prior to relocating the compost for curing, storage, and distribution. This alternative will look at a pull-out pipe construction for aerated static pile composting. This alternative will require a large amount of improved space to maneuver the pipes and will also increase operational requirements during the composting process compared with the trenched pipe construction.

Improvements necessary under this alternative are summarized as follows:

a) New Screen
b) New batch mixer
c) New aeration and control system
d) New concrete floor and pull-out pipe system
e) Site improvements to provide additional sufficient all-weather surface, but not as much area as for windrow composting

Option 4. Sludge Drying – Indirect or Direct Dryer

Dried biosolids is an entirely different product than compost. Most of the water is removed and there is no amendment, so the resulting product volume is much less than with composting. It is more effective than composting in preserving the nitrogen value in the biosolids and is used as a low-strength organic fertilizer. Under this alternative, a sludge dryer would be co-located with the dewatering equipment in the existing composting facility. This option will look at both indirect and direct dryers. For indirect drying, sludge comes in contact with hot metal surfaces in a jacketed mixer with hollow flights. Conversely, during direct drying, sludge passes through a tunnel on a chain link conveyer belt as hot air passes downward through the drying sludge and belt. Both systems will require a full time operator and the following improvements:

a) Pipeline for digested sludge
b) Return line for filtrate and dryer condenser water.
c) Digester gas supply
d) Plant effluent for condenser
e) Potable water for belt wash (direct belt dryer only)
f) Return exhaust air, if treated in activated sludge tanks (indirect dryer only)
g) Electrical power
h) Instrumentation and controls

Comparison of Alternatives

The four options' pros, cons, and costs are compared in Table **7.25**.

Table 7.25 Pros, Cons, and Costs of Biosolids Ultimate Use and Beneficial Use Alternatives

Option	Pros	Cons	Total Project Cost [(a)], $ Million	Annual O&M if Operating in 2011, $
1. Enhanced Windrow Composting	▪ Process familiarity ▪ Well accepted by public ▪ Inexpensive ▪ Solids content from dewatering is not as critical	▪ Relies on availability of bulking agent	0.6	93,000
2. Aerated Static Piles	▪ Gives more control to the City	▪ New equipment required ▪ High heating requirement ▪ Drier biosolids feed (20%) required ▪ Requires finding sites/end users for land application	1.9	125,000
3. Aerated Static Piles – Pull Out Pipes	▪ Gives more control to the City ▪ Compatible with capacity and redundancy upgrades required for digestion ▪ Increases biogas production	▪ Requires marketing study and securing contracts with end users; ▪ Drier biosolids feed (20%) required ▪ Transporting costs may be a factor	1.2	133,000
4. Sludge Drying	▪ Does not require amendments ▪ Produces commercial grade fertilizer product ▪ Small footprint	▪ Expensive ▪ Requires drier feed (20% solids from dewatering) ▪ Not the most cost effective use of biogas (see Section 8) ▪ Heavy mechanical equipment	7.1	195,000

Notes:

(a) September 2008 basis. Total project cost estimates reflect planning level and were developed including materials, equipment, and labor, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%). See Section 6

Biosolids Ultimate Use and Beneficial Use Recommendation

It is recommended that the City continues windrow composting to produce its Class A biosolids. This process has been well-accepted by the staff and the public, is most flexible in terms of dewatered feed, and would require the least capital investment of the four evaluated alternatives.

7.5 Ancillary Upgrades

While main unit processes were evaluated and options generated to come up with the best recommendation for the City, a number of other ancillary upgrades need to be included in the City's long-term plans. For these other improvements, only preliminary studies were conducted to provide the City with reasonable recommendations and cost estimates. Such upgrades should be evaluated in more detail during design activities. These recommended ancillary upgrades are described below, with cost estimates incorporated with the plant wide alternatives in **Section 7.6**.

Effluent Piping Modifications

Modifications would add a new effluent outbox to the east of Clarifier No. 1, site piping to the new or future tertiary filtration facilities, final disinfection, and final pumping to off-site discharge.

Effluent Pumping

Because of the insufficient or non-existent mixing in Lake Ewauna, it is anticipated that a new outfall or off-site disposal of most (if not all) effluent will be required. As described in the effluent disposal alternatives technical memorandum, a new outfall near Highway 97 or using winter storage ponds for summer land application are alternatives that would require off-site pumping. For this plan, it was assumed that the existing 24-inch and 12-inch cogeneration and blowdown lines would be used to pump and discharge off-site, with no cogeneration blowdown return. The existing on-site effluent (cogeneration) pump station would be expanded with dry weather pumps in the two open slots within the well while a new wet weather pump station would be added adjacent to it (see **Figure 7.55**).

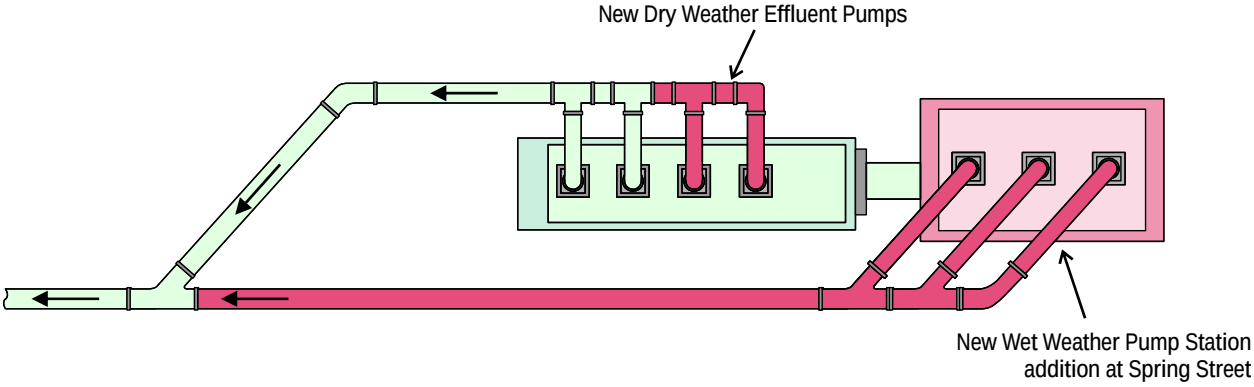


Figure 7.55 Effluent Cogen Pump Station Modifications for Remote Outfall Pumping

Final effluent pumping via the existing 24-inch and 12-inch pipelines to the cogeneration plant requires high pressure pumping, especially at peak wet weather flows. At the same time, these pipelines are assumed to be capable of sustaining 100 psi of pressure. To maintain the integrity of the existing pipelines, an intermediate booster pump station is required to deliver final effluent to the proposed Highway 97 outfall area or a storage pond. Although high head pumps would be required because of the relatively small diameter of the existing pipes, the higher flows are not expected to be sustained. The possibility of allowing the infrequent use of the existing outfalls in Lake Ewauna as peak wet weather flow discharge points should be discussed during design activities. This would avoid power surges and minimize the size of the pumps and motors. Impacts on water quality of such a mode of wet weather operation should be discussed with DEQ.

Maintenance Building

A new maintenance building with 3 truck bays would be provided where the existing wood building west of the composting building is located. For this plan and cost development, a metal building of 60′ by 30′ by 20′ was assumed.

Biogas Boiler

The cost of a new biogas boiler was developed and included to respond to the City's desire for better energy efficiency, and following the recommendation of the Biogas Management evaluation (see **Section 8** of this Plan).

Plant Water Pumps

The existing plant water pumps were given a score of 3 (Show significant wear. Provide low pressure and flow) in the condition assessment. The piping is complicated, the installation old, and the pumps undersized. New plant water pumps in a new metal building were assumed for this plan.

Existing Plant Water Pumps

Clarifier No 1 RAS Pumps

The cost of replacing the existing Clarifier No 1 RAS pumps is included in Section 7.6, as the pumps were given a rating of 3, with the DC drive units given a rating of 1.5 in the condition assessment.

Septage Receiving Station

Based on annual septic pumping reports for 2007 (4 pumpers), the total septage received approaches 1 million gallons per year, with an average of 3 – 1,500 gallon trucks per week. This operation would require 10,000 gallons of vault storage, flushing water connection, and a dump pad. The septage receiving station could be built as part of a headworks upgrade, as it would discharge ahead of the headworks screens.

7.6 Development and Evaluation of Complete Alternatives

The Spring Street Facilities Condition Assessment placed an emphasis on the aging facilities and need for increased reliability regardless of TMDL outcome. While the main impact of TMDL would be reflected in the

biological system upgrades whether or not tertiary treatment would be required. As this Plan was progressing, TMDLs were still under development and effluent quality criteria undefined. For this reason, a number of secondary treatment alternatives were developed to achieve various levels of treatment. Also, effluent disposal options were also examined to address the fact that increasing pressures to meet stringent water quality criteria and poor mixing conditions in Lake Ewauna may require new effluent disposal options. As information from DEQ became available, it became clear that the City faces two major choices: either providing year-round nutrient removal with advanced treatment and a remote outfall, or, more drastically, getting out of the river altogether, with summer irrigation and winter effluent storage, thereby avoiding the need for nutrient removal facilities, or more specifically:

1. Year-Round Effluent Discharge into the River, but with New Diffuser and Advanced Treatment to meet TMDL Waste Load Allocations and In-stream Water Quality Standards

2. Summer Agricultural Land Application with Winter Storage (No River Discharge Alternative)

These two complete alternatives are compared side by side in this section to clarify the cost and non-cost impacts of each. Since the final outcome of TMDLs, permitting, and other non-engineering aspects are still unknown, the inputs for the alternatives comparisons are detailed to the greatest extent possible while still allowing room for modifications as regulatory conditions are clarified.

7.6.1 Common Upgrades to Complete Alternatives

A number of Spring Street STP upgrades are common to the two proposed complete alternatives, based on the non-TMDL driven necessities. The recommendations for the specific upgrades are based on preliminary screening, cost, and non-cost evaluation completed in **Section 7.2** through **Section 7.4** of this Plan. Again, these recommendations would need to be reexamined and optimized as each project enters predesign activities. Recommended common upgrades and cost estimates for each are listed in **Table 7.26**.

Estimates of probable costs for implementation for each of the upgraded items listed above are included in **Table 7.27** at the end of this section. Cost estimates are planning level cost estimates and were developed following the methodology and factors indicated in Section 6, including site construction, concrete, metals, equipment, instrumentation and controls, electrical, mechanical, installation, field office overhead (10 percent), home office overhead (6 percent) estimator's contingency (30 percent), margin (10 percent), builder's all risk insurance (1 percent), liability insurance (2 percent), bond (2 percent), escalation to midpoint of construction (6 percent), and engineering and administration (25 percent). If they were all implemented in 2008, total project costs for the common parameters would total $54 million dollars under current assumptions, of which primary clarifiers upgrade is the most expensive upgrade.

Table 7.26 Cost of Implementation - Common Upgrades(1)

Improvement	Total Capital Cost(2), Million US$	Annual O&M Estimate of Upgraded Facility if Operating in Year 2011 $
1. New influent IPS and headworks	7.3	50,100
2. New conventional primaries (2) in new location	11.3	28,900
3. New Aeration Basins (1)	5.6	24,500
4. Add one DAFT	3.3	43,100
5. Modify to thermophilic digestion and add (1) 500,000 digester	6.3	38,500
6. Relocate existing belt filterpress and add (1) by composting area	2.0	70,500
7. Enhancements to windrow composting	0.6	93,200
8. Site piping modifications around clarifiers, including tertiary/disinfection booster pumping station	7.0	6,500
9. New RAS pumps for Clarifier No 1	1.4	9,100
10. Expand Co-Gen Pump Station for effluent pumping	5.1	59,000
11. New intermediate off-site pump station	8.1	64,800
12. New plant water pumps (at existing BFP location)	0.6	3,000
13. New maintenance building	1.3	-
14. Septage Receiving Station	0.25	Revenue based on tipping fee
TOTAL, Common upgrades	$ 60 M	$ 491,000/year

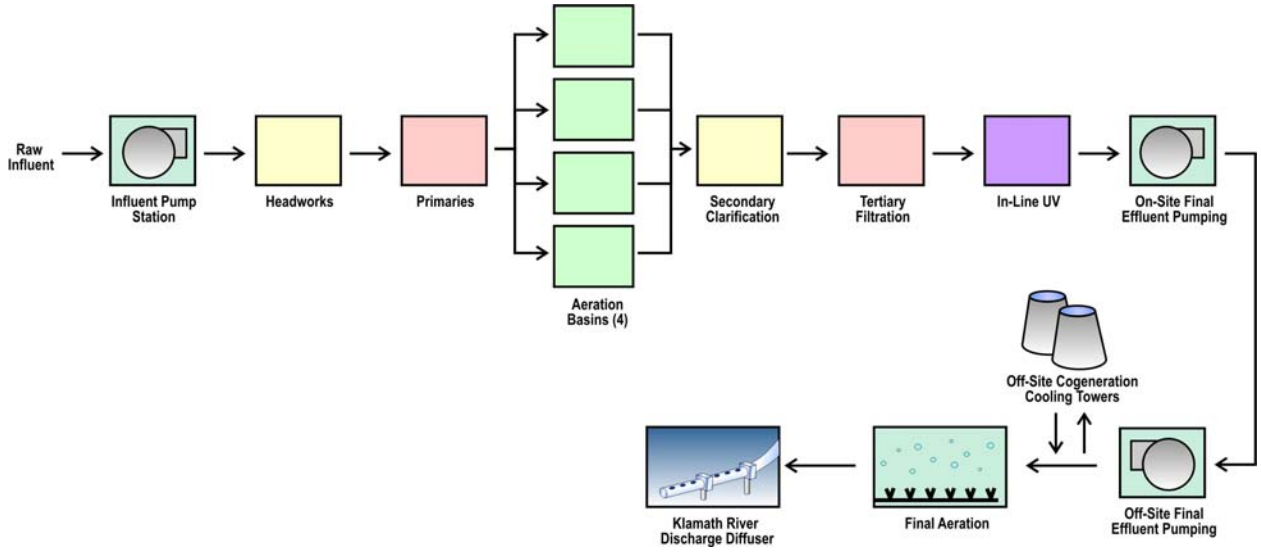
Notes:

(1) Estimates reflect September 2008 economic indexes and conditions.

(2) Total Capital Cost includes site construction, concrete, metals, equipment, instrumentation and controls, electrical, mechanical, installation, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%).

7.6.2 Development of Two Complete Alternatives

For each of the two complete alternatives developed, main differentiators that have significant cost and non-cost impacts are described in this section. **Figure 7.56** and **Figure 7.57** show the



main process differences between the two alternatives:

Figure 7.56 Year Round River Discharge with Advanced Treatment and New Off-Site Diffuser

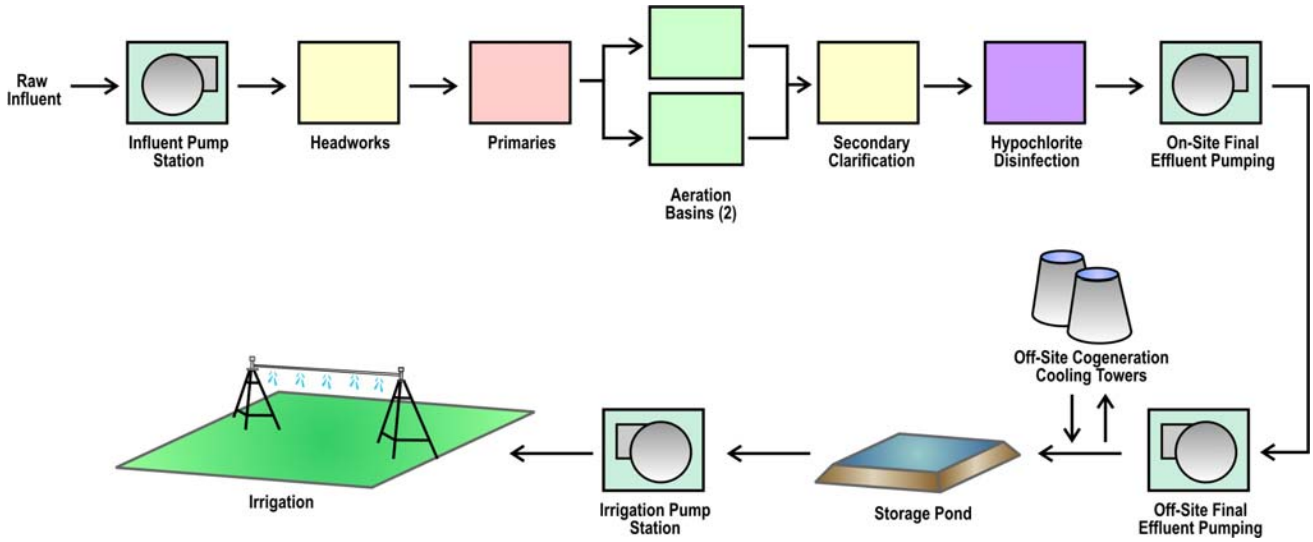


Figure 7.57 Summer Agricultural Land Application with Winter Storage (No River Discharge)

Year-Round Effluent River Discharge with Advanced Treatment and New Off-Site Diffuser

Under this alternative, Spring Street STP would upgrade the secondary treatment process to allow for biological nutrient removal, including phosphorus via the addition of aeration basins and anaerobic zones providing a total of 15 days SRT at the projected maximum month flow. Meeting a year-round limit requires the facilities to be sized based on maximum month flow (which is twice the average dry weather flow for the Spring Street STP service area). Also, tertiary filtration in continuously backwashed sand filters requires the addition of ferric chloride, which is flow-paced rather than concentration-based. Effluent from the filtration units would be of exceptional quality for ultraviolet disinfection, which would be provided in-line, in-pipe, or closed (as opposed to in-channel or open) to preserve both hydraulic head and footprint. The latest information from DEQ indicates that discharges from the Spring Street STP will be required to meet a maximum mass discharge limit of 5 kg/day of total phosphorus. With a year-round limit, the treatment facilities would need to meet effluent phosphorus concentrations down to 0.13 mg/L in year 2030. Current technology indicates that single pass sand filtration is likely to meet phosphorus concentrations of 0.2 to 0.5 mg/L while meeting phosphorus concentrations below 0.2 mg/L could eventually require dual-stage tertiary filtration. It would be prudent to plan facilities for the eventual addition of a second filtration stage, which would require additional head to operate. Tertiary filtration with continuously backwashed sand filters in a single stage configuration rated for maximum month flow would require:

- Three additional selector activated sludge aeration basins (additional 3 million gallons of tankage) to provide a total system SRT of 15 days, allow nitrification, and biological phosphorus removal. The existing aeration basins would be used in series as a polishing stage to the new aeration basins.
- Single stage tertiary filtration with ten quads of 200 gpm sand filtration units with the cone bottoms grouted in concrete. An open channel would gravity feed the filtration units.
- Two ferric chloride tanks and metering facilities of 8,000 gallons (**not shown** on **Figure 7.56**) which would be located in the existing chemical storage building in lieu of hypochlorite tanks.
- Four closed, in-line units of 5.2 mgd each, medium pressure.
- One 20 ft by 20 ft electrical building for UV units (**not shown** on **Figure 7.56**).
- Liquid sodium hypochlorite injection at final effluent pumping wet well for chlorine residual (Spring Street site).
- Effluent re-aeration facilities at the outfall site.
- Liquid sodium hypochlorite injection prior to effluent discharge for chlorine residual.
- New effluent outfall and diffuser.

A schematic depicting main elements of the effluent pumping and discharge items of this alternative is recalled from **Section 7.3** in **Figure 7.58** below.

