City of Bend Water Reclamation Facility (WRF) Secondary Expansion Value Engineering Report

City Project No: SW0802

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PREPARED BY

CH2MHILL

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Contents

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September 18, 2009

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City of Bend
745 NW Bond Street
Bend, Oregon 97709-0431

Subject: Final Value Engineering Report; Value Engineering Study
Bend Water Reclamation Facility—City Project SW0802

CH2M HILL is pleased to submit this Final Value Engineering (VE) Report for the Bend Water Reclamation Facility (WRF) Secondary Improvement Project. CH2M HILL facilitated the VE study in Portland, Oregon, from Tuesday, June 23, through Thursday, June 25, 2009.

This VE study for the Bend WRF was considered a concept-level or planning-level VE study, conducted over a 3-day period, with the intent of addressing and rating high-level alternatives that have the potential to address existing treatment concerns and capacity issues at the WRF. The proposals that have the potential to improve plant operations and save costs (in the opinion of the VE team and the City of Bend) are recommended to be further developed by the City and the CH2M HILL design team as part of the upcoming Preliminary Design effort.

The VE team established criteria for evaluation of plant process alternatives, in categories such as Treatment Effectiveness, Plant Operations, Sustainability, and Cost Saving Potential. The City of Bend conducted a review of the Preliminary Value Engineering Report, and provided input on Operational Ease, Future Operations and Maintenance, and overall City of Bend acceptance. The VE team then prioritized alternatives as Priorities 1, 2, or 3.

- Priority P1 alternatives are highly recommended for further technical evaluation in preliminary design, as are the moderate Priority P2 proposals.
- The lower-rated proposals with a P3 rating are recommended to be dropped from further consideration due to the comments noted in the proposals that favor other more highly rated proposals and the need to streamline the list to a manageable number of proposals for design team follow-up.
- Observations are also made for design team and City follow-up.

During the VE study, 38 VE proposals were developed. Additionally, the VE team developed 32 observations that were written on a variety of subjects to serve as reminders to the design team as the design progresses further.

This Final VE Report includes recommendations from the VE team for the design team and City of Bend to strongly consider implementation of 15 VE proposals (Priority 1) and also consider implementation of 9 VE proposals that are of moderate priority (Priority 2). These proposals, in the opinion of the VE team, provide opportunities to address plant operational issues and maximize efficiency in plant processes as part of the Bend WRF Secondary Improvement Project.

Please refer to the enclosed summary tables for a list of VE Proposals and Observations. Complete descriptions of all the proposals can be found in the main body of the report.

With the City's review of the Preliminary VE Report, CH2M HILL has now determined the disposition of each proposal, identifying proposals and observations that are 'Accepted for Further Review', and capturing any comments that the City or the VE Team provided regarding the proposals and observations. Again, Tables 1 and 3 present the High Priority (P1) and the Moderate Priority (P2) proposals that the VE Team, along with the City, recommends for 'further review' during Predesign.

CH2M HILL plans to document the final VE study results as part of the follow-on predesign work.

CH2M HILL appreciates this opportunity to provide value engineering services on this important Bend WRF project. We look forward to partnering with you to achieve success through design completion and construction. Please contact Paul Johnson at (208) 383-6299 or Dave Green at (503) 872-4440 should you have any questions or comments concerning this Final VE Report.

Sincerely,

CH2M HILL

Paul Johnson, CVS
Value Engineering Team Facilitator

Dave Green, PE
Project Manager

c: CH2M HILL Design Team c/o Brady Fuller
Value Engineering Team

VE Summary

Summary Narrative

CH2M HILL conducted a Value Engineering (VE) study of the Bend Water Reclamation Facility (WRF) Project, from Tuesday, June 23, through Thursday, June 25, 2009.

Mid-Design VE studies typically are conducted over a 5-day (40-team-hour) period. However, this VE study for the Bend WRF was conducted at the end of the Facility Planning phase, just prior to launching the Predesign work. As a result, this concept-level or planning-level VE study was conducted over an abbreviated 3-day period, with the intent of addressing and rating high level alternatives that have the potential for addressing existing treatment concerns and capacity issues at the WRF.