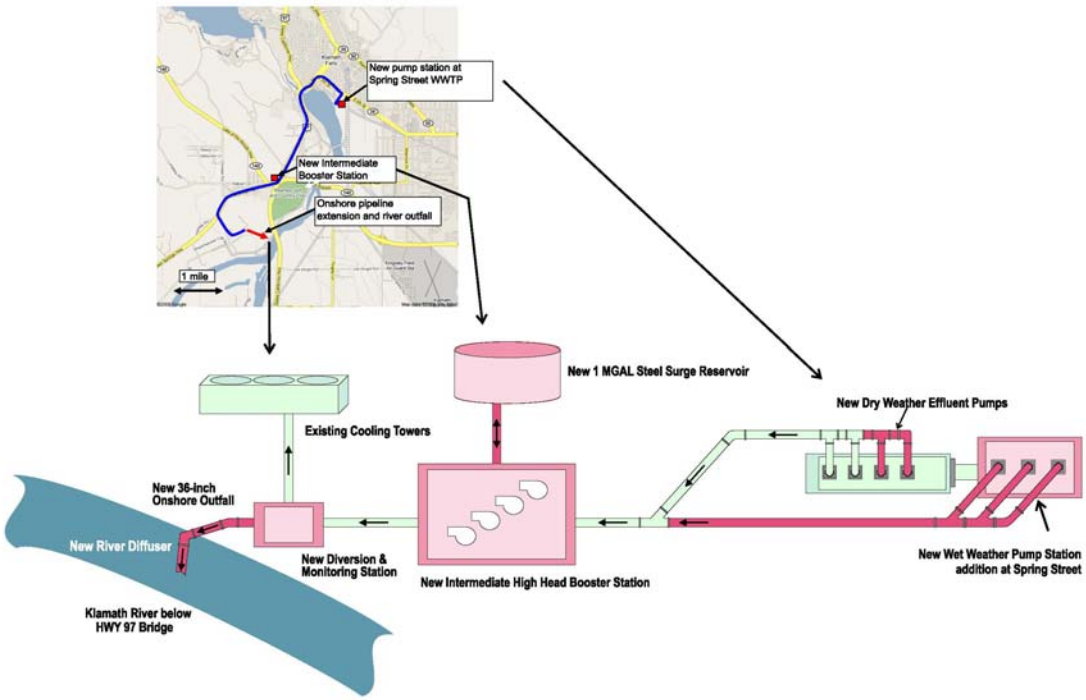


Figure 7.58 Schematic of River Discharge Alternative with Effluent Pumping and Discharge Element

Summer Agricultural Land Application with Winter Storage ("No River Discharge" Alternative)

Under this alternative, Spring Street's effluent would be stored during the non-irrigation season and would be irrigated at agronomic rates during the irrigation season. There would be no discharge to surface waters. Based upon current projected design flows, the storage basins would require 380 acres, assuming a depth of 10 feet. Agronomic irrigation at 3 feet per year would require an irrigation area of 2000 acres. Wastewater quality requirements set forth in ODEQ's rules for using recycled water depend upon the actual use. Irrigation of non-food crops such as forage would require a 7-day median total coliform limit of 23 CFU/100 mls with no two consecutive samples exceeding 240 CFU/100mls. Virtually any mechanical, biological sewage treatment process with disinfection should be able to achieve these levels. If food crops destined for human consumption were to be irrigated with recycled water, higher levels of treatment and disinfection would be required to achieve a Class A recycled water treated to reuse standards and disposed off-site. Although there would be no nutrient removal

requirements to meet, the NTU and disinfection requirements are such that tertiary filtration may still be required. This alternative would then require:

- Two additional, smaller selector activated sludge aeration basins (additional 1 million gallons of tankage, or one third of advanced treatment option above) to provide a total system SRT of 5 days for carbonaceous BOD removal only. Existing aeration basin would be used in series with the new basins.
- New Chlorine contact channels
- Liquid sodium hypochlorite injection at intermediate pumping station for chlorine residual
- Storage pond (380 acres by 10 feet deep), lined
- Irrigation facilities

Figure 7.59 recalls the main effluent pumping and disposal elements of this alternative.

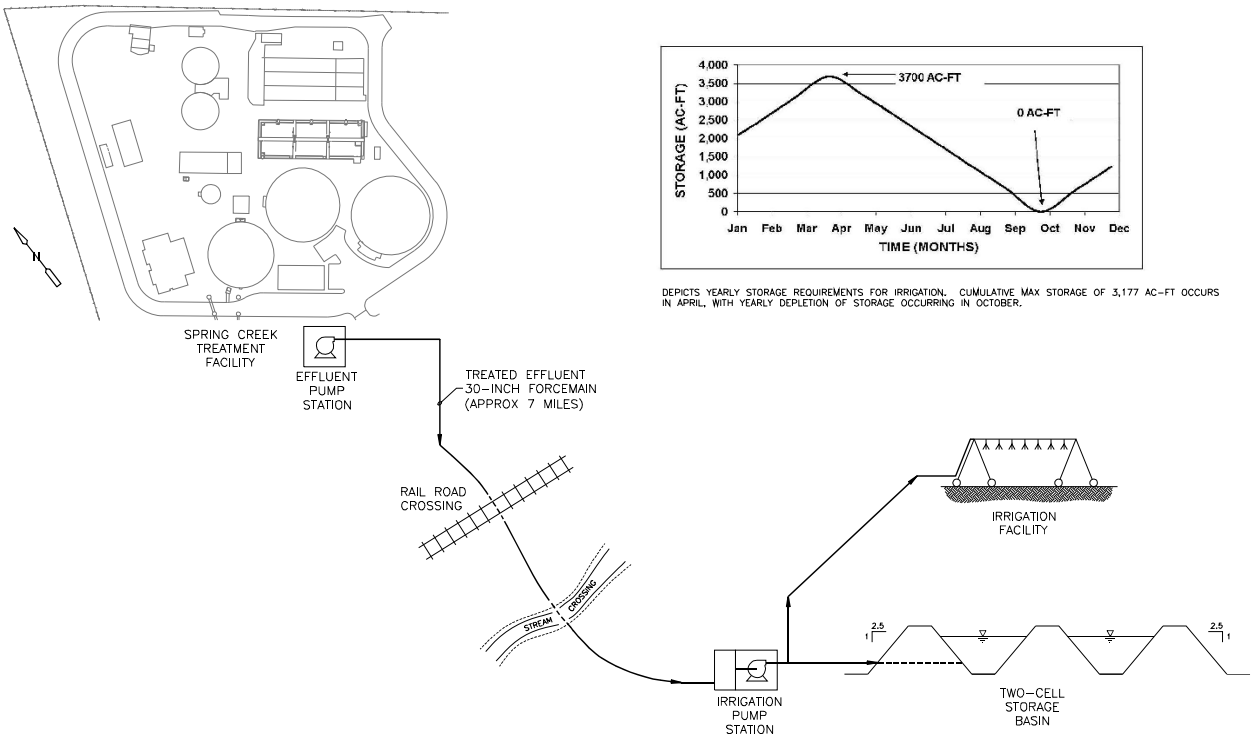


Figure 7.59 Schematic of Agricultural Irrigation/Winter Storage Alternative Effluent Pumping and Discharge Elements

7.6.3 Cost Comparison of Complete Alternatives

Total capital costs and O&M costs are compared in **Table 7.27** for both alternatives. The comparison shows a significant difference between both options, with the no river discharge option being more than twice the cost of the river discharge alternative.

Table 7.27 Cost of Implementation – Complete Alternatives(1)

	Total Capital Cost(2), Million US$		Annual O&M Estimate of upgraded facility if Operating in year 2011 $	
Improvement	**Alternative 1: River Discharge**	**Alternative 2: No Discharge**	**Alternative 1: River Discharge**	**Alternative 2: No Discharge**
1 to 12. Common Upgrades (Table 7.26)	60	60	491,000	491,000
15. New Aeration Basins	10	-	49,500	-
16. New Continuously Backwashed Sand Filters, single stage	8.7	-	74,400	-
17. Ultraviolet Disinfection	3.3	-	47,600	-
18. Hypochlorite Disinfection	-	3.4	-	19,400
19. Effluent Reaeration, final chemical injection and New Outfall	5.0	-	24,100	-
20. Storage Pond, Low Head Pumping Station and Irrigation Facilities	-	123	-	By tenant farmer
TOTAL, All Upgrades	$ 87 M	$ 186 M	$ 750,000/year	$ 510,000/year

Notes:

(1) Estimates reflect September 2008 economic indexes and conditions.

(2) Total Capital Cost includes site construction, concrete, metals, equipment, instrumentation and controls, electrical, mechanical, installation, field office overhead (10%), home office overhead (6%) estimator's contingency (30%), margin (10%), builder's all risk insurance (1%), liability insurance (2%), bond (2%), escalation to midpoint of construction (6%), and engineering and administration (25%).

7.6.4 Business Case Evaluation of Complete Alternatives

Detailed business case evaluations are commonly made when comparing alternatives to ensure that non-cost factors are included in the final selection process. In this case, the outcome of the TMDL ultimately resulted in only two viable plant-wide alternatives, for which the cost difference is so much that a business case evaluation is less meaningful and would not help in

the final recommendation. In other words, the non-economic factors would have to be significant to overcome a $100M difference and make the analysis favor the other alternative. Instead, the following factors further support the implementation of the river discharge alternative with advanced treatment:

- Getting out of the Klamath River and totally to land application could be more than three times the cost of locating a new effluent outfall
- The treatment train can be adapted to more advanced biological nutrient removal processes to help offset some costs of operation, such as aeration demands and phosphorus removal chemicals, for example. It is also adaptable to advanced nitrogen removal configurations or part of an overall reuse strategy should the need arise.
- The same treatment train used for phosphorus removal can be adapted to produce any class of reuse water in Oregon, including Class A.
- The filtration step can be used as pretreatment for meeting any future requirements for toxic organics, metals removal, and arsenic, which have been mentioned throughout the planning process but without clear indications.
- Long solids residence times (SRT) in aeration trains has been shown to enhance destruction or removal of endocrine disrupters/human growth hormones and other pharmaceuticals. The proposed conventional design provides more flexibility to adapt to such requirements than other, more aggressive processes which leave less room for expansion.
- The conventional treatment recommended is the most flexible for upgrading to more innovative processes in the future, should regional treatment, unexpected growth, increased wet weather flows, or very long SRTs be required in the future.
- Limiting the capital invested in effluent disposal allows time for technology to develop that might reduce the City's cost.

Overall, we are presenting Klamath Falls with the least risky path and set of processes.

7.7 Recommended Alternative

The recommended alternative to meet the long-term needs of the City is illustrated in **Figure 7.60**. The preliminary design information for the complete and upgraded 2030 facilities is listed in **Table 7.28** at the end of this section.

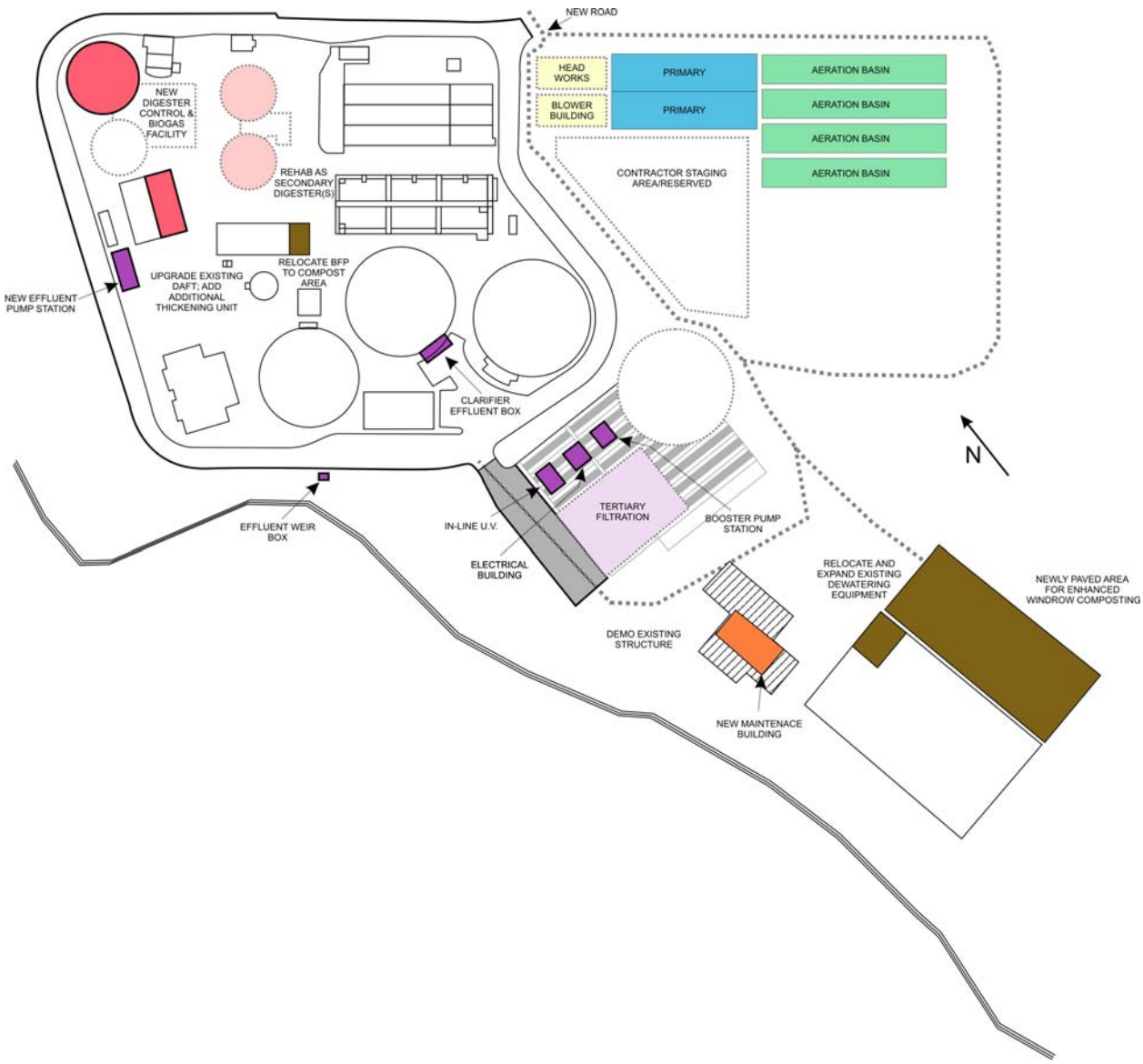


Figure 7.60 Recommended Treatment Plant Upgrades

7.7.1 Recommended Evaluations prior to Implementation

The recommendations above represent a conservative scenario for the City's planning purposes. A number of optimization measures should be evaluated during predesign. Risk analysis and discussions with DEQ on some alternatives would be beneficial. Suggested optimization measures:

Explore the possibility of a wet weather discharge to Lake Ewauna:

- Benefits: smaller effluent pumps stations, less power requirements, less power usage
- Cons: permitting with DEQ. Operating two outfalls. Existing outfall still requires diffuser upgrades.
- Actions: water quality modeling

Moving tertiary filtration after effluent evaporation at cogeneration facility

- Benefits: reduces hydraulic sizing on tertiary filtration and final disinfection by 3 mgd or more. Increases the chances of requiring only single stage filtration because effluent would need to meet 0.18 mg/L total P instead of 0.13 mg/L in year 2030, based on maximum allocation of 5 kg/day total P.
- Cons: permitting with DEQ and agreements with Cogeneration plant to ensure operation of cooling tower. Operation of tertiary filtration and final disinfection would be 7 miles from the main plant. May not be able to count on cooling towers operating continuously to evaporate the effluent.

Use final effluent piping as contact tank for chlorine disinfection

- Benefits: no need for UV disinfection on-site and minimizes regrowth in effluent piping
- Cons: relies on chemical for main disinfection and incompatible with wet weather (or emergency) discharge to Lake Ewauna (if allowed). Permitting with DEQ. May require additional chemical feed facilities being built for tertiary filtration since that space would not be available anymore.

Dry season nutrient removal

- Benefits: cuts at least in half tertiary filtration facilities needs (from 10.4 mgd to 5.2 mgd), more if tertiary filtration occurs downstream of final effluent evaporation at the cogeneration site (down to 2.2 mgd or less).
- Cons: permitting with DEQ and TMDLs

7.7.2 Recommended Alternative Design Data

Preliminary design data for the upgraded Spring Street STP facilities is provided in **Table 7.28**. Existing equipment data is included for comparison.

Table 7.28 Recommended Alternative Design Data

Item	Value	
	Existing Design Data(1)	**Year 2030**
Design Flow		
Maximum month, MGD	6(2)	10.4
Peak wet weather (PWWF), MGD	18(2)	22
Design Loads		
BOD Maximum month, ppd	11,000(2)	10,700
TSS Maximum month, ppd	11,000(2)	10,000
Headworks		
Influent Pumping Station		
Number of pumps	3	5 (new)
Capacity each, MGD	1@2.6 2@5.2	3 @ 3.5 2 @ 11.0
Pump station capacity (firm), MGD	7.8	22.0
Grit Removal		
Type	Channel	Vortex
Number of units	1	1
Length, feet	56	-
Depth, feet	5	-
Velocity at PWWF, fps	1	-
Diameter, feet	-	15
Screening		
Number of units	1	2
Type	In-channel, cylindrical	Chain-driven
Opening size, inch	0.25	0.25
Capacity each, MGD	9	18
Primary Clarification		
Clarifiers		
Type	Conventional	Conventional
Number of basins	2	2 (new)
Width, feet	1@ 37.5	38 (each)

Item	Value	
	Existing Design Data(1)	**Year 2030**
	1@ 18.0	
Length, feet	140	140
Average sidewater depth, feet	8.75	10.5
Surface overflow rate at PWWF, gpd/sf	2,300	2,100
Surface overflow rate at Max Month, gpd/sf	770	980
Primary Sludge Pumps		
Number of units	2	4
Type	Centrifugal	Progressive cavity
Capacity, gpm	200	200
Primary Sludge Grinders		
Number of units	-	2
Horsepower, Hp	-	5
Aeration Basins		
Main aeration tanks		
Total Design SRT, days	Not available	15
Number	1	4
Number of parallel trains	1	4
Total volume, MG	0.75	3.0
Sidewater depth, feet	14	18
Anaerobic/Anoxic cells		
Number of cells	2	8
Number of parallel trains	1	4
Number of mixers per cell	2	2
Type	Surface mixer	Surface mixer
Horsepower, each mixer	3	3

Item	Value	
	Existing Design Data[1]	**Year 2030**
Post aeration tanks		
Number	-	2 (existing aeration tanks, split in parallel trains)
Number of parallel trains	-	2
Total volume, MG	-	0.375
Sidewater depth, feet	-	14
Aeration System		
Type	Fine bubble	Fine bubble
Number of aeration blowers	3	5
Aeration blower capacity, each, scfm	1,000	3 @ 2,400 2 @ 1,000
Aeration blower horsepower, each	60	3@150 2@60
Mixed Liquor Recycle		
Number of pumps	1	2
Type	submersible	submersible
Capacity, mgd	12.0	12.0 (each)
Horsepower	15	25
WAS Pumps		
Number	3	3
Type	Rotary lobe	Rotary lobe
Capacity, each, gpm	88	88
Horsepower, each	5	5
Secondary Clarifiers		
Number of units	2	2
Diameter, feet	1@110 (No.2) 1@100 (No. 1)	1@110 1@100
Sidewater depth, feet	1@20 1@12	1@20 1@12