Although there was not sufficient time to develop full cost estimates for each proposal, the highest recommended proposals that have the potential, in the VE team's opinion, to improve plant operations and save cost are recommended to be further developed by the design team as part of CH2M HILL's upcoming preliminary design effort.

Technical representatives from CH2M HILL (not involved in Bend WRF planning or design to date) participated in the 3-day VE study. On Day 1 of the study, CH2M HILL design representatives presented information about the existing plant, and provided an overview of the Facilities Plan (FP) that had been prepared by Carollo Engineers, dated April 2008. City of Bend representatives participated in the VE orientation meeting on Day 1 by LiveMeeting™ (conference call) from Bend.

The VE team established criteria for evaluation of plant process alternatives, in categories such as Treatment Effectiveness, Plant Operations, Sustainability, and Cost-Saving Potential. Ideas were initially brainstormed by the VE team pertaining to all major plant unit processes. Advantages and disadvantages of the ideas were discussed in the analysis phase of the study, and each idea received a pass or fail rating.

The VE team prioritized alternatives as Priority 1, 2, or 3 (P1, P2, or P3). P1 alternatives are highly recommended for further technical evaluation in preliminary design, as are the moderate P2 proposals. The lower-rated proposals with a P3 rating are recommended to be dropped from further consideration due to the comments noted in the proposals that favor other higher rated proposals, the low potential for cost savings or improved performance, and the need to streamline the list to a manageable number of proposals for design team follow-up. Observations are also made for design team and City follow-up. For each of the P1 and P2 proposals, the VE team developed a narrative as to how well the proposal appears to meet the criteria.

During the VE study, 38 potential proposals were developed. Of these, 15 were rated P1, 9 P2, and 14 P3. For summaries, refer to the following:

> **Table 1—VE High Priority Proposal Summary**: identifies P1 proposals recommended by the VE team for follow-up during the predesign phase of the project.

Table 2—VE Observations: identifies additional comments made by the VE team to the design team and City. These "observations" are typically recommendations for features that should be included in the project, where possible. No additional evaluation is typically needed.

Table 3—VE Moderate Priority Proposal Summary: identifies P2 proposals recommended by the VE team for follow-up during the predesign phase of the project.

Table 4—VE Low Priority Proposal Summary: identifies P3 proposals, which are not recommended by the VE team for additional follow-up.

Table 5—VE Ideas that Failed during Analysis Phase: identifies the VE brainstormed ideas that failed upon further scrutiny, and are included in this report simply for documentation purposes.

The proposal narratives can be found in the body of this report. An overview of the VE methodology that was followed during the study is also included.

Following review of the Preliminary VE Report by the City of Bend and consultation with the CH2M HILL design team, CH2M HILL and the City determined the disposition of each proposal. This included identifying the proposals and observations that were 'Accepted for Further Review' while capturing any comments that the City or the VE Team provided regarding the proposals and observations. Again, Tables 1 and 3 present the High Priority (P1) and Moderate Priority (P2) proposals that the VE Team, along with the City, recommends for 'further review' during Predesign.

CH2M HILL plans to document the final VE study results as part of the follow-on predesign work.

TABLE 1
VE Proposal Summary, High Priority Proposals
Bend Water Reclamation Facility