Item	Value	
	Existing Design Data[1]	**Year 2030**
Overflow rates		
Max Month, gpd/sf	660 (6 mgd) 760 (6 mgd)	1,100 (10.4 mgd) 1,300 (10.4 mgd)
50% of PWWF, gpd/sf	950 (9 mgd) 1,150 (9 mgd)	1,160 (11 mgd) 1,400 (11 mgd)
Weir		
length, feet	1@346 1@314	1@346 1@314
overflow rate at max month, gpd/ft	17,300 (6 mgd) 19,100 (6 mgd)	30,060 (10.4 mgd) 33,120 (10.4 mgd)
overflow rate at 50% of PWWF, gpd/sf	26,010 (9 mgd) 28,660 (9 mgd)	31,790 (11 mgd) 35,030 (11 mgd)
RAS Pumps		
Number	2 (clar No 2) 2 (clar No. 1)	2 (clar No 2) 2 (clar No. 1)
Type	centrifugal	centrifugal
Capacity, each, gpm	2,100	2,100
Horsepower, each	40 (No. 2) 25 (No.1)	40 (No. 2) 25 (No.1)
Sludge and Scum Collector		
Number	1 each clarifier	1 each clarifier
horsepower	0.5	0.5
Scum Pumps		
Number	1 each clarifier	1 each clarifier
Capacity, gpm	50	50
Horsepower	7.5	7.5
Tertiary Filtration Booster Pumps		
Number	-	3
Type	-	Vertical Can
Capacity, each, gpm	-	3@2,400 1@7,200

Item	Value	
	Existing Design Data(1)	**Year 2030**
Horsepower, each	-	2@15 1@40
Tertiary Filtration		
Number	-	10 quads
Type	-	Continuously backwashed, single stage
Capacity, each, gpm	-	200 gpm
Ferric Chloride Dosage	-	10 mg/L
Disinfection		
Number	1 basin	4
Type	Chlorine Contact	In-pipe UV, medium pressure
Capacity, each, mgd	18 mgd	5.2 mgd
Transmittance	N/A	55% transmittance
Final Effluent Pumps – On site		
Number	2 (cogen)	5
Type	Vertical	Vertical turbine
Capacity, each, gpm	3,500	3@3,500 2@7,700
Horsepower, each	250	3@ 50 2@ 800
Final Effluent Pumps – Off-site		
Number	-	4
Type	-	Vertical turbine
Capacity, each, gpm	-	3@3,500 2@7,700
Horsepower, each	-	3@50 2@800
DAFT Thickening		
DAFT		

Item	Value	
	Existing Design Data[1]	**Year 2030**
Number of units	1	2
Length, feet	41.5	41.5
Width, feet	7.5	7.5
Surface area, sf	250	250
Average WAS concentration, mg/L	1,400-2,200	2,500
Average WAS flow, gpm	66	66
Average WAS solids, lb/sf/hr	0.33	0.33
Peak WAS solids, lb/sf/hr	0.75	0.75
Thickened sludge concentration, percent	5	5
Minimum air: solids ratio	0.03	0.03
Recirculation/Pressurization System		
Recirculation pumps		
Number	2	2
Capacity, each, gpm	250	250
Horsepower, each	15	15
Air Compressors	2	2
Air Compressor		
Capacity, scfm	2.5	2.5
Air Compressor horsepower	1.5	1.5
Minimum pressure, psi	55 [75]	55 [75]
Pressurization tank		
Number	1	1
Volume, cuft	10	10
Detention time at 45 psi, min	1	1
Sludge Pumps		
Number	1 – Float 1-Bottom,	1 – Float 1-Bottom,
Type	Progressing cavity	Progressing cavity
Capacity, each, gpm	100 [10 to 50?]	100 [10 to 50?]
Horsepower, each	10	10
Gravity Thickener (standby)		

Item	Value	
	Existing Design Data[1]	Year 2030
Number	1	-
Diameter, feet	24	-
Sidewater [sidewall?] depth, feet	10	-
Volume, gallons	33,840	-
Detention time at 200 gpm feed rate, hours	2.8	-
Solids Stabilization		
Anaerobic Digester		
Number	1	3
Type	Mesophilic	Thermophilic
Temperature, F	98	98-135
Diameter, feet	50	50
Center depth, feet	26.5	1@26.5 1@25.5 1@ 25
Volume, gallons	299,000	1@299,000 1@289,000
Detention time, days	12	10-15
Heating	Geothermal and Natural gas	Geothermal and Biogas
Mixing pumps		
Number	1	1 per digester
type	Centrifugal	Rotamix system
capacity, gpm	400	N/A
Horsepower	10	2@30 1@50
Sludge storage		
Type	Digester Volume	Digester Volume
Available volume, gallons	529,000	979,000
Storage time at annual average flow, days	23	31
Digested Sludge Pumps		
Number	1	2

Item	Value	
	Existing Design Data(1)	**Year 2030**
Type	Plunger	Plunger
Capacity, each, gpm	100	100
Horsepower, each	5	5
Biogas Treatment (Minimum)		
Type	-	H_2S Scrubber
Capacity, scfm	-	60
Sludge Dewatering		
Belt Filter Press		
Number of units	1	2
Belt width, meters	1.5	1.5
Washwater pumps		
Number	2	2
type	Centrifugal	Centrifugal
Capacity, gpm	40	40
Horsepower	5	5
Polymer Feed		
Polymer type		tbd
Number of pumps	2	2
Capacity, each, gph		tbd
Biosolids Final Stabilization and Composting		
Lagoon		
Total area, square feet	17,500	-
Average depth, feet	5	-
Drying beds		
Total area, square feet	11,250	-
Composting		
Type	Windrow	Enhanced Windrow
Feed Hopper Conveyor		
Number	1	1

Item	Value	
	Existing Design Data(1)	**Year 2030**
Capacity, lb/h		
Horsepower		
Trommel Screen		
Number	1	1
Capacity, lb/h		
Horsepower		
Waste Conveyor		
Number	1	1
Capacity, lb/h		
Horsepower		
Finished Product Loader		
Number	1	1
Capacity, lb/h		
Horsepower		
Stormwater Pump Station		
Pumps		
Number	4	4
Type	Centrifugal	Centrifugal
Horsepower, each	2@10 2@30	2@10 2@30
Plant Water Pumps		
Number	2	4
Type	Centrifugal	Centrifugal
Capacity, each, gpm	250	500
Horsepower, each	15	25
Standby Generator		
Number	1	1
Capacity, kW	500	500

Notes:

(1) From sheet G-9 Design Data, *Spring Street WWTP Reliability Improvements* design drawings, March 2000.

(2) These numbers from sheet G-9 Design Data (note 1). Recorded average flows and loads were as follows over 2002-2006 (see Section 5 for more details):

a. Maximum month flow = 5.4 mgd
b. Peak wet weather = not available; current pumping and flow meter limited at 14.6 mgd
c. Maximum month BOD = 5,700 lb/day
d. Maximum month TSS = 5,300 lb/day

Section 8
Biogas Management

Biogas management and planning requires different considerations than those of the liquid stream and solid stream management processes. Unlike the other process streams, biogas has a quantifiable economic value associated with it that plays a key role in its application and utilization. Further, biogas management is not typically included within a facilities plan. The standard facilities plan outline provided by the Oregon DEQ makes no provisions for a biogas management section. However, increased concern over greenhouse gas emissions, escalating energy prices, and the high energy potential of biogas have caused facilities to scrutinize their biogas management practices more carefully and begin to include biogas management as an operational consideration. The City of Klamath Falls identified biogas management at the Spring Street STP as a point of interest and a key area to consider in facilities planning. CDM has included this section on biogas management in the facilities plan to aid Klamath Falls in its decision-making process regarding its biogas production. The level of detail and the structure of this section differs from the liquid stream and solid stream sections to address the issues and considerations specific to biogas management. Cost estimates in this section were developed to the planning level based on CDM's experience and rules of thumb and are intended to be relative in nature. Quotes were fielded for major equipment pieces only to confirm pricing structures.

To provide Klamath Falls with the necessary information to make an informed decision regarding biogas management at Spring Street, a preliminary evaluation of the biogas system has been made including the following:

- Existing Biogas System
- Energy Profile
- Alternatives Description
- Biogas Energy Value
- Recommendation

8.1 Existing System

Biogas is a byproduct of the anaerobic digestion process. The gas typically contains between 55 to 65 percent methane and 35 to 45 percent carbon dioxide by volume. Biogas also contains other trace impurities such as siloxanes, hydrogen sulfide and moisture. The large methane content within biogas makes it a valuable energy source and a useful fuel for many wastewater treatment plants. Biogas utilization applications include boiler fuel for plant and digester heating, combined heat and power production (cogeneration), fuel for sludge drying, and cleaning to natural gas (biomethane) quality for resale or compression/liquefication for use as vehicle fuel.

Biogas at Spring Street is generated on-site within the two anaerobic digesters, which are part of the solids stabilization process. Monthly biogas production rates for the year 2007 are contained in **Table 8.1** below. Previously, biogas had been used to fuel a firetube boiler and was the primary heat source for the plant and digesters, with the City's geothermal system on standby. This practice was halted due to excessive corrosion and operational difficulties caused by the hydrogen sulfide in the biogas. While gas treatment or an operational modification could have been implemented to improve the biogas-fueled boiler operation, the City decided to make the geothermal system the primary plant heat source and to suspend biogas boiler operation. The boiler remains on site in poor condition and is fired with natural gas two to three months a year to provide supplemental and backup digester heating. Under current operations, all biogas produced at the Spring Street STP is flared with none captured for beneficial use.

Table 8.1 Spring Street STP Monthly Biogas Production (2007)

Period	Average ft^3/day
January	43,600
February	46,800
March	45,800
April	46,400
May	46,500
June	43,100
July	42,400
August	41,100
September	39,600
October	34,100
November	39,300
December	41,400
Yearly	42,500

Spring Street had its biogas tested in May 2005 for common constituents; the results of this test are depicted in **Table 8.2**. All measured values and constituents were typical of biogas. The test did not measure the siloxane content of the biogas. Siloxanes are an emerging constituent of concern due to the glassy precipitates they can leave on the surface of equipment after combustion. Prior to developing any major biogas utilization upgrades, it is recommended that Spring Street begin a more regular biogas testing program that includes periodic tests for siloxane content. Regular and accurate biogas data will aid the design process and will ensure that appropriate equipment protection is provided; this will in turn reduce operational and maintenance costs.

Table 8.2 Spring Street STP Biogas Data (2005)

Component	Volume (%)	Mass (%)
Methane	57.8	33.9
Carbon Dioxide	39.0	62.7
Hydrogen Sulfide	0.12	0.15
Heating Value, BTU/ ft³		
Low Heating Value (LHV)	528	
High Heating Value (HHV)	586	

*The values depicted above are the average values for two separate tests

Based on a low heating value of 528 BTU/ ft^3 and an average daily flow of 42,500 ft^3, the biogas at the Spring Street facility represents approximately 275 kW of fuel (kWfuel). Treatment and conversion of the biogas could generate 175 gasoline gallon equivalents/day (GGE/day), 95 kW of electricity (kWe) or 220 kW of thermal energy (kWth).

However, based on CDM's experience and standard guidelines, there is reason to suspect that the biogas production data for Klamath Falls is inaccurate. Plant operational data indicates an average volatile solids destruction of 60.7 percent through the anaerobic digestion process in 2007. Typical volatile solids destruction rates for mesophilic digestion range between 50 and 55 percent. The poor heating and mixing within the existing digesters would likely limit the solids destruction to below 50 percent. Further, biogas is assumed to be generated at a rate of 15 cubic feet per pound of solids destroyed. Based on the Klamath Falls data, it is achieving just 11 cubic feet per pound of solids destroyed. This information suggests that the biogas production numbers may not be accurate and that the sampling and measuring methodology should be evaluated for accuracy.

Current deficiencies for biogas utilization would mainly be related to the following:

- No beneficial end use for a valuable energy source
- Continued reliance on external energy sources
- Increased pollutant and greenhouse gas air emissions from fossil fuel consumption
- Limited biogas testing data
- Inaccurate biogas production data (volatile solids destruction and flow measurement)

8.2 Energy Profile

An effective biogas management plan will correctly describe a facility's existing energy demands and resources, forecast future conditions, and identify potential areas of improvement. Typically, to facilitate this effort, a plant-wide energy profile is plotted, depicting energy demands and resources in common terms. At Spring Street, the energy profile includes electricity, natural gas, and geothermal energy purchases, as well as biogas production.

8.2.1 Background

8.2.1.1 Existing Demand

According to operational data and billing statements, the average electrical demand at Spring Street was 270 kWe in 2007. The average plant heat demand was 180 kWth[1], including 60 kWth for the anaerobic digesters. Unfortunately, peak electrical and heat demands were not available from Spring Street. Based on operational data from similar plants, the peak demands are estimated to be twice the average demand. The sum of natural gas, geothermal, and electrical purchases was approximately $190,000 in 2007. Geothermal is an internal cost to the City and totaled $29,500 in 2007.

8.2.1.2 Existing Energy System

The heat and electrical needs at Spring Street are currently met through City-owned and private utilities. Electricity is supplied by PacifiCorp Power Marketing (PPM). Heat demands are met primarily through the City-owned Klamath Falls Geothermal Utility. The Spring Street STP does not have a dedicated geothermal line; thus, when the geothermal system is down for maintenance, plant spaces are not heated, and the digesters are heated with a natural gas supplement in a firetube boiler. Natural gas is purchased from Avista Utilities.

8.2.1.3 Potential for Improvement

The substantial energy demands at the Spring Street facility, coupled with the available and unused biogas, suggest the potential to improve the Spring Street biogas management system. Improvements could provide greater system reliability, increased heat and electrical capacity, cost effectiveness, and beneficial use of biogas. A number of technologies are available that would enable the Spring Street facility to effectively and economically utilize its available biogas. These technologies include new biogas boilers, power generating systems, and biomethane systems, including the production of vehicular fuel. Each technology would be coupled with the appropriate biogas treatment technology, as needed, in order to ensure consistent and viable operation. As such, the City was approached to install photovoltaic solar panels, which would supply power to the Spring Street Facility under a long-term net-metering agreement. The impact of such an implementation will need to be revisited as biogas utilization alternatives are refined.

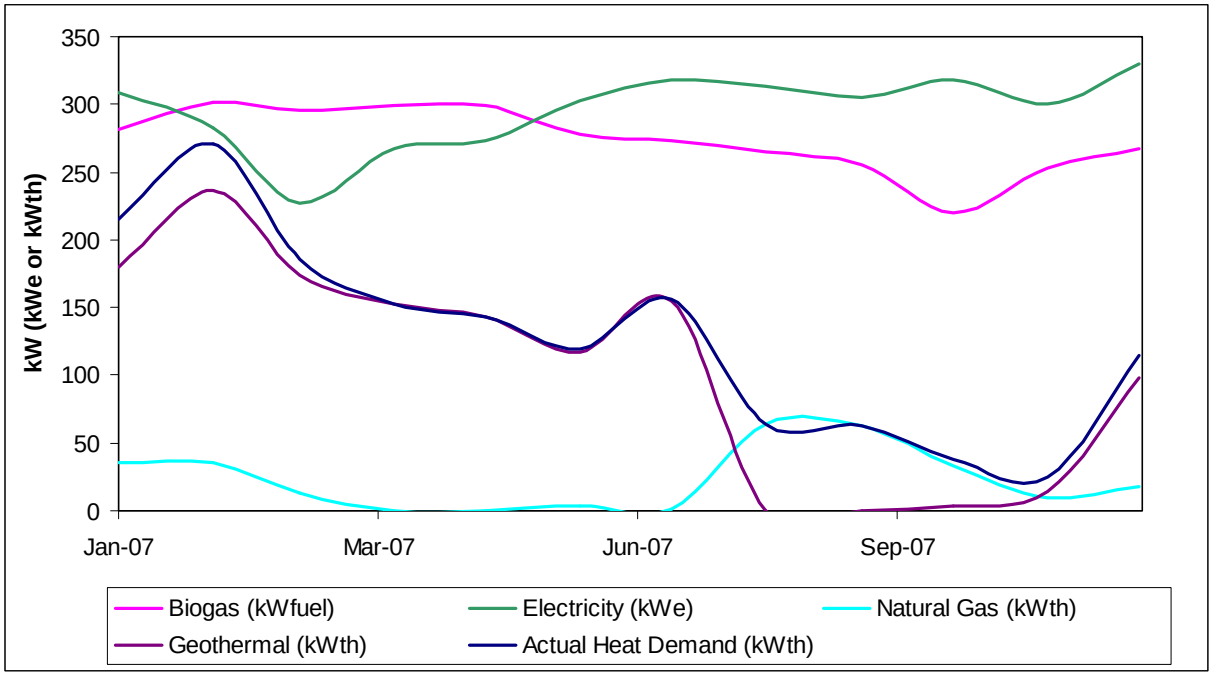
8.2.2 Current Yearly Demand

8.2.2.1 Energy Profile

In order to illustrate broad trends at Spring Street, **Figure 8.1** was developed. **Figure 8.1** graphs the energy profile at Spring Street, including the biogas production rate, the electrical, natural gas and geothermal purchases, and the estimated heat demand at the facility during 2007. The estimated heat demand was taken as the sum of geothermal and natural gas purchases. Biogas is depicted by its raw energy value (kWfuel). To convert the biogas energy into a usable form, system efficiencies would need to be applied. These efficiencies vary by technology. For instance, boilers typically operate at 75-80 percent efficiency, while combined heat and power (cogeneration or CHP) systems operate between 35-40 percent efficiency for electricity

[1] Average plant heat demand was based on the average heat demand from January to July when the geothermal system was available.

generation and 40-45 percent for heat generation. Biomethane scrubbing systems that clean the biogas to natural gas quality operate at 90-96 percent efficiency.



*Graph depicts monthly averages and is not intended to represent peak demands and peak productions.

Figure 8.1 Spring Street WWTP Energy Profile 2007

The energy profile depicted in **Figure 8.1** indicates that the energy demands and resources at Spring Street are significant. Further, the electrical and heat demands are shown to fluctuate throughout the year. The fluctuation in demand is largely due to seasonal variations in flows, loads, and ambient temperature; however, the most pronounced variation in heat demand is a result of the geothermal system being shut down from August through October. Spring Street does not have a dedicated geothermal line; thus, when yearly maintenance is performed on the geothermal system, the facility must purchase natural gas to heat the digesters while facility spaces are allowed to cool and plant staff must adjust to cooler facilities. The most effective operation would allow Spring Street facility to use the geothermal system year round in order to maintain space heating and limit natural gas purchases.

8.2.2.2 Biogas Energetic Capacity

The energy profile also illustrates that there is, on average, approximately 275 kWfuel of biogas available for other uses. This amount of biogas is commensurate with the other energy demands at the facility and further supports an exploration of appropriate utilization technologies. Applying the system efficiencies previously discussed, **Table 8.3** was developed in order to quantify the potential capacities of the utilization alternatives.

Table 8.3 Biogas Utilization Alternatives

System	Conversion Efficiency	Output, 2007	Units
Cogeneration			
Electricity	35%	95	kWe
Heat	40%	110	kWth
Boiler			
Biogas Boiler	80%	220	kWth
Biomethane			
Re-Sale	90%	245	kW
Vehicle Fuel	90%	175	GGE/day[1]

[1] GGE or Gasoline Gallon Equivalent is the energy equivalent of 1 gallon of gasoline: 114,100 BTUs/gallon

Note that the systems explored above could be installed in concert with one another. A common installation will pair a cogeneration system with biogas boilers in which the biogas is preferentially sent to the boiler and surplus gas is used to power the cogeneration system to maximize the systematic energetic efficiencies. Other utilization pairings are possible, such as pairing a boiler with vehicle fuel production or a cogeneration system with biomethane re-sale.