Proposal No.	Proposal Description	Treatment Effectiveness Potential	Initial Cost-Saving Potential High > $1 Mil Mod $250K to $1 Mil Low < $250K	Ease of Future Operations and Maintenance (O&M)	Responds to Immediate Plant Priority	Overall VE Team Recommendation
	Primary Treatment (PT) Proposals					
PT-1	Chemically enhanced primary treatment (CEPT) in lieu of one or both of the new clarifiers.	High	Moderate	Moderate	Moderate	VE team strongly recommends this proposal for further evaluation during Predesign by the design team.
PT-2	Add the gravity thickener to improve capacity, in lieu of new clarifiers.	High	Moderate	Moderate	High	VE team strongly recommends this proposal for further evaluation during Predesign by the design team. Design team needs to evaluate thickener capacity versus future primary clarifier capacity to optimize the initial size.
PT-3	Step feed in lieu of: Sidestream treatment Aeration basin Secondary clarifier Ammonia addition (common to all step feed processes) Aeration basin and secondary clarifier	High	Moderate	Moderate	High	Step feed system addresses nitrogen removal capacity and wet weather treatment issues. VE team strongly recommends this proposal for further evaluation during Predesign by the design team. Future design should accommodate very rapid increases in wet weather flows.
PT-4	Wet weather (high flow) contact stabilization, versus current wet weather mode. Upsize the existing 12” line that leads to the first aerobic zone, and extend it to the most downstream aerobic zone.	High	Savings are reflected in step feed proposal	High	High	Regardless of other secondary improvements, the VE team recommends incorporating this feature into the selected aeration basin arrangement.
PT-5	Evaluate the conversion of third anoxic zone to swing zone in winter, as an option to baseline process, in lieu of filtrate reaeration.	Moderate	High	High	Low	Design team is requested to evaluate technical feasibility of this proposal, based on winter nitrification rates. If the proposal is technically feasible it could potentially save a lot of money. VE team strongly recommends this proposal for further evaluation during Predesign by the design team.

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PT-6	Provide bio-augmentation (seeding nitrifiers from sidestream treatment) in lieu of filtrate reaeration.	High	High	Moderate	High	VE team strongly recommends this proposal for further evaluation during Predesign by the design team.
PT-7	High intensity air rate in the first aerobic zone for bulking control in lieu of a secondary clarifier in the current project.	High	High	High	High	The VE team recommends further investigation of this proposal because of the value which could be realized if shown to be successful in reducing microthrix. VE team strongly recommends this proposal for further evaluation during Predesign by the design team.
PT-8	Biological foam removal (optimized skimming system on aeration basin) for microthrix filament control (surface waste).	High	High	High	High	Regardless of other secondary improvements, the VE team recommends incorporating this feature into the selected aeration basin arrangement. The VE team recommends further development of this feature by the design team (as to how to implement in the aeration basins, i.e. need for baffle walls, actual skimming device, etc.).
PT-9	Optimize RAS chlorination to enhance bulking control.	High	High	Moderate	High	VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal as part of plant operations. The VE team also recommends that current scum disposal practices be modified such that scum is not reintroduced to RAS or other plant recycle streams.

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Proposal No.	Proposal Description	Treatment Effectiveness Potential	Initial Cost-Saving Potential High > $1 Mil Mod $250K to $1 Mil Low < $250K	Ease of Future Operations and Maintenance (O&M)	Responds to Immediate Plant Priority	Overall VE Team Recommendation
PT-10	Chlorine surface sprays for filament control.	High	High	Moderate	High	Regardless of other secondary improvements, the VE team recommends incorporating this feature into the selected aeration basin arrangement. VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal. The VE team also recommends that current scum disposal practices be modified such that scum is not reintroduced to RAS or other plant recycle streams.
PT-11	Integrated fixed film activated sludge (IFAS), in lieu of current arrangement.	High	Moderate to low	Moderate	High	The VE team recommends that the design team evaluate this proposal further during Predesign. Performance enhancements and cost effectiveness of IFAS versus step feed systems needs to be evaluated, with the optimal proposal selected.
PT-12	Add a Primary Clarifier in the current project, and another in the future 2014+ project. This is the base facility plan approach and is a workable solution. The VE proposals generated compare to this base facility plan approach.	High	Low	--	--	VE team strongly recommends that this Base Facility Plan proposal be carried forward for further evaluation by the design team.
	Blower System (B) Proposals					
B-1	Replace existing multi-stage blowers with turbo blowers.	High	Moderate to low	High	High	The VE team recommends evaluation of high speed turbo blowers during Predesign to provide additional aeration capacity.

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	Secondary Clarifier (SC) Proposals					
SC-1	Direct connect RAS suction line to pumps to bypass the RAS wet well.	High	Moderate to low	High	High	Regardless of other secondary improvements, the VE team recommends incorporating this feature into the selected RAS arrangement. VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal.
SC-2	Full radius skimmer in lieu of smaller conventional scum trough.	High	Low	--	--	VE team recommends that the Design team work with Bend Operations staff to further evaluate this proposal as part of Predesign.