To aid comparison and to further support this biogas management study, the anticipated energetic output of the biogas utilization technologies have been compared against the average demands for the year 2007. **Table 8.4** below illustrates the percent of average demand that could be supplied by the available biogas in relative terms. **Table 8.4** is not intended to capture operations during peak demand and does not address other operational issues such as supply and demand matching and biogas storage. **Table 8.4** is intended for comparison purposes only.

Table 8.4 Alternative Comparison

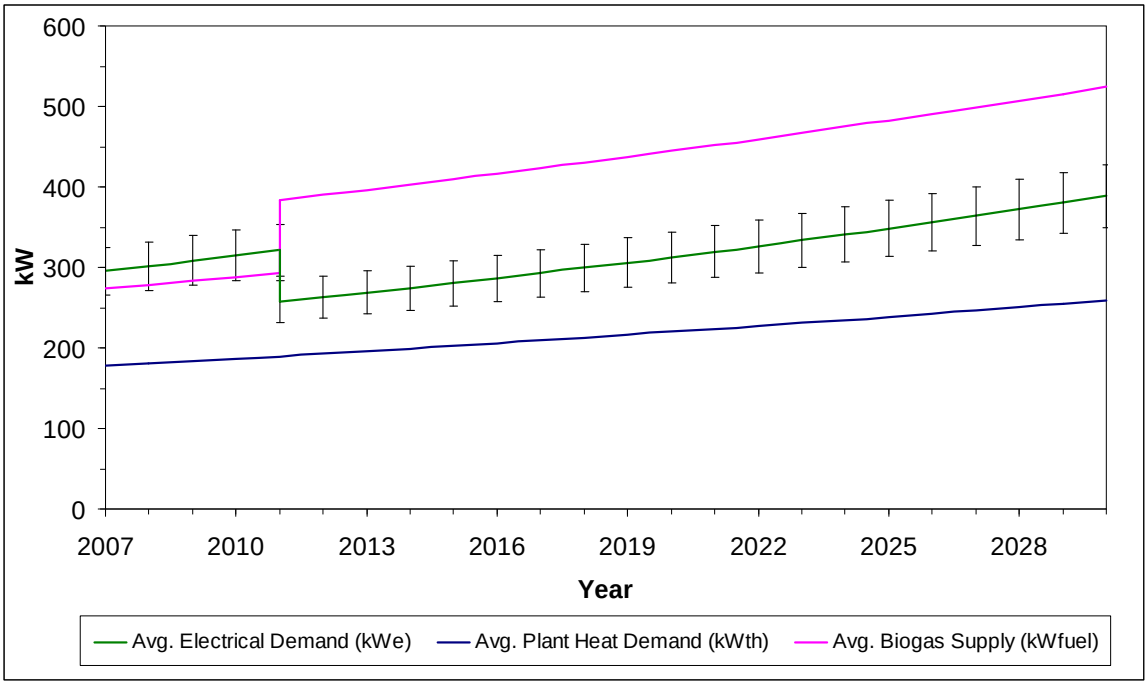
System	Output	2007 Avg. Demand	Units	Avg. Demand Supplied
Cogeneration				
Electricity	95	295	kWe	32%[1]
Heat	110	180	kWth	61%[2]
Boiler				
Biogas Boiler	220	180	kWth	122%[3]
Biomethane				
Re-Sale	245	25	kW	980%[4]
Vehicle Fuel	175	N/A[5]	GGE/day	N/A[5]

[1] Percent based on cogeneration electrical output and average electrical demand for 2007.
[2] Percent based on cogeneration heat output and average plant heat demand for January through July 2007.
[3] Percent based on biogas boiler heat output and average plant heat demand for January through July 2007.
[4] Percent based on biomethane production and average natural gas demand for 2007. Peak month natural gas demand was 64 kW.
[5] At the time of writing, vehicle fuel demands at Spring Street were not available.

The information depicted in **Table 8.4** suggests that the available biogas could be used to meet a substantial portion of the energy needs at Spring Street.

8.2.3 Future Energy Demand

Over the next 20 years, heat demands at Spring Street are expected to increase linearly as the result of service population growth and process modifications. Power demands are expected to decrease initially after new, more efficient facilities (pumps, blowers, etc.) are constructed, then continue a linear increase. Specific process modifications, such as energy conservation measures or effluent pumping have the potential to drastically influence the power demand. To account for this variation, error bars have been added to the electrical power demand in **Figure 8.2**.



[1] Graph is not intended to capture operating conditions during peak demand.
[2] Average plant heat demand based on heat demand from January through July 2007

Figure 8.2 Projected Energy Profile

The projected biogas production is also anticipated to increase proportionally to the population growth; however, a single step increase is anticipated as a result of upgrading the existing digesters in 2011. Upgrading the existing digesters is expected to increase capacity, process stability, and process efficacy and thus also biogas production rates. Projected gas production rates are based on 55 percent volatile solids destruction and 15 cubic feet of biogas per pound of volatile solids destroyed; these are average values for well-functioning mesophilic digesters. Should Spring Street elect to decommission their digesters or delay upgrading them, which would continue their reliance on another biosolids stabilization method, the biogas production will change accordingly. Additionally, a major process modification, such as initiating

thermophilic digestion or co-digestion of organic waste with the plant's sludge, could result in a sharp increase in biogas production. Co-digestion of organic waste with sewage sludge can effectively double the volume of gas produced per unit volume of digestive capabilities. The Spring Street STP currently does not have the surplus digestion capacity or an identified waste source to initiate co-digestion.

8.2.4 Energy Profile Summary and Conclusions

Under current operations, Spring Street is not making good use of its biogas and has room to improve the geothermal system operations. Klamath Falls should investigate installing a dedicated geothermal line to the Spring Street STP to allow the facility to receive geothermal heating year-round, avoid natural gas purchases, and free the available biogas for other uses. Klamath Falls should also explore biogas utilization technologies to improve their energy system. Improvements could provide greater system reliability, increased heat and electrical capacity, cost effectiveness, and beneficial use of biogas.

The key findings developed during this energy profile analysis are as follows:

- Electrical and heat demands at Spring Street are substantial, and are expected to increase as the service population grows and process modifications are implemented.
- Average plant heat demand is expected to grow to 260 kWth and peak demand to 520 kWth by 2030.
- Average electrical demand is expected to grow to between 350 and 435 kWe by 2030.
- Spring Street could reduce natural gas and electrical purchases through the implementation of a biogas utilization technology. A power generating system would help to shave electrical purchase while a boiler system could help to limit natural gas purchases and provide redundancy to the geothermal system.
- Spring Street could reduce natural gas purchases by installing a dedicated geothermal line to the Spring Street STP that would provide geothermal heating year round.
- Vehicle fuel purchases could be limited by the implementation of a biomethane vehicle fueling system, which cleans biogas to natural gas quality and compresses it to 3,000 to 3,600 psi to use as fuel. This system would require that new vehicles are purchased or existing vehicles are modified to use the biomethane vehicle fuel.
- On average, enough biogas is available (275 kWfuel) to produce 95 kWe and 110 kWth in a cogeneration system, 220 kWth in a boiler system, 245 kW (200 therms/day) in a biomethane system and 175 gasoline gallon equivalents/day in a vehicle fuel system. The available biogas is expected to nearly double by 2030.
- The quantity, quality, and availability of biogas are directly related to the inclusion of functional digesters in the solids handling system

8.3 Alternatives Description

Based on the quantity of biogas available at Spring Street, CDM began the preliminary alternatives development for potential application and utilization at the facility. The alternatives were developed to address current and future conditions and site specific considerations such as the City-owned geothermal and cogeneration utilities. The City-owned utilities make operations at Spring Street unique as the money paid by the facility for energy, is paid back, at least in part, to the City. CDM was conscious of these considerations during the alternatives development and has made note of this where appropriate. The following alternatives were evaluated for the Spring Street facility:

Option 1: Flare

Option 2: Produce Heat with Biogas Boiler

Option 3: Power Generation

Option 4: Biomethane Generation – Sell Back

Option 5: Vehicle Fuel

A sixth option, a biogas sludge dryer, was investigated and dismissed as part of the composting and ultimate disposal section.

Option 1. Flare

Under this option, Spring Street would continue to flare all biogas produced on-site. This alternative requires no major capital or operational expenditure, but does not beneficially use the available biogas and continues to rely on external energy sources for electricity, heat, and vehicle fuel.

Option 2. Produce Heat with Biogas-Fueled Boiler

To provide backup heating for the plant and digesters and to address the poor condition of the existing boiler, a new boiler would be installed. The boiler would be biogas fueled and would have the capability to burn natural gas (dual fuel). Biogas treatment to remove hydrogen sulfide would be included within this option to protect the boiler equipment and prevent corrosion. The geothermal system would remain the primary heating system and would operate nine to twelve months a year, depending on the availability of the geothermal system. The biogas boiler would provide supplemental and backup digester and plant heating during the period that the geothermal system is unavailable. A photo of the existing biogas boiler is pictured to the right.

Option 3. Power Generation

In this option, Spring Street would generate electricity via a biogas fueled internal combustion engine, micro-turbine, or Stirling engine. The actual sizing of the system and the specific

generating equipment would be determined during a preliminary design. Preliminary evaluation suggests a 150 kWe system would be sufficient to accommodate future growth. A power generating system would reduce external electrical purchases, increase system reliability and decrease greenhouse gas emissions. Provisions for heat recovery were not included in this alternative due to the availability of the geothermal heat source in Klamath Falls, which minimized the economic value of heat recovery.

Option 4. Biomethane Generation – Sell Back

The production of biomethane requires the removal of the non-methane portion of biogas including moisture, particulates, hydrogen sulfide, siloxanes, and carbon dioxide yielding a gas equivalent to natural gas. Under this option, a hydrogen sulfide scrubber and pressure swing adsorption system or water scrubber would be installed in series to produce biomethane at Spring Street. The biomethane could then be sold back to the natural gas utility by tying into the nearest distribution header, or pressurized and piped to the City-owned cogeneration facility. Given the high cost of a dedicated pipeline to the Cogeneration facility, estimated at $3.1 to $5.1 million,[2] this alternative will look at the cost of generating the biomethane on site with a utility tie in. The sell back rate for biomethane is assumed to be equivalent to the retail rate due to the green energy credit of this source.

Option 5. Vehicle Fuel

Like the biomethane sell back, this alternative would generate biomethane on-site; however, the resultant gas would be compressed between 3,000 and 3,600 psi for use as vehicle fuel. The system would utilize compressed natural gas (CNG) storage vessels to enable the facility to store the excess fuel generated and to operate fast fill fueling stations. The use of CNG as a vehicle fuel requires the purchase of new CNG vehicles or modification/replacement of the existing vehicle's fuel tank and fuel delivery system. As the quantity of vehicle fuel that could be produced on site is substantial (approximately 175 GGE/day under 2007 conditions), the City would need to develop a sizeable CNG fleet either through the purchase of new vehicles or retrofitting the existing fleet. The development of a CNG fleet could be done gradually or by attrition and could be done on a variety of vehicles, including garbage trucks, city and school buses, and passenger vehicles. A photo of an installed system is pictured to the right.

8.4 Biogas Energy Value

To provide a basic economic comparison of each alternative, CDM estimated the biogas energy value for each utilization technology identified as an alternative at Spring Street. The value was determined by subtracting the cost of producing the energy product using biogas from the cost of purchasing the energy using the conventional fuel source or purchasing mechanism (i.e., the

[2] Construction cost estimate based on annual construction cost reporting done through FERC as provided in the Oil and Gas Journal's *Annual Pipeline Economics Report* and *Using Natural Gas Transmission Pipeline Costs to Estimate Hydrogen Pipeline Cost* (Parker, Nathan).

conventional method). Energy values were developed on a unit basis ($/therm$_{fuel}$) to provide Spring Street with a simple metric of valuing the available biogas.

For example, the net biogas energy value of vehicle fuel is $1.88/therm$_{fuel}$. Spring Street currently produces 81,900 therm$_{fuel}$/year in the form of biogas for a potential revenue and savings of $154,000/year. The biogas alternative with the largest net value is the alternative that will have the highest net revenue/savings or shortest payback period over the economic period assuming that the entire energy product is utilized.

The cost of production was developed as the sum of the amortized capital expenses and annual O&M expenses divided by the system size and multiplied by the system efficiency. Amortized capital costs assumed a bond financing structure with a 20-year period, 5 percent interest, and an inflation rate of 2.5 percent. The cost of the conventional fuel source was taken from the market rate and billing statements, and was multiplied by the appropriate system efficiency to yield consistent units.

The values developed here are general and relative estimates, and are intended to enable a first-cut, go/no-go analysis of various options for use of the biogas. The information developed here will be used in evaluating the identified alternatives.

8.4.1 Cost of Production Estimates

Capital and O&M estimates for the five identified alternatives were developed to the planning level based on CDM's design and operations experience and rules of thumb. Quotes were fielded for major equipment pieces in order to confirm previous pricing and estimating structures. The estimates provided here are relative in nature and are intended for comparison purposes only. The estimates are summarized in **Table 8.5** below.

Table 8.5 Cost of Production

Alternative	Size, kW	Capital Cost, $1,000	O&M, $/kWh	Cost of Production, $/therm$_{fuel}$
Flare	0	0	0	0.05
Boiler	300	390	0.007	0.39
Power Generation	150	675	0.020	0.55
Biomethane	500	1,100	0.025	0.65
Vehicle Fuel	500	1,200	0.034	0.91

8.4.2 Conventional Fuel Source Costs

The cost of the conventional fuel source was taken from historic billing statements and industry published data. To ensure a consistent comparison with the cost of production using biogas, the cost per unit energy of the conventional source was converted to the cost per unit of biogas fuel required to generate the energy product by multiplying by system efficiencies. **Table 8.6** summarizes the costs of conventional fuel sources below.

Table 8.6 Conventional Fuel Source Cost

Conventional Fuel Source	$/kWh	$/therm	Biogas Efficiency, %	Conventional Fuel, $/therm$_{fuel}$
Natural Gas Boiler(1)	0.070	2.06	80	1.65
Electric Provider	0.055	1.61	35	0.56
Natural Gas Provider	0.058	1.35	90	1.22
Retail Vehicle Fuel	0.106	3.10	90	2.79

(1) The biogas boiler was compared against a natural gas boiler assuming the geothermal system will remain the primary heat source and the existing boiler requires replacement due to deterioration and projected growth

8.4.2.1 Biogas Value Summary

Figure 8.3 summarizes the unit costs of production and of the conventional fuel source, as well the net biogas energy values for the identified alternatives.

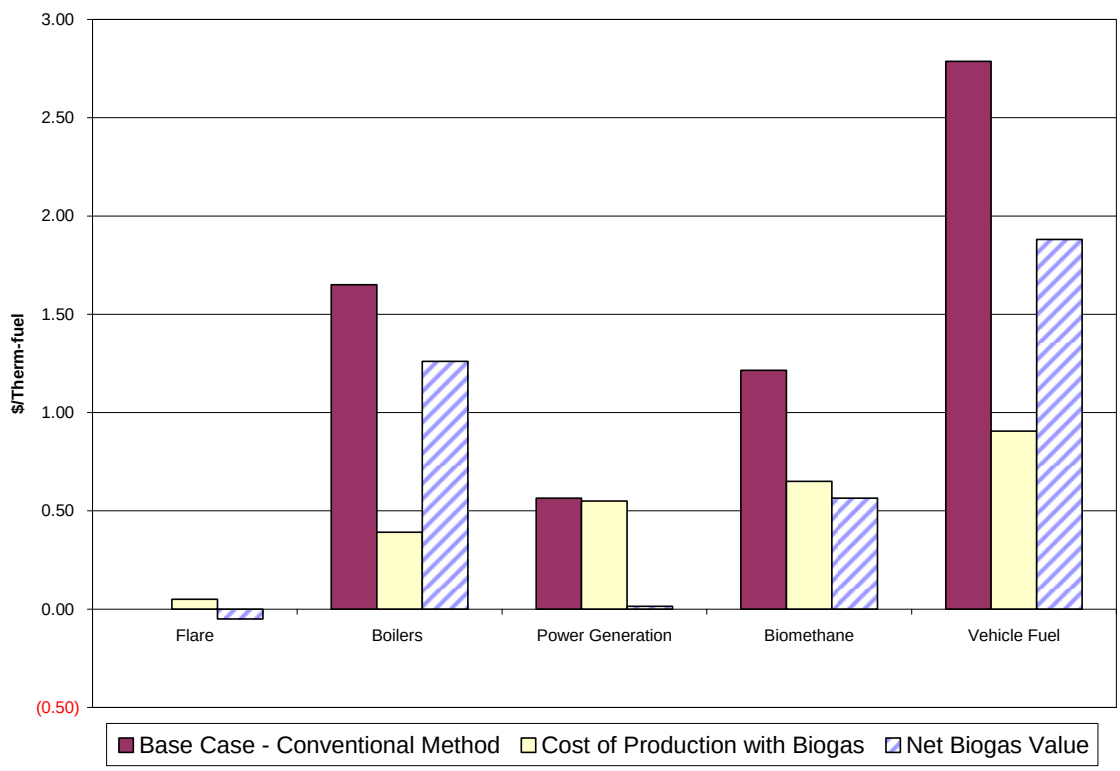


Figure 8.3 Biogas Value Summary

The following conclusions can be made based on the biogas value and the discussion above:

- The end product with the highest value is vehicle fuel for retail sale. However, to fully realize this value, a CNG vehicle market or fleet would need to be developed.
- The next highest value is burning biogas in boilers to provide secondary and supplemental heating when the geothermal system is unavailable. However, because more biogas is

produced than can be utilized for secondary heating purposes, it is suggested that this alternative be paired with another utilization alternative to make full use of the available biogas.

- Biomethane has a substantial economic value; although, its value is directly related to the purchasing agreement that can be negotiated with the utility.
- The generation of power on-site has a minimal economic value and is not suggested for further evaluation.
- Flaring biogas provides no economic benefit to Spring Street at this time.

8.5 Recommendation

Based on the site specific circumstances at Spring Street, including the City-owned geothermal utility, the poor condition of existing boiler infrastructure, and substantial biogas production, it is recommended that Klamath Falls begin the process for a full scale biogas management study.

The biogas value developed as part of this study suggests that numerous potential applications hold a positive economic value, including the installation of dual fuel biogas boilers, biomethane production for utility sell back, and vehicle fuel production. Based on the poor condition of the existing boilers, which require replacement, the need for supplemental heating when the geothermal system is unavailable, and the substantial economic value associated with utilizing the biogas for boiler fuel, it is recommended that the installation of a dual fuel boiler for plant and digester supplemental heating be considered the base case utilization method and additional utilization technologies be evaluated for implementation in concert with a new boiler.

It is recommended that the biomethane alternatives, sell back, and vehicle fuel production be investigated more fully during a comprehensive biogas management study. The biomethane alternatives have substantial economic values that do not interfere with the City utility structures and contribute to the City's stated goal of beneficially using the biogas resource.

The generation of vehicle fuel demonstrates a substantial economic value and potential at Spring Street. In addition to reducing fuel costs for the City, the use of biomethane as a vehicle fuel would also reduce pollutant and greenhouse gas emissions associated with vehicle operation. Further, it would help to distinguish Klamath Falls as a leader in energy management as it would be one of the first such installations in the Northwest. The comprehensive biogas management study would need to investigate the economics of purchasing or leasing equipment and the feasibility of converting a portion of the Klamath Falls vehicle fleet to operate on CNG with re-fueling at the Spring Street facility or distribution to another refueling location.

While the above recommendations are expected to require substantial capital and operational investments, the economic and environmental values of the projects are anticipated to be substantial enough to justify the expense. Federal and State grants and tax credits are available to support the project. The Oregon Energy Trust, Bonneville Energy Foundation Renewable

Energy Grant, and Federal Alternative Fuel Tax Credits have already been identified as potential funding opportunities.

The findings of this preliminary biogas management study have been summarized below:

- Klamath Falls and the Spring Street STP do not have a beneficial end use for the available biogas.
- Spring Street does not have a regular biogas testing protocol. It is suggested that the facility initiate regular biogas testing, including periodic tests for siloxanes, in order to provide adequate information in the design phase of a biogas utilization technology.
- The Spring Street facility requires an upgrade to the heating system including the replacement of the existing boiler.
- The City of Klamath Falls should investigate providing a dedicated geothermal line to the Spring Street STP to provide heat year round and to use biogas for other beneficial means.
- A number of biogas utilization alternatives have been identified as having a potential positive economic value:
    - The replacement of the existing boiler with a dual-fuel biogas boiler should be considered the base case biogas utilization alternative to be implemented in concert with another alternative.
    - The production of biomethane for either sellback or the production of vehicle has a positive economic value, which suggests the potential for application at Spring Street.
- It is recommended that Klamath Falls consider a comprehensive biogas management plan in order to fully develop the biogas utilization alternatives recommended above. This would include consideration of the impact of installing photovoltaic solar panels at the Spring Street site for power generation under a net metering agreement.
- Klamath Falls should investigate different Federal and State energy grants as part of its biogas management plan, including The Oregon Energy Trust and the Bonneville Energy Foundation grants.

The recommendations of this Biogas Management Section are intended to provide the City with a state-of-the-art facility that addresses increased concern over greenhouse gas emissions, escalating energy prices, and the high energy potential of biogas. **Figure 8.4** captures the recommendation in a graphic to facilitate discussion. The recommendation of this Section addresses known operational and mechanical deficiencies, such as the existing boiler heat system, while also identifying additional alternatives that hold a high economic and operational value, such as the production of biomethane or vehicle fuel. With its geothermal heat source and surplus biogas production, the City of Klamath Falls is in a unique position to address its

energy needs, and it is strongly recommended that the City initiate a detailed evaluation of its biogas management and utilization system.

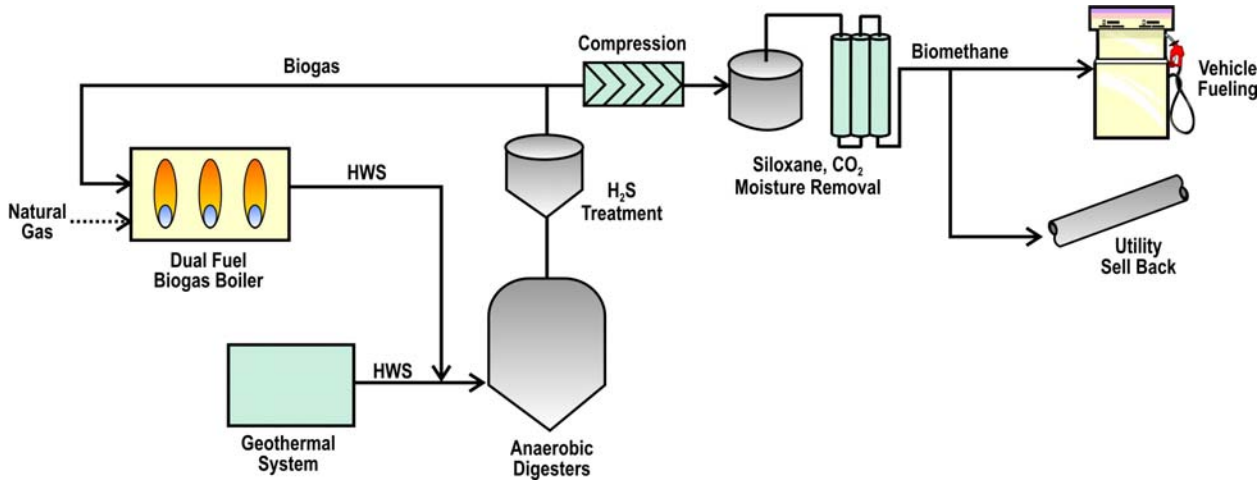


Figure 8.4 Schematic of the Recommended Biogas Management Plan

Section 9
Financial Plans for Alternatives

This Section of the Facilities Plan develops financial plans for the two proposed alternatives presented in **Section 7**. In addition, we provide an evaluation of feasibility of the alternatives using the Environmental Protection Agency's (EPA) affordability guidelines. The City's Spring Street STP serves the City of Klamath Falls, the Kingsley Field area, the Oregon Institute of Technology, the Running Y Resort, and the Pacific Klamath Energy Cogeneration Plant.

The City operates on an accrual basis of accounting under which revenues are recognized when earned, and expenses are recorded when an obligation has been incurred. The City operates under a fiscal year, which runs from July 1 through June 30. Fiscal years will be identified by their ending year, for example, FY 09 will refer to July 1, 2008, through June 30, 2009.

Methodology for Evaluation

Feasibility will be measured based on required rate increases needed to meet revenue requirements as well as determination of whether or not the average bill for a residential user would be more than 2 percent of their annual income. The EPA sets this threshold as a guideline of affordability.

Financial data used in the analysis presented herein were obtained from the following documents:

- City of Klamath Falls, Statement of Net Assets, June 30, 2008
- City of Klamath Falls, Rate Schedules
- City of Klamath Falls, Notes to Financial Statements, June 30, 2008
- Line Item Budget for FY 09, Adjusted Budget; FY 10 Projected; FY 11 Projected

Data in these documents were supplemented with information provided by City of Klamath Falls staff.

9.1 Existing Rates and Rate Methodology

The City charges for sewer services based on water usage. During April through November, sewer charges are based on the previous winter average water use. Sewer charges during December through March are based on actual water usage. New customers who do not have previous winter account usage are charged at a flat rate during the first non-winter months.

The City recognizes four sewer customer classes: single family-duplex, multi-family, commercial, and industrial. Sewer rates contain only a commodity charge. However, if monthly usage is less than 2 units, the customer will be billed a minimum 2 unit charge. One unit equals 100 cubic feet ("hcf"). The rate schedules in effect during FY 09 are presented in

Table 9.1. The average FY 09 rate is also shown and is used in this analysis. This average presumes that usage in the first 6 months is the same as usage in the second 6 months.

Table 9.1 Sewer Rate Schedule and Number of Accounts

Customer Class	2008 Rate, $/unit (b)	2009 Rate, $/unit	Average FY 09 Rate, $/unit	Number of Accounts
Single Family-Duplex	4.88	5.12	5.00	6,450
Multi-Family	3.79	3.98	3.89	211
Commercial	4.87	5.11	4.99	658
Industrial (a)	2.40	2.52	2.46	3

Notes:
(a) Strength charges are calculated on an individual basis.
(b) One unit equals one hundred cubic feet.

9.2 Projected Accounts and Annual Usage

Projected gross billings have been developed by applying the approved schedules of existing rates to projections of customer accounts and water sales. Projected customer accounts are based on forecasted annual growth of approximately 1.2 percent, and are presented in **Table 9.2**. Projected billable sewer volume is estimated based on the average usage per account times the projected customer accounts, and are presented in **Table 9.3**. The annual growth in estimated billed volume varies between 1.1 percent and 1.2 percent due to rounding.

Table 9.2 Projected Number of Accounts

Line No	Customer Class	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
1	Single Family-Duplex	6,527	6,605	6,684	6,765	6,846	6,928	7,011	7,095	7,180	7,267	7,354
2	Multi-Family	213	216	218	221	223	226	229	232	234	237	240
3	Commercial	665	673	681	690	698	706	715	723	732	741	750
4	Industrial	3	3	3	3	3	3	3	3	3	3	3
5	Total	7,408	7,497	7,586	7,679	7,770	7,863	7,958	8,053	8,149	8,248	8,347
6	Annual Growth		1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%	1.2%

Table 9.3 Projected Billable Sewer Volume

Line No	Customer Class	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
1	Single Family-Duplex	476,000	481,700	487,400	493,300	499,300	505,200	511,300	517,400	523,600	530,000	536,300
2	Multi-Family	110,200	111,800	112,800	114,400	115,400	117,000	118,500	120,100	121,100	122,700	124,200
3	Commercial	293,200	296,800	300,300	304,300	307,800	311,300	315,300	318,800	322,800	326,700	330,700
4	Industrial	65,600	65,600	65,600	65,600	65,600	65,600	65,600	65,600	65,600	65,600	65,600
5	Total	945,000	955,900	966,100	977,600	988,100	999,100	1,010,700	1,021,900	1,033,100	1,045,000	1,056,800
6	Annual Growth		1.2%	1.1%	1.2%	1.1%	1.1%	1.2%	1.1%	1.1%	1.2%	1.1%

9.3 Capital Improvement Financing

CDM identified two alternative designs for the Spring Street STP: Alt 1: Year-round River Discharge with Year-round Nutrient Removal and Alt 2: No River Discharge.

Table 9.4 and **Table 9.5** show the phased capital cost expenditures between FY 10 and FY 15 on an encumbrance basis, that is, the total cost of each project is shown in the year that design of the project is scheduled to commence. No capital is expected to be spent in FY 16 – FY 19 at this time. The costs shown in the tables reflect the estimated total costs of the various projects during the analysis period.

CDM anticipates that the CIP will be financed through future revenue bonds, future state revolving fund (SRF) loans, interest earnings, and available cash. **Table 9.6** and **Table 9.7** show the anticipated sources and uses of capital funds for the alternatives. CDM assumed that revenue bonds would be issued no more frequently than every two years. For Alt 1, CDM shows bond issues of $26 million in FY 10, $35 million in FY 12, and $3 million in FY 15. For Alt 2, CDM shows bond issues of $19 million in FY 10, $86.5 million in FY 12, and $80 million in FY 14. CDM presumes that the City will apply for SRF loans and annually request increases to the loan amount. The Oregon DEQ, which administers the SRF loan program, is forecasting maximum loan issues to any single agency of $4.8 million in 2009. Since available funding is determined each year, CDM has assumed that funding will be available each year in an amount similar to the current year.

Table 9.4 Alt 1 Capital Cost Phasing

Line No	Customer Class	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15
		$	$	$	$	$	$
1	Liquid Stream - IPS/Headworks Upgrades	1,500,000	4,400,000	1,500,000			
2	Liquid Stream - Primaries Upgrades	1,100,000	3,400,000	4,500,000	2,300,000		
3	Liquid Stream - Aeration Basins Upgrade	1,600,000	4,700,000	6,200,000	3,100,000		
4	Liquid Stream - Tertiary Treatment Addition - year round	900,000	2,600,000	3,500,000	1,700,000		
5	Liquid Stream - Effluent Disinfection Upgrade		300,000	2,000,000	1,000,000		
6	Liquid Stream - Effluent Piping Modifications	4,200,000	2,800,000				
7	Ancillary - Plant Water Pumps Upgrade	570,000					
8	Liquid Stream - RAS Pumps Upgrades				1,370,000		
9	Ancillary - Maintenance Building	1,330,000					
10	Liquid Stream - Effluent Pump Station - Onsite			1,000,000	2,000,000	2,000,000	
11	Effluent Discharge - Effluent Pump Station - Offsite			1,600,000	3,200,000	3,200,000	
12	Effluent Discharge - Outfall, Final Aeration, and Effluent Polishing			1,000,000	2,000,000	2,000,000	
13	Solids - Sludge Thickening Upgrades						3,260,000
14	Solids - Sludge Digestion Upgrades	300,000	1,300,000				4,700,000
15	Solids - Sludge Dewatering Upgrades			1,960,000			
16	Solids - Composting Area Upgrades			640,000			
17	Subtotal (Uninflated)	11,500,000	19,500,000	23,900,000	16,670,000	7,200,000	7,960,000
18	Subtotal (Inflated)	11,787,600	20,487,200	25,737,600	18,400,500	8,146,100	9,231,200

Table 9.5 Alt 2 Capital Cost Phasing

Line No	Customer Class	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15
		$	$	$	$	$	$
1	Liquid Stream - IPS/Headworks Upgrades	1,500,000	4,400,000	1,500,000			
2	Liquid Stream - Primaries Upgrades	1,100,000	3,400,000	4,500,000	2,300,000		
3	Liquid Stream - Aeration Basins Upgrade	600,000	2,200,000	1,700,000	1,100,000		
4	Liquid Stream - Effluent Disinfection Upgrade	300,000	1,000,000	1,400,000	700,000		
5	Liquid Stream - Effluent Piping Modifications	4,200,000	2,800,000				
6	Ancillary - Plant Water Pumps Upgrade	570,000					
7	Liquid Stream - RAS Pumps Upgrades					1,370,000	
8	Ancillary - Maintenance Building	1,330,000					
9	Liquid Stream - Effluent Pump Station - Onsite			1,000,000	2,000,000	2,000,000	
10	Effluent Discharge - Effluent Pump Station - Offsite			1,600,000	3,200,000	3,200,000	
11	Effluent Discharge - Winter Storage and Irrigation Facilities			12,300,000	49,200,000	49,200,000	12,300,000
12	Solids - Sludge Thickening Upgrades						3,260,000
13	Solids - Sludge Digestion Upgrades	300,000	1,300,000				4,700,000
14	Solids - Sludge Dewatering Upgrades			1,960,000			
15	Solids - Composting Area Upgrades			640,000			
16	Subtotal (Uninflated)	9,900,000	15,100,000	26,600,000	58,500,000	55,770,000	20,260,000
17	Subtotal (Inflated)	10,147,600	15,864,500	28,645,200	64,573,100	63,098,600	23,495,400

Table 9.6 Alt 1 Funding Plan

Line No	Description	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
		$	$	$	$	$	$	$	$	$	$	$
1	Beginning Fund Bal.	0	255,100	14,685,700	2,764,000	11,848,900	2,924,100	1,472,300	1,089,100	1,270,400	1,460,400	1,659,600
	Sources of Funds											
2	Transfer from Wastewater Fund	0	0	0	2,000,000	0	3,000,000	1,500,000	0	0	0	0
3	Connection Fee Revenue	250,000	126,300	127,500	128,800	130,100	131,400	132,800	134,100	135,400	136,800	138,200
4	Proposed Rev. Bond Proceeds	0	26,000,000	0	35,000,000	0	5,000,000	0	0	0	0	0
5	Proposed SRF Loan Proceeds	0	4,800,000	4,800,000	4,800,000	4,800,000	4,800,000	4,800,000	0	0	0	0
6	Grants/Contributions	0	0	0	0	0	0	0	0	0	0	0
7	Interest Income	5,100	339,400	358,000	298,100	278,500	88,800	109,100	52,600	60,200	68,200	76,600
8	Total Sources of Funds	255,100	31,265,700	5,285,500	42,226,900	5,208,600	13,020,200	6,541,900	186,700	195,600	205,000	214,800
	Uses of Funds											
9	CIP	0	11,787,600	20,487,200	25,737,600	18,400,500	8,146,100	9,231,200	0	0	0	0
10	Transfer to Wastewater Fund	0	0	0	0	0	0	0	0	0	0	0
11	Bond Issuance Expense	0	520,000	0	700,000	0	100,000	0	0	0	0	0
12	Bond Reserve Fund Requirement	0	2,500,700	325,000	3,253,800	325,000	743,400	325,000	0	0	0	0
13	Total Uses of Funds	0	14,808,300	20,812,200	29,691,400	18,725,500	8,989,500	9,556,200	0	0	0	0
	Fund Balance											
14	Net Annual Cash Bal.	255,100	16,457,400	(15,526,700)	12,535,500	(13,516,900)	4,030,700	(3,014,300)	186,700	195,600	205,000	214,800
15	Cumulative Fund Bal.	255,100	16,712,500	1,185,800	13,721,300	204,400	4,235,100	1,220,800	1,407,500	1,603,100	1,808,100	2,022,900

Table 9.7 Alt 2 Funding Plan

Line No	Description	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
		$	$	$	$	$	$	$	$	$	$	$
1	Beginning Fund Bal.	0	255,100	11,983,700	981,000	57,643,800	1,100,700	17,179,800	2,179,400	2,405,200	2,641,500	2,888,900
	Sources of Funds											
2	Transfer from Wastewater Fund	0	0	0	2,000,000	2,250,000	2,500,000	3,500,000	0	0	0	0
3	Connection Fee Revenue	250,000	126,300	127,500	128,800	130,100	131,400	132,800	134,100	135,400	136,800	138,200
4	Proposed Rev. Bond Proceeds	0	19,000,000	0	86,500,000	0	80,000,000	0	0	0	0	0
5	Proposed SRF Loan Proceeds	0	4,800,000	4,800,000	4,800,000	4,800,000	4,800,000	4,800,000	0	0	0	0
6	Grants/Contributions	0	0	0	0	0	0	0	0	0	0	0
7	Interest Income	5,100	244,800	259,300	1,172,500	1,174,900	365,600	387,200	91.700	100,900	110,600	120,700
8	Total Sources of Funds	255,100	24,171,100	5,186,800	94,601,300	8,355,000	87,797,000	8,820,000	225,800	236,300	247,400	258,900
	Uses of Funds											
9	CIP	0	10,147,600	15,864,500	28,645,200	64,573,100	63,098,600	23,495,400	0	0	0	0
10	Transfer to Wastewater Fund	0	0	0	0	0	0	0	0	0	0	0
11	Bond Issuance Expense	0	380,000	0	1,730,000	0	1,600,000	0	0	0	0	0
12	Bond Reserve Fund Requirement	0	1,914,900	325,000	7,563,300	325,000	7,019,300	325,000	0	0	0	0
13	Total Uses of Funds	0	12,442,500	16,189,500	37,938,500	64,898,100	71,717,900	23,820,400	0	0	0	0
	Fund Balance											
14	Net Annual Cash Bal.	255,100	11,728,600	(11,002,700)	56,662,800	(56,543,100)	16,079,100	(15,000,400)	225,800	236,300	247,400	258,900
15	Cumulative Fund Bal.	255,100	11,983,700	981,000	57,643,800	1,100,700	17,179,800	2,179,400	2,405,200	2,641,500	2,888,900	3,147,800

Line 1 of **Table 9.6** and **Table 9.7** show the beginning balance available for funding capital projects. Line 2 shows the transfers of available cash from the wastewater fund. These transfers are used to lower bond issues whenever possible. Line 3 shows the connection fee revenue, which is used to help fund a portion of the CIP as the CIP has a small, growth-related component. Line 4 shows the total amount of proposed bond issues used to finance a portion of the City's CIP. Line 5 shows proposed SRF loans of $4.8 million each year. Line 6 shows that CDM is assuming that grants will not be available. Interest earnings of 4 percent are anticipated to be earned on available balances within this set of construction funds, as shown on Line 7. Uses of funds are shown on Lines 9 through 12 and include the CIP, bond issuance expense, and bond reserve fund requirement[1]. Issuance costs are estimated at 2 percent of the bond issue.