TABLE 2
VE Observations
Bend Water Reclamation Facility

No.	Observation Title
	Primary Treatment (PT)
PT-O-1	No upgrade viewed as necessary for next plant upgrade.
PT-O-2	Flow-pace or nitrate-pace mixed liquor recycle pumping.
PT-O-3	Increase mixed liquor recycle (MLR) and direct supplemental carbon for nitrogen removal. Observation. Consider only if discharge requirements become more stringent.
PT-O-4	Four-stage Bardenpho for nitrogen removal. Observation. Consider only if discharge requirements become more stringent.
PT-O-5	Denitrification filters. Observation. Consider only if discharge requirements become more stringent.
PT-O-6	Optimize the equalization of filtrate, which is the current plant operational standard. Observation. Detailed wastewater characterization required to optimize filtrate management.
	Blowers (B)
B-O-1	Consider utilizing blower manufacturer to front-fund blower system improvements, with payback over time.
B-O-2	Continue to utilize existing blowers, and add new to match existing blower type.
B-O-3	Improve air delivery control system to optimize energy usage.
B-O-4	Evaluate performance of different dissolved oxygen (DO) concentrations in aerobic zones, to minimize energy usage.
	Secondary Clarifier (SC) Proposals
SC-O-1	Evaluate existing baffles vs. industry best practice to improve clarifier performance. Coordinate with other clarifier improvements.
SC-O-2	Evaluate current clarifier inlet and replace with better floc well design. Coordinate with other clarifier improvements.
SC-O-3	Flow-pace RAS. Observation. Works primarily with direct connection of RAS pumps to secondary clarifier.
SC-O-4	Provide weir cleaning method. Observation. Check with plant staff about need.
SC-O-5	Separate scum from sludge lines per the current operation. Review record drawings for comments to RAS piping routing. Coordinate with tank drain piping modifications. Observation. High priority for design team follow-up.

TABLE 2
VE Observations
Bend Water Reclamation Facility

No.	Observation Title
	Disinfection (DI)
DI-O-1	Baseline recommendation from facilities plan: Convert to sodium hypochlorite, in lieu of chlorine gas. Observation. Concur.
DI-O-2	Support continued use of high energy mixing device (Waterchamp).
DI-O-3	Address need for split disinfection with the chlorine contact basins. Need improved understanding of how the Facility Plan team came to this recommendation. Coordinate with current re-use regulations.
DI-O-4	Automatic diversion for non-spec reuse water.
	Tertiary Treatment (TT)
TT-O-1	Current plant appears to have adequate capacity with current technology for tertiary treatment. Observation: No change recommended.
	Discharge (DIS) to Infiltration/Seepage Ponds and/or Water Reuse System
DIS-O-1	Comment on current plans for increased capacity of current infiltration/seepage pond system.
	Primary Sludge Thickening (PST)
PST-O-1	Pump style (diaphragm pump) appears to be appropriate for sludge pumping.
PST-O-2	Use gravity thickening to equalize primary sludge load to digesters, to improve gas production when gas is in demand.
PST-O-3	Co-thicken in the gravity thickener or centrifuge in lieu of the hybrid gravity belt thickener/belt filter press. Observation – suggest design team evaluate to provide backup capability.
	Digestion (DG)
DG-O-1	Heat recovery for building heat.
DG-O-2	Divert high strength waste directly to digester.
DG-O-3	Address degree to which industrial waste can be treated at industry prior to discharge to plant. Review benefits of waste from these sources, such as high BOD waste that the plant benefits from.
DG-O-4	Consider fill and spill conversion for foam control in digesters.
DG-O-5	Insulate digesters to avoid heat loss.
	Biosolids Dewatering (BD)
BD-O-1	Comment on current plan for second belt press. There is a lot of redundancy in this process compared to other processes.
	Land Application of Biosolids (LAB)
LAB-O-1	Existing land application process appears cost-effective.