9.4 Projected Revenue Requirements

The annual revenue requirements of the Spring Street STP consist of operating expenses for existing and proposed wastewater system facilities, debt service on all obligations issued by the City related to Spring Street STP, and projected transfers to the capital fund. Revenues must also be adequate to meet applicable rate covenants.

9.4.1 Operating Expenses

Operating expenses consist of all costs of the City necessary and appropriate for the operation, maintenance, and administration of the wastewater system during each year. Projections of operating expenses are shown in **Table 9.8**. For this evaluation, CDM assumed that O&M costs are the same for the two alternatives. Even though Alt 2 has a lower annual O&M as shown in **Section 7**, the difference represents only 6 percent of total O&M costs. The significantly higher capital costs of Alt 2 overwhelm any potential benefit from slightly lower O&M costs. Projections of operating expenses include labor, supplies, utilities, contractual services, collected system related costs, and new O&M related to process changes at Spring Street STP. Based on the City's budget and forecast, O&M costs are projected to decrease in FY 10 from FY 09. However, costs increase in FY 11 when the new systems come on-line. After FY 11, O&M expenses are anticipated to escalate at inflation.

[1] The bond reserve requirement, if any, is defined in the bond contract documents. For this study, CDM has assumed that a bond reserve fund will need to be created for each bond issue and that the fund requirement will equal the annual debt service (i.e. the principal and interest payments for one year).

Table 9.8 Operation and Maintenance Expenses

Line No	Description	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
		$	$	$	$	$	$	$	$	$	$	$
1	Salaries Regular	899,325	876,325	898,233	920,689	943,706	967,299	991,481	1,016,268	1,041,675	1,067,717	1,094,410
2	Salaries-Overtime	49,825	49,850	51,096	52,374	53,683	55,025	56,401	57,811	59,256	60,737	62,256
3	Benefits	452,625	505,225	517,856	530,802	544,072	557,674	571,616	585,906	600,554	615,568	630,957
4	Subtotal	1,401,775	1,431,400	1,467,185	1,503,865	1,541,461	1,579,998	1,619,498	1,659,985	1,701,485	1,744,022	1,787,622
	Maintenance &Operations											
5	Capitalized Personal Services	(5,000)	(5,000)	(5,125)	(5,253)	(5,384)	(5,519)	(5,657)	(5,798)	(5,943)	(6,092)	(6,244)
6	Communications	60,800	55,725	57,118	58,546	60,010	61,510	63,048	64,624	66,240	67,896	69,593
7	Supplies	271,625	337,575	346,014	354,665	363,531	372,620	381,935	391,484	401,271	411,302	421,585
8	Non-Capital Equipment	51,150	45,600	46,740	47,909	49,106	50,334	51,592	52,882	54,204	55,559	56,948
9	Maintenance & Repairs	205,850	153,775	100,747	103,266	105,847	108,493	111,206	113,986	116,836	119,757	122,750
10	Travel/Training	24,475	6,925	7,098	7,276	7,457	7,644	7,835	8,031	8,232	8,437	8,648
11	Printing/Marketing	17,500	9,025	9,251	9,482	9,719	9,962	10,211	10,466	10,728	10,996	11,271
12	Utilities	270,925	305,575	170,213	174,469	178,831	183,301	187,884	192,581	197,395	202,330	207,389
13	Professional Service Contracts	875,625	264,075	270,677	277,444	284,380	291,489	298,777	306,246	313,902	321,750	329,793
14	Other Material & Services	104,950	95,575	97,964	100,413	102,924	105,497	108,134	110,838	113,609	116,449	119,360
15	Internal Service Charges	888,725	1,011,675	1,036,967	1,062,891	1,089,463	1,116,700	1,144,617	1,173,233	1,202,564	1,232,628	1,263,443
16	Insurance	96,900	90,550	92,814	95,134	97,512	99,950	102,449	105,010	107,635	110,326	113,085
17	Vehicles	0	50,000	51,250	52,531	53,845	55,191	56,570	57,985	59,434	60,920	62,443
18	Wastewater Billing	23,725	22,625	23,191	23,770	24,365	24,974	25,598	26,238	26,894	27,566	28,256
19	New Plant Incremental O&M											
19a	Power			266,593	273,258	280,089	287,092	294,269	301,626	309,166	316,895	324,818
19b	Fuel			16,799	17,219	17,649	18,091	18,543	19,007	19,482	19,969	20,468
19c	Chemicals, Polymers, etc			191,456	196,242	201,148	206,177	211,332	216,615	222,030	227,581	233,271
19d	Contract Labor			22,500	23,063	23,639	24,230	24,836	25,457	26,093	26,745	27,414
19e	Labor: O&M & periodic act.			214,345	219,704	225,196	230,826	236,597	242,512	248,574	254,789	261,159
20	Transfers Out	0	8,425	8,636	8,852	9,073	9,300	9,532	9,770	10,015	10,265	10,522
21	Contingency	605,325	519,150	532,129	545,432	559,068	573,044	587,371	602,055	617,106	632,534	648,347
22	Subtotal expense	3,492,575	2,971,275	3,557,377	3,646,311	3,737,469	3,830,906	3,926,678	4,024,845	4,125,466	4,228,603	4,334,318
23	Total O&M	4,894,350	4,402,675	5,024,562	5,150,176	5,278,930	5,410,903	5,546,176	5,684,830	5,826,951	5,972,625	6,121,940
24	Average Percent Increase		-10.0%	14.1%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%

9.4.2 Debt Service Requirements

Projected debt service on outstanding bonds is shown on Line 1 of **Table 9.9** and **Table 9.10** for the study period. Existing debt service comprises the Series 2000 and 2005 Bonds and the SPWF -Klamath Falls industrial park. The Series 2000 Bonds are expected to be paid off in FY 10. The proposed bonds and loans are modeled to be issued half-way through the respective fiscal year. The revenue bonds have an assumed interest rate of 5.5 percent over a 20 year term. The SRF loans have an assumed interest rate of 3.08 percent and a term of 20 years, based on fall 2008 interest rates published by the Oregon DEQ SRF loan program. The SRF loans also carry a 0.5 percent annual fee on the unpaid balance of the loan.

9.5 Adequacy of Revenues to Meet Projected Revenue Requirements

Table 9.11 and **Table 9.12** present a statement of projected revenue and revenue requirements for wastewater operations for FY 09 – FY 19 for Alt 1 and Alt 2, respectively. These tables provide an indication of the adequacy of the City's revenues to meet annual costs, as well as the feasibility of the proposed bond issues for each alternative.

Line 1 shows the beginning wastewater fund balance. At the beginning of FY 09, approximately $2.3 million was in the fund. Line 2 shows the projected revenue under the existing rates for FY 09, which are the average of the rates in effect during the first half of FY 09 and the rates that became effective January 1, 2009. Lines 3 through 12 indicate the additional revenue needed to meet projected revenue requirements in each fiscal year. Lines 14 through 18 summarize other operating and non-operating revenue, including TMDLs at 8 percent of total rate revenue, effluent cost and fee revenues as projected by the City, and interest income.

Line 20 shows the total O&M expense, and is consistent with Line 23 on **Table 9.8**. Lines 22 through 26 show the existing and proposed debt service. Line 30 shows the total revenue requirements. **Figure 9.1** and **Figure 9.2** compare the annual O&M and capital requirements versus revenue under existing rates and revenue under proposed rates for the alternatives. The figures show that additional revenue is required to meet annual operating and debt service costs. For some of the years, the proposed revenues are not quite enough to offset operating and debt service. However, the operating fund balance is sufficient to overcome that deficit.

Lines 34 – 37 of **Table 9.11** and **Table 9.12** show the debt service coverage calculation. Debt service coverage is the ratio of revenues less expenses to the annual debt service. Line 37 shows that the assumed minimum coverage of 120 percent is obtained each year of the study period.

Table 9.9 Alt 1 Summary of Existing and Projected Debt Service

Line No	Description	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
		$	$	$	$	$	$	$	$	$	$	$
1	Existing Debt Service	894,600	894,100	937,600	942,400	941,200	885,800	883,000	867,400	866,300	864,100	870,600
	Estimated Future Debt Service Payments											
2	Series 2010 Bond		1,087,900	2,175,700	2,175,700	2,175,700	2,175,700	2,175,700	2,175,700	2,175,700	2,175,700	2,175,700
3	Series 2012 Bond				1,464,400	2,928,800	2,928,800	2,928,800	2,928,800	2,928,800	2,928,800	2,928,800
4	Series 2014 Bond						209,200	418,400	418,400	418,400	418,400	418,400
5	SRF Loan	0	208,728	715,459	1,067,344	1,418,431	1,768,698	2,118,117	2,281,049	2,281,495	2,281,954	2,282,427
6	Total	894,600	2,190,728	3,828,759	5,649,844	7,464,131	7,968,198	8,524,017	8,671,349	8,670,695	8,668,954	8,675,927

Table 9.10 Alt 2 Summary of Existing and Projected Debt Service

Line No	Description	FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
		$	$	$	$	$	$	$	$	$	$	$
1	Existing Debt Service	894,600	894,100	937,600	942,400	941,200	885,800	883,000	867,400	866,300	864,100	870,600
	Estimated Future Debt Service Payments											
2	Series 2010 Bond		795,000	1,589,900	1,589,900	1,589,900	1,589,900	1,589,900	1,589,900	1,589,900	1,589,900	1,589,900
3	Series 2012 Bond				3,619,200	7,238,300	7,238,300	7,238,300	7,238,300	7,238,300	7,238,300	7,238,300
4	Series 2014 Bond						3,347,200	6,694,300	6,694,300	6,694,300	6,694,300	6,694,300
5	SRF Loan	0	208,728	715,459	1,067,344	1,418,431	1,768,698	2,118,117	2,281,049	2,281,495	2,281,954	2,282,427
6	Total	894,600	1,897,828	3,242,959	7,218,844	11,187,831	14,829,898	18,523,617	18,670,949	18,670,295	18,668,554	18,675,527

Table 9.11 Alt 1 Adequacy of Projected Revenues to Meet Projected Revenue Requirements

Line No.	Description				FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
					$	$	$	$	$	$	$	$	$	$	$
1	Beginning Fund Balance				2,348,800	1,425,608	1,738,780	2,370,821	1,374,678	2,715,446	1,474,448	1,566,331	3,460,982	5,476,087	7,623,133
	Revenue														
2	Revenue Under Existing Rates				4,432,600	4,485,200	4,535,100	4,590,800	4,642,100	4,695,300	4,751,600	4,805,800	4,860,700	4,918,300	4,975,600
	Additional Revenue Required:														
	FY	Percent	Months Effective												
3	2010	62.50%	6			1,401,600	2,834,400	2,869,300	2,901,300	2,934,600	2,969,800	3,003,600	3,037,900	3,073,900	3,109,800
4	2011	24.00%	6				884,300	1,790,400	1,810,400	1,831,200	1,853,100	1,874,300	1,895,700	1,918,100	1,940,500
5	2012	25.00%	6					1,156,300	2,338,500	2,365,300	2,393,600	2,420,900	2,448,600	2,477,600	2,506,500
6	2013	14.00%	6						818,500	1,655,700	1,675,500	1,694,600	1,714,000	1,734,300	1,754,500
7	2014	0.00%	6							0	0	0	0	0	0
8	2015	5.00%	6								341,100	690,000	697,800	706,100	714,300
9	2016	0.00%	6									0	0	0	0
10	2017	0.00%	6										0	0	0
11	2018	0.00%	6											0	0
12	2019	0.00%	6												0
13	Total Revenue From Rates				4,432,600	5,886,800	8,253,800	10,406,800	12,510,800	13,482,100	13,984,700	14,489,200	14,654,700	14,828,300	15,001,200
14	TMDLs				354,608	470,900	660,300	832,500	1,000,900	1,078,600	1,118,800	1,159,100	1,172,400	1,186,300	1,200,100
15	Other Revenue				3,100	485,600	489,100	489,700	490,400	493,600	497,800	502,000	507,000	512,000	517,100
16	Impact Fee Revenue				250,000	126,300	127,500	128,800	130,100	131,400	132,800	134,100	135,400	136,800	138,200
17	Transfer from Capital Fund				0	0	0	0	0	0	0	0	0	0	0
18	Interest - Wastewater Fund				75,500	63,300	82,200	74,900	81,800	83,800	60,800	100,500	178,700	262,000	350,300
19	Total Revenue				5,115,808	7,032,900	9,612,900	11,932,700	14,214,000	15,269,500	15,794,900	16,384,900	16,648,200	16,925,400	17,206,900
	Revenue Requirements														
20	O&M Expense				4,894,400	4,402,700	5,024,600	5,150,200	5,279,000	5,410,900	5,546,200	5,684,800	5,827,000	5,972,600	6,121,900
21	Total Operating Requirement				4,894,400	4,402,700	5,024,600	5,150,200	5,279,000	5,410,900	5,546,200	5,684,800	5,827,000	5,972,600	6,121,900
	Debt Service														
22	Total Existing Debt				894,600	894,100	937,600	942,400	941,200	885,800	883,000	867,400	866,300	864,100	870,600
	Proposed Debt														
23	Revenue Bonds				0	1,087,900	2,175,700	3,640,100	5,104,500	5,313,700	5,522,900	5,522,900	5,522,900	5,522,900	5,522,900
24	General Obligation Bonds				0	0	0	0	0	0	0	0	0	0	0
25	SRF Loans				0	208,728	715,459	1,067,344	1,418,431	1,768,698	2,118,117	2,281,049	2,281,495	2,281,954	2,282,427
26	Total Debt Service				894,600	2,190,728	3,828,759	5,649,844	7,464,131	7,968,198	8,524,017	8,671,349	8,670,695	8,668,954	8,675,927
27	Routine Capital Outlays				0	0	0	0	0	0	0	0	0	0	0
28	Transfer Impact Fee to Capital Fund				250,000	126,300	127,500	128,800	130,100	131,400	132,800	134,100	135,400	136,800	138,200
29	Transfer to Capital Fund				0	0	0	2,000,000	0	3,000,000	1,500,000	0	0	0	0
30	Total Revenue Requirements				6,039,000	6,719,728	8,980,859	12,928,844	12,873,231	16,510,498	15,703,017	14,490,249	14,633,095	14,778,354	14,936,027
	Operating Fund Balance														
31	Net Annual Cash Balance				(923,192)	313,172	632,041	(996,144)	1,340,769	(1,240,998)	91,883	1,894,651	2,015,105	2,147,046	2,270,873
32	Net Cumulative Fund Balance				1,425,608	1,738,780	2,370,821	1,374,678	2,715,446	1,474,448	1,566,331	3,460,982	5,476,087	7,623,133	9,894,006
33	Minimum Desired Balance				1,223,600	1,100,700	1,256,200	1,287,600	1,319,800	1,352,700	1,386,600	1,421,200	1,456,800	1,493,200	1,530,500
	Debt Coverage														
34	Revenues (Line 19)				5,115,808	7,032,900	9,612,900	11,932,700	14,214,000	15,269,500	15,794,900	16,384,900	16,648,200	16,925,400	17,206,900
35	O&M Expense (Line 20)				4,894,400	4,402,700	5,024,600	5,150,200	5,279,000	5,410,900	5,546,200	5,684,800	5,827,000	5,972,600	6,121,900
36	Debt Service (Lines 22 - 25)				894,600	2,190,728	3,828,759	5,649,844	7,464,131	7,968,198	8,524,017	8,671,349	8,670,695	8,668,954	8,675,927
37	Debt Service Coverage					120%	120%	120%	120%	124%	120%	123%	125%	126%	128%

Table 9.12 Alt 2 Adequacy of Projected Revenues to Meet Projected Revenue Requirements

Line No.	Description				FY 09	FY 10	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19
					$	$	$	$	$	$	$	$	$	$	$
1	Beginning Fund Balance				2,348,800	1,425,608	1,679,280	2,187,421	1,534,578	1,353,046	1,745,548	1,765,931	5,932,182	10,454,187	15,360,133
	Revenue														
2	Revenue Under Existing Rates				4,432,600	4,485,200	4,535,100	4,590,800	4,642,100	4,695,300	4,751,600	4,805,800	4,860,700	4,918,300	4,975,600
	Additional Revenue Required:														
	FY	Percent	Months Effective												
3	2010	48.00%	6			1,076,400	2,176,800	2,203,600	2,228,200	2,253,700	2,280,800	2,306,800	2,333,100	2,360,800	2,388,300
4	2011	26.50%	6				889,300	1,800,500	1,820,600	1,841,500	1,863,600	1,884,800	1,906,400	1,929,000	1,951,400
5	2012	83.50%	6					3,588,400	7,256,900	7,340,100	7,428,200	7,512,800	7,598,700	7,688,800	7,778,300
6	2013	9.00%	6						717,700	1,451,800	1,469,200	1,485,900	1,502,900	1,520,700	1,538,400
7	2014	38.00%	6							3,340,700	6,761,500	6,838,500	6,916,700	6,998,700	7,080,200
8	2015	4.00%	6								491,100	993,400	1,004,700	1,016,700	1,028,500
9	2016	0.00%	6									0	0	0	0
10	2017	0.00%	6										0	0	0
11	2018	0.00%	6											0	0
12	2019	0.00%	6												0
13	Total Revenue From Rates				4,432,600	5,561,600	7,601,200	12,183,300	16,665,500	20,923,100	25,046,000	25,828,000	26,123,200	26,433,000	26,740,700
14	TMDLs				354,608	444,900	608,100	974,700	1,333,200	1,673,800	2,003,700	2,066,200	2,089,900	2,114,600	2,139,300
15	Other Revenue				3,100	485,600	489,100	483,800	478,800	474,400	470,300	473,800	478,500	483,200	487,900
16	Impact Fee Revenue				250,000	126,300	127,500	128,800	130,100	131,400	132,800	134,100	135,400	136,800	138,200
17	Transfer from Capital Fund				0	0	0	0	0	0	0	0	0	0	0
18	Interest - Wastewater Fund				75,500	62,100	77,300	74,400	57,800	62,000	70,200	154,000	327,700	516,300	720,200
19	Total Revenue				5,115,808	6,680,500	8,903,200	13,845,000	18,665,400	23,264,700	27,723,000	28,656,100	29,154,700	29,683,900	30,226,300
	Revenue Requirements														
20	O&M Expense				4,894,400	4,402,700	5,024,600	5,150,200	5,279,000	5,410,900	5,546,200	5,684,800	5,827,000	5,972,600	6,121,900
21	Total Operating Requirement				4,894,400	4,402,700	5,024,600	5,150,200	5,279,000	5,410,900	5,546,200	5,684,800	5,827,000	5,972,600	6,121,900
	Debt Service														
22	Total Existing Debt				894,600	894,100	937,600	942,400	941,200	885,800	883,000	867,400	866,300	864,100	870,600
	Proposed Debt														
23	Revenue Bonds				0	795,000	1,589,900	5,209,100	8,828,200	12,175,400	15,522,500	15,522,500	15,522,500	15,522,500	15,522,500
24	General Obligation Bonds				0	0	0	0	0	0	0	0	0	0	0
25	SRF Loans				0	208,728	715,459	1,067,344	1,418,431	1,768,698	2,118,117	2,281,049	2,281,495	2,281,954	2,282,427
26	Total Debt Service				894,600	1,897,828	3,242,959	7,218,844	11,187,831	14,829,898	18,523,617	18,670,949	18,670,295	18,668,554	18,675,527
27	Routine Capital Outlays				0	0	0	0	0	0	0	0	0	0	0
28	Transfer Impact Fee to Capital Fund				250,000	126,300	127,500	128,800	130,100	131,400	132,800	134,100	135,400	136,800	138,200
29	Transfer to Capital Fund				0	0	0	2,000,000	2,250,000	2,500,000	3,500,000	0	0	0	0
30	Total Revenue Requirements				6,039,000	6,426,828	8,395,059	14,497,844	18,846,931	22,872,198	27,702,617	24,489,849	24,632,695	24,777,954	24,935,627
	Operating Fund Balance														
31	Net Annual Cash Balance				(923,192)	253,672	508,141	(652,844)	(181,531)	392,502	20,383	4,166,251	4,522,005	4,905,946	5,290,673
32	Net Cumulative Fund Balance				1,425,608	1,679,280	2,187,421	1,534,578	1,353,046	1,745,548	1,765,931	5,932,182	10,454,187	15,360,133	20,650,806
33	Minimum Desired Balance				1,223,600	1,100,700	1,256,200	1,287,600	1,319,800	1,352,700	1,386,600	1,421,200	1,456,800	1,493,200	1,530,500
	Debt Coverage														
34	Revenues (Line 19)				5,115,808	6,680,500	8,903,200	13,845,000	18,665,400	23,264,700	27,723,000	28,656,100	29,154,700	29,683,900	30,226,300
35	O&M Expense (Line 20)				4,894,400	4,402,700	5,024,600	5,150,200	5,279,000	5,410,900	5,546,200	5,684,800	5,827,000	5,972,600	6,121,900
36	Debt Service (Lines 22 - 25)				894,600	1,897,828	3,242,959	7,218,844	11,187,831	14,829,898	18,523,617	18,670,949	18,670,295	18,668,554	18,675,527
37	Debt Service Coverage					120%	120%	120%	120%	120%	120%	123%	125%	127%	129%