TABLE 2
VE Observations
Bend Water Reclamation Facility

No.	Observation Title
	Support Facilities (SF)
SF-O-1	Concur with current approach to defer support facilities upgrades in favor of other priorities.
	Overall Plant Improvements (OPI)
OPI-O-1	Conduct a wastewater characterization study for influent, flow within the plant, and effluent, which are important for design and prioritization of the design package. Observation priority 1.
OPI-O-2	Confirm the current capacity analysis. Observation priority 2.
OPI-O-3	Evaluate need for immediate upgrades given the downturn in the economy. Observation, priority 3.
OPI-O-4	Comment on appropriate extent of automation within the plant.

TABLE 3
VE Proposal Summary, Moderate Priority Proposals
Bend Water Reclamation Facility

Proposal No.	Proposal Description	Treatment Effectiveness Potential	Initial Cost-Saving Potential High > $1 Mil Mod $250K to $1 Mil Low < $250K	Ease of Future Operations and Maintenance (O&M)	Responds to Immediate Plant Priority	Overall VE Team Recommendation
	Primary Treatment (PT)					
PT-18	Polyaluminum chloride (PAX) addition for bulking control.	High	Low	Moderate	High	The VE team recommends that the design team carry this Facility Plan recommendation (PAX for microthrix control) forward for further evaluation during Predesign. If the Predesign evaluation recommends PAX for microthrix control, a demonstration scale study should be conducted to prove performance.

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Proposal No.	Proposal Description	Treatment Effectiveness Potential	Initial Cost-Saving Potential High > $1 Mil Mod $250K to $1 Mil Low < $250K	Ease of Future Operations and Maintenance (O&M)	Responds to Immediate Plant Priority	Overall VE Team Recommendation
PT-19	Reduce fats, oils, grease (FOG) into aeration basins to enhance bulking control.	Moderate	Moderate	--	--	VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal as part of plant operations. The VE team believes that plant treatment effectiveness can be improved through reduction of FOG. CH2M HILL can provide additional assistance, as needed, for source control of FOG. The FOG program could entail enhanced digester gas production through the direct digestion of collected FOG material.

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Proposal No.	Proposal Description	Treatment Effectiveness Potential	Initial Cost-Saving Potential High > $1 Mil Mod $250K to $1 Mil Low < $250K	Ease of Future Operations and Maintenance (O&M)	Responds to Immediate Plant Priority	Overall VE Team Recommendation
	Activated Sludge, and Sidestream Process (AS) Proposals					
AS-1	Add RAS re-aeration, and to defer future aeration basin to 2017. This is the base facility plan approach.	Moderate	Moderate	Moderate	Moderate	Other VE proposals compare to this approach. The VE team does not feel that enough information was provided in the facilities plan to establish the likelihood of success for RAS re-aeration. VE team recommends that this Base Facility Plan proposal be carried forward into Predesign for comparison to other alternatives.
AS-2	High efficiency diffusers versus conventional membrane diffusers.	High	Low	High	--	This is a straightforward energy cost comparison that should be completed during Predesign in order to select the appropriate type of aeration diffuser. If this proposal is combined with the turbo blowers, then a significant energy savings may be realized.

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Proposal No.	Proposal Description	Treatment Effectiveness Potential	Initial Cost-Saving Potential High > $1 Mil Mod $250K to $1 Mil Low < $250K	Ease of Future Operations and Maintenance (O&M)	Responds to Immediate Plant Priority	Overall VE Team Recommendation
AS-3	Add one aeration basin in lieu of filtrate re-aeration plus one secondary clarifier.	High	Low	Moderate	High	This is an extension of the baseline facilities plan recommendation. It should serve as a basis against which other cost saving and functional proposals are compared, such as sidestream plus one aeration basin, or step feed, or IFAS.
AS-5	Reduce fats, oils, grease (FOG) into aeration basins to enhance bulking control.	Moderate	Moderate	--	--	VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal as part of plant operations.
	Blower System (B) Proposals					
B-2	Separate process aeration and mechanical mixing energy in last aerobic zone.	High	Low	High	Moderate	The VE team recommends this proposal be evaluated further by the design team for future aeration basins, to explore the potential for energy savings at the plant. Economics likely do not promote the retrofit of existing aeration basins.