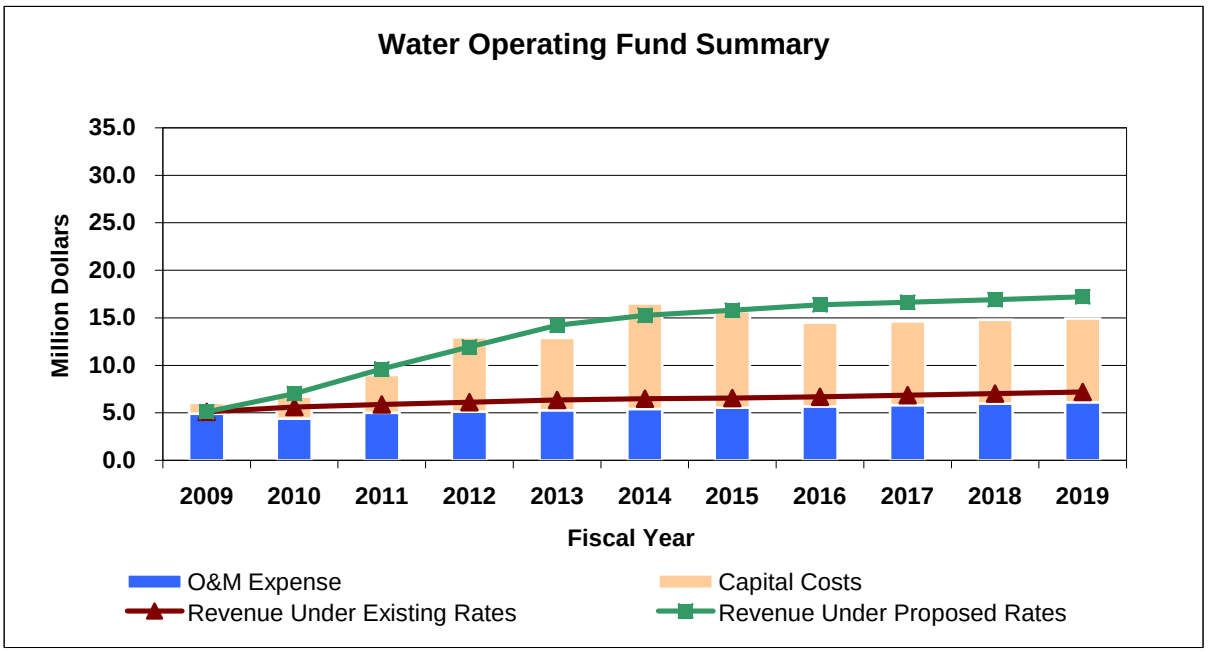


Figure 9.1 Water Operating Fund Summary, Alt 1

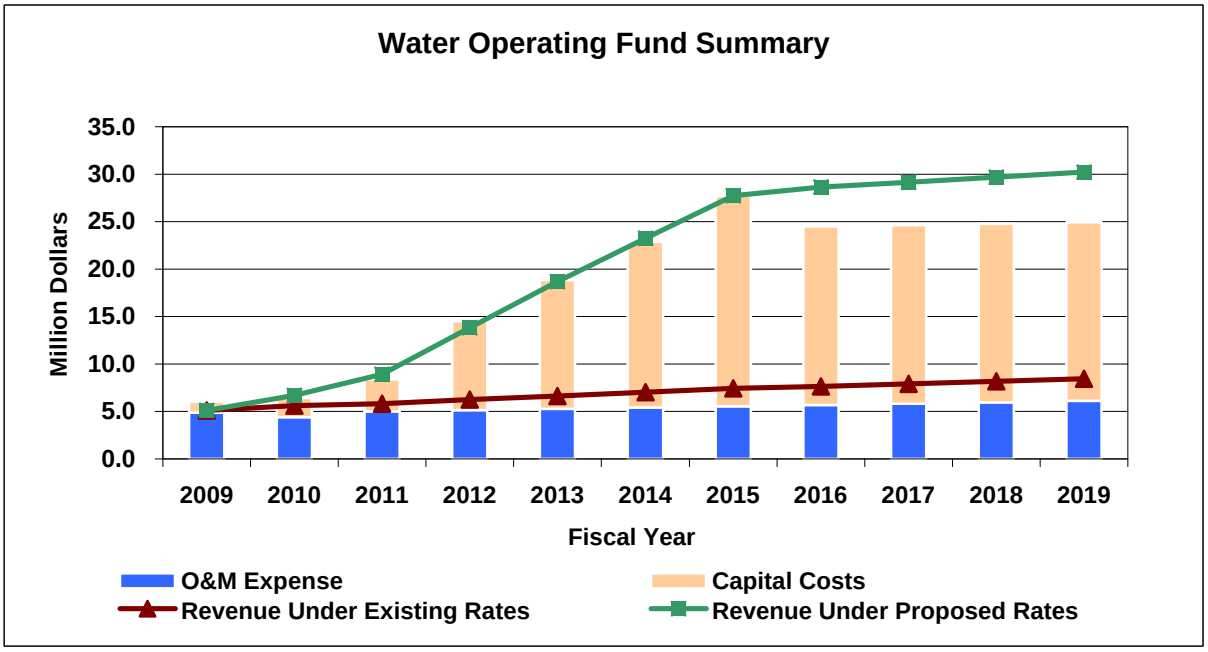


Figure 9.2 Water Operating Fund Summary, Alt 2

Table 9.13 summarizes the anticipated rate increases required for each scenario. Each scenario requires significant rate increases early in the project life to meet anticipated revenue requirements and an assumed minimum debt service coverage of 120 percent. The revenue requirements assume the City maintains at least 90 days of O&M expenses in the operating fund balance. If a higher minimum debt service coverage ratio or larger O&M fund balance is required, the rates would need to be further adjusted upwards.

Table 9.13 Required Rate Increases

FY	Months Effective	Alt 1	Alt 2
2010	6	62.50%	48.00%
2011	6	24.00%	26.50%
2012	6	25.00%	83.50%
2013	6	14.00%	9.00%
2014	6	--	38.00%
2015	6	5.00%	4.00%
2016	6	--	--
2017	6	--	--
2018	6	--	--
2019	6	--	--

9.6 Affordability

The monthly bill for a single family - duplex customer using an average of 6 hcf/mo is shown in **Table 9.14** for each alternative.

Table 9.14 Average Monthly Bill, Single Family - Duplex Customer

FY	Alt 1	Alt 2
2009	$30.39	$30.39
2010	$49.38	$44.97
2011	$61.23	$56.89
2012	$76.53	$104.39
2013	$87.25	$113.79
2014	$87.25	$157.02
2015	$91.61	$163.31
2016	$91.61	$163.31
2017	$91.61	$163.31
2018	$91.61	$163.31
2019	$91.61	$163.31

The 2000 US Census reported the median household income for the City of Klamath Falls at almost $28,500[2]. The typical monthly wastewater bill of $30 for an average single family

[2] Table 13. Household Income in 1999, "Oregon: 2000, Summary Social, Economic, and Housing Characteristics", *2000 Census of Population and Housing*, U.S. Bureau of the Census, Issued March 2003. Page 76.

residence, based on the average effective rate during FY 09, represents 1.3 percent of this median household income. As such, the FY 09 projected monthly bill is below the 2.0 percent median household income threshold used as the industry standard for affordability by the EPA. Using the 2000 census data, each alternative nears or exceeds the threshold with the FY 10 rate increase, as shown in **Table 9.15**. However, median household income has likely risen since the census. For the FY 15 monthly bill to be no more than 2 percent of median household income, the median household income in the City would need to be approximately $55,000 for Alt 1 or $98,000 for Alt 2. Those values would likely not be achieved.

Table 9.15 Affordability, Percent of Median Household Income

FY	Alt 1	Alt 2
2009	1.3%	1.3%
2010	2.1%	1.9%
2011	2.6%	2.4%
2012	3.2%	4.4%
2013	3.7%	4.8%
2014	3.7%	6.6%
2015	3.9%	6.9%
2016	3.9%	6.9%
2017	3.9%	6.9%
2018	3.9%	6.9%
2019	3.9%	6.9%

9.7 Conclusion

Both alternatives to upgrade the Spring Street STP require significant capital investment. Under the most likely financing scenario used in this analysis, the City's wastewater customers would need to pay a potentially unaffordable rate from the increases required to finance the new debt service associated with either alternative. More affordable solutions will need to be developed to meet DEQ requirements without making wastewater rates unaffordable. These solutions may include a much slower CIP or a significantly scaled-down CIP. While more funding may become available in the short-term via the SRF program, unless the DEQ cap is removed, the City would not be able to finance larger portions of the CIP with SRF Loans.

Section 10
Environmental Considerations

Before state or federal agencies will consider financial assistance to design or construct wastewater facilities, they expect an environmental report to be prepared and submitted to them for review. The environmental report must consider a host of issues including, but not limited to, land use, wetlands, flooding, etc. The report should evaluate these issues relative to a specific site where the facilities will be located. At this point in time, the locations of planned facilities are only known for the river discharge option. With the exception of the treatment plant site, the location for the effluent storage and land irrigation facilities has not been determined. Therefore, this report section will address site specific issues for the river discharge option. For the land irrigation option, this document will indicate the type and extent of information that will be needed to complete a final environmental report.

In the final environmental report, review agencies will expect that conclusions in this report be confirmed or verified by the appropriate agencies. When a final proposed selected alternative is determined, confirmation or verification correspondence can be requested of the appropriate agencies.

This Facilities Plan section has been prepared as a stand-alone document and includes portions that are also included in the technical sections of the Facilities Plan. It is a stand-alone document because the financial assistance agency people who review this section will likely not also review the technical sections of the Facilities Plan. The Facilities Plan section is organized and formatted in a way that will lend itself to completion of environmental documents that will be required should the City seek to obtain financial subsidies from state and federal funding agencies.

10.1 Purpose and Need for the Project

10.1.1 Project Description (Proposed Project)

The City of Klamath Falls proposes to upgrade and expand its sewerage facility in one of two ways:

1. The existing Spring Street wastewater treatment plant will be expanded and modified at the existing site to produce an effluent that meets all of the discharge requirements of the Oregon Department of Environmental Quality (ODEQ). In addition, the existing outfall will be replaced with a diffuser located in the Klamath River downstream of the U.S. Highway 97 bridge. Effluent would be transported to the diffuser primarily through pipelines that already exist for the purpose of supply and returning reuse water to the Klamath Cogeneration Facility near the Highway 97 bridge. Hereinafter, this option will be termed: "discharge option."

2. The existing Spring Street wastewater treatment plant will be expanded and modified to produce an effluent suitable for agricultural irrigation. Treated effluent would be piped to a site that is yet to be determined for storage during the non-irrigation season and

irrigation during the growing season. Hereinafter, this option will be termed: "irrigation option."

10.1.2 Purpose and Need for the Project

The City of Klamath Falls proposes to upgrade its sewerage facility to both accommodate growth and development for the next 20 years and to meet much more rigorous discharge requirements imposed by the ODEQ. These discharge requirements will be the result, in part, of a pending total maximum daily load (TMDL) that addresses existing federally-approved State of Oregon in-stream water quality standards violations of dissolved oxygen, pH, ammonia-toxicity, nuisance algae, and temperature in the Klamath River. The discharge requirements will also include limitations to prevent violation of other in-stream water quality standards that are currently being met but that could be at risk from the discharge of wastewater.

10.2 Alternative to the Proposed Action

Under Task 4A, Part 1, eight effluent disposal options were identified and assessed in regards to meeting the needs of growth and State of Oregon and federal discharge permit and other regulatory requirements. These were:

- Effluent Discharge into the River, but with Advanced Treatment and New Diffuser
- Effluent Discharge into the River, but with Additional, More Stringent Treatment (to background quality) and New Diffuser
- Agricultural Land Application with Winter Storage
- Constructed Wetland(s) with Indirect discharge to Surface Waters
- State Wildlife Refuge for Land Application
- Indirect Subsurface Discharge – Hyporheic Zone
- "A" Canal Discharge for Land Application
- Pollutant Load Offset Trading

After consideration of the draft TMDLs, only the first and third disposal alternatives (also listed in **Section 10.1.1**) have been determined to be viable. The other six alternatives were discarded for the following reasons as noted below:

- *Effluent Discharge in to the River, but with Additional, more Stringent Treatment (to background quality) and New Diffuser.* The concept behind this option was to treat to background nutrient concentrations in the Klamath River thereby making the requirements of the nutrient TMDL irrelevant. At the time this concept was developed, the City feared that an expanded treatment plant would be needed before DEQ finalized

the TMDL. DEQ has released its tentative TMDL waste load allocations for the City and, therefore, there is no need to pursue this concept.

- *Constructed Wetland(s) with Indirect Discharge to Surface Waters.* This option would still require an NPDES permit and anticipated pollutant attenuation via the wetlands would unlikely provide sufficient treatment to meet the TMDL and other water quality standards. Additional, advanced treatment would be required by a treatment plant prior to discharge into the constructed wetlands. So it provides no real benefits over that provided by a direct discharge via a new outfall diffuser.

- *State Wildlife Refuge for Land Application.* Contacts with the Oregon Department of Fish and Wildlife that owns the nearby refuge has indicated that it would not be interested in pursuing this option.

- *Indirect Subsurface Discharge – Hyporheic Zone.* This option has similar problems and issues as are encountered with a constructed wetland with indirect discharge and, therefore, has no real benefit over that provided by a direct discharge via a new outfall diffuser.

- *"A" Canal Discharge for Land Application.* The water in "A" canal is distributed to farmers by various irrigation districts. Discharge of effluent into the "A" canal could eliminate the irrigation district's NPDES permit exemption for the discharge of irrigation return flows. Based upon this, it is highly likely that this option would be aggressively opposed by the U. S. Bureau of Reclamation and the irrigation districts that obtain water via the "A" canal.

- *Pollutant Load Offset Trading.* At this time there is no known source of pollutant loads that the City could obtain that would significantly increase the pollutant discharges required by ODEQ meet the TMDL. If the City selects to eliminate its discharge by summer irrigation and winter storage, it may have discharge credits that it could sell to other pollutant sources that have been assigned restrictive load allocations under the TMDL for the Klamath River.

- *Injection into the geothermal aquifer beneath the City of Klamath Falls.* This option was not one of the original options under consideration, but was added because it seemed like a possible low cost option for effluent disposal. This option, however, has been discarded because direct injection is prohibited by ODEQ administrative rules and indirect injection is not feasible because the aquifer is confined and under pressure.

10.3 Affected Environmental/Environmental Consequences

10.3.1 Land Use/Important Farmland/Formally Classified Lands

10.3.1.1 Affected Environment

River Option. The only components of the river option that will affect land use are the additional effluent transport line and effluent diffuser outfall in the Klamath River. All expanded and upgraded treatment facilities will be located at the existing site. This option

intends to use two existing pipelines to transport treated effluent almost all the way to the location of the diffuser outfall. These pipelines currently transport treated effluent to the cogeneration facility for use as cooling water make-up and return cooling water blowdown back to the treatment plant. Under this option, the pipelines will still transport treated effluent to the cogeneration facility, but will also transport additional effluent that will be diverted to the diffuser outfall. Blowdown water will not return to the treatment plant, but will be diverted to the diffuser outfall. Eliminating the return of blowdown water to the treatment plant may require additional treatment of the blowdown prior to discharge to eliminate chlorine residual and to lower temperature.

The pipeline to transport effluent to the diffuser will tee off from the existing pipelines near the cogeneration facility. According to Klamath County zoning maps, the land between the existing pipelines and the river is zoned heavy industrial. The Klamath County Land Development Code indicates that construction of utilities would require a conditional use permit in land zoned heavy industrial. Because the land is zoned heavy industrial, it should not also be considered prime farm land, which is required to be protected under the Farmland Protection Policy Act of 1981.

The land under the Klamath River where the diffuser would be located apparently has no zoning designation. Further investigation will be needed to determine if Klamath County Land Development Code would regulate construction of the diffuser.

Irrigation Option. To implement this option, effluent pipelines will have to be constructed to the effluent and irrigation site. Since no location has been identified, an analysis of land use impacts is not possible. It is likely, however, that at least some of the facilities will be located on land zoned exclusive farm use (EFU). Klamath County Land Development Code will allow, subject to conditional use approval, utility facilities in EFU that are necessary for public service, and which must be situated in an agricultural zone for that service to be provided.

State Law (ORS 215.246(3) allows land application of treated effluent and its storage in EFU zoned land; it does not allow treatment units on EFU land. For DEQ to approve land application at an EFU site, it must require the applicant to explain in writing how alternatives identified in public comments on the land use decision were considered and, if the alternatives are not used, explain in writing the reasons for not using the alternatives. The applicant must consider only those alternatives that are identified with sufficient specificity to afford the applicant an adequate opportunity to consider the alternatives.

In addition, this option will have to address the federal Farmland Protection Policy Act of 1981. The Farmland Protection Policy Act (FPPA) is intended to minimize the extent to which federal activities contribute to the unnecessary and irreversible conversion of agricultural land to nonagricultural uses.

The rating form is based on a Land Evaluation and Site Assessment (LESA) system. LESA is a numerical system that measures the quality of farmland. LESA systems have two components. The Land Evaluation element rates soil quality. The Site Assessment component measures other factors that affect the farm's viability, including but not limited to proximity to water and sewer

lines and the size of the parcel. In general, the higher the LESA score, the more appropriate the site is for protection.

Under FPPA, federal agencies sponsoring a project subject to the law complete a site assessment. Natural Resource Conservation Service (NRCS) is responsible for the land evaluation component. Sites receiving a combined score of less than 160 do not require further evaluation. Alternatives should be proposed for sites with a combined score greater than 160 points. On the basis of this analysis, a federal agency may, but is not required, to deny assistance to private parties and state and local governments undertaking projects that would convert farmland.

Other land use restrictions could apply depending upon the zoning of the land under consideration.

10.3.1.2 Environmental Consequences

River Option. There appears to be no consequences relative to land use for this option.