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	Disinfection (DI) Proposals					
DI-1	Expand disinfection with UV disinfection rather than hypochlorite. Recommend UV for seepage pond water. Retain chlorine for reuse.	High	Low	Moderate	Moderate	The VE team recommends that the Design team evaluate the costs and potential for UV process implementation. This is a combination of processes that apparently was not evaluated in the facilities plan. There is a potential for a life-cycle cost benefit to the City.
	Digestion (DG) Proposals					
DG-1	Implement post-aerobic digestion for nitrogen removal.	High	Low	Moderate	High	The VE team recommends this proposal for further evaluation by the design team. Successful application of this proposal may eliminate the need for sidestream treatment alternatives.

TABLE 4
VE Proposal Summary, Low Priority Proposals
Bend Water Reclamation Facility

Proposal No.	Proposal Description	Treatment Effectiveness Potential	Initial Cost-Saving Potential High > $1 Mil Mod $250K to $1 Mil Low < $250K	Ease of Future Operations and Maintenance (O&M)	Responds to Immediate Plant Priority	Overall VE Team Recommendation
	Primary Treatment (PT) Proposals					
PT-13	Partial primary treatment, with bypass of remainder to secondary treatment process.	Low	Moderate	--	--	The VE team has proposed other alternatives that appear more favorable than this concept for primary treatment. This alternative can be eliminated from further consideration.
PT-14	Do nothing alternative: do not add any new clarifiers.	Low	Moderate	--	--	The VE team believes that viable alternatives to enhance primary clarification will provide needed capacity and improved performance. The do-nothing alternative is not recommended.
PT-15	Ferment primary sludge to improve nitrogen removal.	Moderate	Neutral	--	--	The VE team recommends the design team evaluate this proposal only if the wastewater characterization study shows primary effluent is unfavorable for nitrogen removal.
PT-16	Thicken primary sludge in gravity belt thickener (GBT) in lieu of deploying the gravity thickener.	High	Moderate or low	--	--	This proposal is not a high priority recommendation by the VE team. It can represent a cost savings, but has significant operational short-comings. This alternative can be eliminated from further consideration.
PT-17	Mixed liquor ozonation for filament control and sludge reduction.	High	Moderate or low	--	--	--

TABLE 4
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Proposal No.	Proposal Description	Treatment Effectiveness Potential	Initial Cost-Saving Potential High > $1 Mil Mod $250K to $1 Mil Low < $250K	Ease of Future Operations and Maintenance (O&M)	Responds to Immediate Plant Priority	Overall VE Team Recommendation
	Blower System (B) Proposals					
B-3	Add variable frequency drives (VFDs) to multistage blowers.	Moderate	Low	--	--	The VE team suggests that this proposal be considered only if multistage centrifugal blowers are found to be more cost-effective than high-speed turbo blowers.
	Secondary Clarifier (SC) Proposals					
SC-3	Optimize existing clarifiers by replacing existing mechanisms. Coordinate with other secondary clarifier improvement options.	Low	Cost increase	--	--	Acceptance of this proposal would be based on the City's need to replace the clarifier mechanisms. The design team should work with the City to confirm the condition assessment of the plant.
	Primary Sludge Thickening (PST)					
PST-1	Refit centrifuge for primary sludge thickening, in lieu of gravity thickener.	Moderate	High	--	--	Follow-up by the design team should be undertaken as part of the evaluation of overall solids handling alternatives.
	Waste Activated Sludge (WAS) Thickening Proposals					
WAS-1	Direct WAS to de-gassing basins as a redundancy measure, in lieu of new gravity belt thickener/belt filter press (GBT/BFP).	High	High	Low	High	VE team recommends that the Design team work with Bend Operations staff to further evaluate this proposal as part of Predesign. There is the potential for operational efficiencies and cost savings.
WAS-2	Provide thickened WAS storage, ahead of digestion	Moderate	Cost increase	--	--	A storage tank provides improved opportunity to store WAS. This would normally be provided in a

TABLE 4
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						new plant. Not highly recommended for follow-up by the design team.
	Digestion (DG) Proposals					
DG-1	Utilize acid gas digestion to reduce foaming concerns.	Low	Cost increase	--	--	This alternative was not considered a high priority by the VE team.
	Biosolids Dewatering					
BD-1	Use existing drying beds to back up the belt press, in lieu of adding a new belt press for dewatering solids.	High	High	High	High	The VE team suggests that given the current climate of limited funding, this proposal provides an opportunity for savings and directing those savings to other plant priorities.
BD-2	Use existing centrifuge as backup to belt press, in lieu of new belt press.	High	High	High	High	The VE team recommends that the Design team evaluate this alternative during Predesign as an alternative method of providing backup to a single belt filter press.
BD-3	Use storage in de-gas basin as backup to belt filter press.	High	High	--	--	The VE team recommends this alternative as another method of providing backup to a single belt filter press. The VE team's preference would be the drying beds or centrifuge as backup to the filter press.