Irrigation Option. Depending on the actual sites selected for this option, there could be consequences relative to land use and the federal Farmland Protection Policy Act.

10.3.1.3 Mitigation

River Option. There appears to be no mitigation necessary relative to land use for this option.

Irrigation Option. Depending on the actual sites selected for this option, mitigation could be needed relative to land use.

10.3.2. Floodplains

10.3.2.1 Affected Environment

River Option. The only components of the river option that do not already exist are the additional effluent transport line and effluent diffuser outfall in the Klamath River. According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM), the land between the existing pipelines and the river is classified as zone C and is outside both the 100 and 500 year floodplains. The diffuser outfall, of course, will be in the river itself. The existing treatment plant site and the existing effluent transport pipelines to the cogeneration facility are also outside the 100 and 500 year flood plains according to the FEMA FIRM.

Discharge Option. No analysis relative to floodplain can be conducted relative to this option until the location is determined.

10.3.3.1 Environmental Consequences

River Option. There appears to be no consequences relative to floodplains for this option.

Irrigation Option. Depending on the actual sites selected for this option, there could be consequences relative to floodplains.

10.3.2.3 Mitigation

River Option. There appears to be no mitigation necessary relative to flood plains for this option.

Irrigation Option. Depending on the actual sites selected for this option, mitigation may be needed relative to floodplains.

10.3.3 Wetlands

10.3.3.1 Affected Environment

Discharge Option. According to U.S. Fish and Wildlife Service wetland delineation maps that are available on the internet, there are no existing wetlands at the site of the existing treatment plant site. A mitigation wetland has been constructed south of the biosolids composting area to replace a wetland that was filled and eliminated at the municipal airport. This mitigation wetland will not be part of the upgrade and expansion of the wastewater facility. There appears to be some wetlands along the existing pipeline to the cogeneration facility. In addition, there are no wetlands in the area where additional effluent pipelines will be constructed to the diffuser outfall in the Klamath River. Obviously, the diffuser will be constructed in a wetland since it will be in the river. The diffuser would like only extend over one quarter of the width of the river.

Irrigation Option. Until a site for the irrigation facility is selected, no wetland analysis can be performed.

10.3.3.2 Environmental Consequences

Discharge Option. Wetlands should not be an issue for the existing effluent transport pipeline. If booster pumps need to be constructed along the existing pipeline to increase flow rates, the sites for these pump stations should be chosen to avoid wetlands.

It is impossible to construct the diffuser outfall to avoid wetlands. In order to construct the diffuser, permits will need to be obtained from both the Oregon Department of State Lands (DSL) and the U.S. Army Corps of Engineers (COE). Prior to the COE issuing its permit, a Clean Water Act Section 401 certification from the ODEQ will be required. In addition, pursuant to the federal Endangered Species Act (ESA), the COE will need to consult with the U.S. Fish and Wildlife Service concerning protection of threatened and endangered species. The two species most likely of concern will be the Lost River Sucker and the Shortnose Sucker, both of which are listed as endangered.

Irrigation Option. Depending on the actual sites selected for this option, there could be consequences relative to wetlands.

10.3.3.3 Mitigation

Discharge Option. The installation of the diffuser should not permanently destroy or displace any significant wetlands. Therefore, it would seem unlikely that the COE would require mitigation.

Irrigation Option. Depending on the actual sites selected for this option, mitigation could be needed relative to wetlands.

10.3.4 Cultural and Historical Resources

10.3.4.1 Affected Environment

Discharge Option. The only potential impact to cultural or historical resources from this option could be the construction of the pipeline from the existing effluent transport pipeline to the river diffuser outfall. Fairhaven Elementary School on Weyerhaeuser Road is the only structure of historical significance found in a search of the Oregon State Historical Preservation Office (SHPO) database near the potential location of pipeline to the diffuser. This school structure would not be affected by the construction of the pipeline to the diffuser.

If this option is selected, prior to any preliminary design work, a specific archeological review of the site should be conducted by a qualified archeologist.

Irrigation Option. No cultural or historical review can be conducted relative to this option until a location for the land irrigation facility is determined.

10.3.4.2 Environmental Consequences

Discharge Option. At this point, there appears to be no cultural or historical consequences for this option.

Irrigation Option. Depending on the actual sites selected for this option, there could be consequences relative to cultural or historical issues.

10.3.4.3 Mitigation

Discharge Option. At this point, no mitigation appears necessary.

Irrigation Option. Depending on the actual sites selected for this option, mitigation could be required to address cultural or historical issues.

10.3.5 Biological Resources

10.3.5.1 Affected Environment

Species that are currently listed in Klamath County by the U.S. Fish and Wildlife Service under the requirements of the ESA are: Northern spotted owl, Shortnose sucker, Lost River sucker, bull trout, and Applegate's milk-vetch.

Discharge Option. The Klamath River, in the vicinity of the proposed project, is habitat for two species that are listed as endangered pursuant to the ESA: the Shortnose Sucker and the Lost River Sucker. Bull trout are not found in the Klamath River in the vicinity of the project. DEQ recognizes resident fish as a beneficial use to be protected in this portion of the river, but resident fish do not include cold water species such as trout. Applegate's mile-vetch, a listed plant species, also may occupy areas along the Klamath River in the vicinity of this option of the project. It is highly unlikely that this option would affect the Northern spotted owl because the discharge option would not involve forest lands.

Irrigation Option. This option would eliminate effluent discharge to the Klamath River, in turn eliminating any potential impact on listed fish. It also highly unlikely that this option would affect the Northern spotted owl because the irrigation project would not involve forest lands. It is possible that Applegate's milk-vetch could be affected depending on the location of the pipeline that would transport treated effluent to the storage site and irrigation.

10.3.5.2 Environmental Consequences

Discharge Option. The Northern spotted owl is listed as threatened. Northern spotted owls live in forests characterized by dense canopy closure of mature and old-growth trees, abundant logs, standing snags, and live trees with broken tops. Although they are known to nest, roost, and feed in a wide variety of habitat types, these owls prefer older forest stands with variety: multi-layered canopies of several tree species of varying size and age, both standing and fallen dead trees, and open space among the lower branches to allow flight under the canopy. The area under consideration for this option is not forested so it is highly unlikely that there will be any impact to the Northern spotted owl.

The shortnose and Lost River suckers dwell in the deeper water of lakes and spawn in springs or tributary streams upstream from its home lake. Some stream dwelling populations also exist. Areas with gravel or close-set stone (cobble) bottoms are generally preferred for spawning habitat. In addition, spawning streams have a fairly shallow shoreline with an abundance of aquatic vegetation; these areas provide a safe haven for the young larvae during their journey back downstream to their home lakes or the deep, quiet waters of rivers. Shoreline vegetation in both lake and river habitats is important for the rearing of larval and juvenile suckers.

Although a number of factors have contributed to the decline of the sucker fish, habitat degradation is considered its primary cause. Streams, rivers, and lakes have been modified by channelization and dams. Grazing in the riparian zone has eliminated stream bank vegetation, and has added nutrients and sediment to river systems. Eggs and larvae, for example, suffocate when the water is cloudy, or dry out or get eaten by other fish when they are not protected by aquatic vegetation. Loss of stream bank vegetation due to overgrazing, logging activities, agricultural practices, and road construction has also led to increases in stream temperatures, high levels of nutrients (which encourages the buildup of excess algae and bacteria), and serious erosion and sedimentation problems. Such water quality problems have reduced the availability of suitable Shortnose sucker habitat and have resulted in major fish mortality. Entire age classes of young suckers are routinely lost due to poor water quality conditions. As a result, few young suckers survive to sexual maturity, and therefore, do not increase the population size. Other factors affecting the decline of the Shortnose and Lost River suckers include previous over-harvesting, chemical pollution from pesticides, herbicides, and forestry practices, and predation and competition from native and non-native fishes such as largemouth bass, blue chub, yellow perch, fathead minnows, and rainbow trout.

No evidence exists that the current Klamath Falls sewerage facility has impacted the sucker fish. One reason for upgrading the facility, however, is to improve treatment and reduce the potential for violating in-stream water quality standards established to protect fish. Therefore, the proposed project should not impact listed sucker fish.

Bull trout are confined to the head waters in the Klamath River system and are not found in the Klamath River in the vicinity of this option.

Applegate's milk-vetch was federally listed as endangered without critical habitat in 1993 (U.S. Fish and Wildlife Service 1993). A recovery plan was published in 1998 (U.S. Fish and Wildlife Service 1998). Applegate's milk-vetch is a slender perennial in the pea family (Fabaceae) with stems 3-4 dm (12-16 in) long. The leaves are typically 3.5-7 cm (1.4-2.8 in) long with 7-11 leaflets. The petals are whitish, measuring up to 7 mm (0.3 in) long. The tip of the keel is faintly lilac-tinged. The fruit is a pod and is widely spreading or declined. Dehiscence (pod opening at maturity) starts at the top of the pod and continues downward. Applegate's milk-vetch typically flowers from June to early August. Applegate's milk-vetch occurs in flat-lying, seasonally moist, strongly alkaline soils dominated by greasewood (Sarcobatus vermiculatus) with sparse, native bunch grasses and patches of bare soil. Urban development, agriculture, weeds, fire suppression, flood control and land reclamation have contributed to the decline of this species. This species is historically known from only four sites, near the City of Klamath Falls in Klamath County, Oregon, approximately 1250 m (4,100 ft) above sea level. The largest population is located near Ewauna Lake in Klamath Falls; a significant portion of the site where this population occurs is owned by The Nature Conservancy.

CDM does not know if this species occupies any of the areas that will be impacted by construction of this option of the project. Prior to any design work, the sites should be surveyed to determine if this species exists on the site.

Irrigation Option. CDM does not know if Applegate's mile-vetch occupies any of the areas that would be impacted by construction of this option of the project. Prior to any design work, the sites should be surveyed to determine if this species exists on the site. This option will not affect any fish species because it eliminates the discharge of pollutants to surface waters of the State. It also is highly unlikely to affect the Northern spotted owl because this option would not be located in forested areas.

10.3.6 Water Quality Issues

10.3.6.1 Affected Environment

Discharge Option. The Klamath River (including Lake Ewauna) from Link River to Keno does not meet federally-approved, State of Oregon in-stream water quality standards for dissolved oxygen and ammonia-toxicity year round, and pH and chlorophyll *a* during the summer. The Klamath River below Keno does not meet dissolved oxygen standards year around or the temperature standard during the summer.

A minimum concentration of dissolved oxygen is needed in the river to sustain fish. Excursions of pH outside a range of 5.5 to 9.0 can be detrimental to fish. Elevated ammonia-nitrogen concentrations are toxic to fish, particularly when the pH of the water is also elevated. Finally, warm water temperatures are detrimental to fish.

In addition to discharge restrictions imposed by the TMDLs, the pending permit may require the City to reduce it level of discharge for other toxic pollutants such as inorganic arsenic,

mercury and lead. This would be necessary to avoid violation of in-stream water quality standards for these pollutants.

Irrigation Option. The irrigation option is also under consideration to address the water quality issues stated above.

10.3.6.2 Environmental Consequences

Discharge Option. Failure to reduce pollutant discharge levels to meet waste load allocations and to avoid violation of in-stream water quality standards would adversely affect fish and, perhaps, wildlife that utilize the river.

Irrigation Option. Failure to reduce pollutant discharge levels to meet waste load allocations and to avoid violation of in-stream water quality standards would adversely affect fish and, perhaps, wildlife that utilize the river.

10.3.6.3 Mitigation

To address the water quality standards violations, ODEQ, with assistance from the U. S. Environmental Protection Agency (EPA), has tentatively proposed TMDLs and associated waste load allocations that would limit the discharge of heat (temperature), carbonaceous biochemical oxygen demand (CBOD), ammonia-nitrogen, and total phosphorus. In addition, the proposal also includes a minimum effluent dissolved oxygen concentration. The temperature WLA is intended to prevent violation of the temperature standard in the Klamath River below Keno. The WLAs for CBOD, total phosphorus, ammonia-nitrogen and dissolved oxygen are intended to deal with dissolved oxygen, pH, and chlorophyll problems in the river. The City of Klamath Falls will be assigned a waste load allocation in a pending permit and will need to reduce its level of pollutant discharge to meet the waste load allocations.

Discharge Option. To meet the TMDLs and other water quality requirements, under this option, wastewater will be treated in an advanced system to reduce discharge level. In addition, a diffuser outfall will be constructed to provide better dilution of the treated effluent in a much smaller portion of the river.

Irrigation Option. Under this option, discharge to surface waters of the State will not occur. Effluent will be irrigated during the growing season so that nutrients are assimilated by growing vegetation and harvested. During the non-growing season, effluent will be stored in a lined impoundment. Irrigation at agronomic rates during the growing season should protect groundwater quality. DEQ may require a groundwater quality protection program as part of this option and would necessitate a monitoring well system to determine groundwater quality impacts.

10.3.7 Socioeconomic/Environmental Justice Issues

10.3.7.1 Affected Environment

The population of the City of Klamath Falls in 2006 was 20,720 according to the Population Resource Center at Portland State University. According to the 2000 U.S. Census, the median

family income in the City was 28,498 in 1999 dollars[1]. Distribution of household income in 1999 for the City is listed in the following table.

Table 10.1 Distribution of Household Income for the City (1999)

Household Income	Percent of Households	Household Income	Percent of Households
Less than $10,000	16.0	$50,000 to $74,999	12.9
$10,000 to $14,999	10.0	$75,000 to $99,999	4.9
$15,000 to $24,999	18.4	$100,000 to $149,999	4.0
$25,000 to $34,999	14.6	$150,000-$199,999	0.8
$35,000 to $49,999	17.8	$200,000 or more	0.7
Source: Table DP-3. Profile of Selected Economic Characteristics: 2000. U.S. Bureau of the Census, Census 2000.			

Also according to the 2000 Census, 16.2 percent of the families in Klamath Falls were below the national poverty level[2].

The 2000 Census indicates that there were 2.61 people per owner-occupied unit and 2.12 people per renter-occupied unit[3]. The average household size was 2.36[4].

Relative to environmental justice issues, for the discharge option, the treatment system will be located on the existing site. The only new component of the proposed facilities would be on heavy industrial land. For the irrigation option, the treatment unit would also be located on the existing site. The effluent storage and irrigation site is not known. At this time, there appear to be no environmental justice issues associated with the project.

10.3.7.2 Environmental Consequences

Discharge Option. A planning level capital cost estimate for this option is $27,000,000. (Note: this does not include costs for operation and maintenance.) If the average household size has remained at 2.36 and the 2006 population is 20,720 people, there would be 8780 households in

[1] Table 13. Household Income in 1999, "Oregon: 2000, Summary Social, Economic, and Housing Characteristics", *2000 Census of Population and Housing*, U.S. Bureau of the Census, Issued March 2003. page 76.
[2] Table 15. Poverty Status in 1999, "Oregon: 2000, Summary Social, Economic, and Housing Characteristics", *2000 Census of Population and Housing*, U.S. Bureau of the Census, Issued March 2003. page 89.
[3] Table 23. Owner and Renter Household Characteristics, "Oregon: 2000, Summary Social, Economic, and Housing Characteristics", *2000 Census of Population and Housing*, U.S. Bureau of the Census, Issued March 2003. page 137.
[4] Table DP-1. Profile of General Demographic Characteristics: 2000. U.S. Bureau of the Census, census 2000.

the City in 2006. If the capital cost is financed over 20 years at 4%interest, the monthly cost per household would be $18.86.

Irrigation Option. A planning level capital cost estimate for this option is $104,000,000. Using the same assumptions and stipulations above, the monthly cost per household would be $72.63.

10.3.7.3 Mitigation

If the irrigation option is undertaken, the capital cost plus O&M costs could be unreasonable for a portion of the community households. Financial assistance may be needed to reduce these costs.

10.3.8 Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) requires that federal fishery management plans describe the habitat essential to the fish being managed and describe threats to that habitat from both fishing and non-fishing activities. In addition, in order to protect this Essential Fish Habitat (EFH), federal agencies are required to consult with the National Marine Fisheries Service (NMFS) on activities that may adversely affect EFH. The Pacific Fishery Management Council manages the fisheries for coho, chinook, and Puget Sound Pink Salmon and has defined EFH for these three species. Salmon EFH includes all the streams, lakes, ponds, wetlands, and other water bodies currently or historically accessible to salmon in Washington, Oregon, Idaho, and California. Salmon EFH excludes areas upstream of longstanding naturally impassible barriers (i.e. natural waterfalls in existence for several hundred years), but includes aquatic areas above all artificial barriers except specifically named impassible dams.

The Upper Klamath River has been identified as an essential fisheries habitat (EFH), but only up to Iron Gate Dam in California. There, it seems that neither project option would require EFH consultation. It is recommended, however, that once a final option is selected, the National Marine Fisheries Service be contacted so that it may confirm that the project will not affect EFH.

10.3.9 Clean Air Act of 1977

There should be no significant air emissions for either of the project options that would require an Air Contaminant Discharge Permit (ACDP) under the federal Clean Air Act of 1977. In Oregon, the ACDP program is administered by the Oregon Department of Environmental Quality (ODEQ). ODEQ requires an ACDP if a wastewater facility has a boiler that burns digester gas and emits over 10 tons of particulate. The proposed project does not contain such a system as part of either option.

10.3.10 Safe Drinking Water Act of 1974

Neither project option would have a direct or indirect discharge of wastewater to groundwater that would be regulated under the federal Underground Injection Control program of the federal Safe Drinking Water Act. In Oregon, this federal river program has been delegated to ODEQ.

10.3.11 Wild and Scenic Rivers or Oregon Scenic Waterways

The Klamath River is a federal Wild and Scenic River and also an Oregon Scenic Waterway from J.C. Boyle powerhouse to the Oregon-California border, an 11 mile distance. The federal Wild and Scenic River for this portion of the Klamath River is administered by the U.S. Bureau of Land Management. The Oregon Scenic Waterway program is administered by the Oregon Department of Parks and Recreation.

10.3.11.1 Affected Environment

Discharge Option: The outfall for the discharge option is at river mile 40, which is 29 miles above the upper most portion of the federal Wild and Scenic River and the Oregon Scenic Waterway.

Irrigation Option: This option would not discharge effluent to the river and would not be located anywhere near the protected river segment of the Klamath River.

10.3.11.2 Environmental Consequences

Discharge Option: Under this option, the discharge of pollutants would be controlled so that it will not contribute to violation of federally-approved, State of Oregon in-stream water quality standards. The new wastewater treatment plant will be designed and constructed to meet the requirements imposed by the pending total maximum daily load (TMDL) and to prevent violation of other in-stream water quality standards not otherwise addressed in the TMDL. This will be accomplished by additional treatment and by providing additional mixing at the outfall. Additional mixing will be provided through the use of a diffuser and by relocating the outfall so that it takes advantage of river flow velocity that is not available at the existing outfall location. Based upon this, there should be no environmental consequences for this option.

Irrigation Option: Under this option, the discharge of wastewater to the Klamath River would be terminated and any potential violation of in-stream water quality standards would be eliminated. This option would slightly reduce flow in the river because the historical discharge would end. However, a review of the administrative rules concerning the Oregon Scenic River program did not appear to consider the elimination of the wastewater discharge as an issue.

10.4 Summary of Mitigation

To be provided in final environmental report to be submitted along with final applications for financial assistance.

10.5 Correspondence

To be provided in final environmental report to be submitted along with final applications for financial assistance.

10.6 Exhibits/Maps

To be provided in final environmental report to be submitted along with final applications for financial assistance.