TABLE 5
VE Ideas That Failed During Analysis Phase
Bend Water Reclamation Facility

Proposal No.	Proposal Description	Reason for Failing Idea
	Brainstorming Ideas that Failed:	
PT-F-1 Fail	Salsnes Filters (fine screen filters) in lieu of new primary clarifiers.	Not a well-proven technology. Results in head loss through pumping. Two parallel primary clarifier technologies.
PT-F-2 Fail	Provide enhanced biological phosphorus removal (EBPR), by converting first anoxic zone to an anaerobic zone, for filament control.	Potential struvite issues in the digester. Potentially reduced nitrogen removal. Won't work well with chemically enhanced primary treatment (CEPT).
PT-F-3	Simultaneous nitrification/denitrification (SNDN) for nitrogen removal.	Potential for increased bulking.
PT-F-4	Intermittent aeration in lieu of current process arrangement.	Microthrix can thrive in an intermittent air environment.
PT-F-5	Add floating high purity oxygen (HPO) aerators in lieu of current diffuser system	Complexity and cost of process.
PT-F-6	Ammonia stripping of filtrate in lieu of biological treatment.	Higher capital cost due to stripper and absorber towers. Higher chemical usage and cost.
PT-F-7	Struvite precipitation in lieu of filtrate re-aeration. (Only viable with BPR which was 'failed'.)	Need phosphoric acid and magnesium hydroxide addition. Much higher operating cost.
PST-F-1	Fournier Press to thicken primary sludge in lieu of gravity thickener.	Requires extensive pilot testing. Works best with highly fibrous sludge.
PST-F-2	Rotary drum thickener	Substantially increased odor issues Substantially increased maintenance
	Digestion (DG)	
DG-F-1	Utilize WAS pre-treatment to reduce foaming, such as: sonication; biogest; biolysis.	Increased cost through significant capital investment. Increased energy cost. Newer, as-yet unproven technology.
	Biosolids Dewatering (BD)	
BD-F-1	Use electrical fields to assist dewatering.	Newer technology, not yet fully proven. Higher energy cost.

TABLE 5
VE Ideas That Failed During Analysis Phase
Bend Water Reclamation Facility

Proposal No.	**Proposal Description**	**Reason for Failing Idea**
	Waste Activated Sludge (WAS)	
WAS-F-1	Provide WAS storage ahead of thickening	Not a cost saving proposal.

VE Overview

Introduction

Value engineering (VE) is a systematic problem-solving technique involving a thorough analysis of project functions using the collective experience and technical expertise of a qualified team to creatively consider design options. Public and private organizations conduct VE workshops, or studies, for their major projects in order to reduce costs while meeting the intended functions, and to maximize functionality for roughly the same cost.

CH2M HILL conducts two types of VE studies:

- Concept-level VE studies
- Mid-design VE studies

This VE study of the Bend Water Reclamation Facility (WRF) project evaluated wastewater plant process treatment options on a concept-level VE study basis. The study was conducted at the planning level phase of design.

To illustrate the importance of Value, Cost, and Function, value engineering can be represented by the following value equation: V = F/C.

- "V" stands for value from the owner's perspective. Value is achieved by either reducing cost but still accommodating the basic function, or by enhancing function for the same cost.
- "F" stands for function. Basic functions of the subject project under study can be described by simple verb-noun definitions, such as: "Protect Health," "Treat Waste," "Increase Capacity," and many other functions.
- "C" stands for cost of the function. High-cost functions become the subject of brainstorming, because various alternatives may be able to accomplish the basic function at a reduced cost.

This VE study of the Bend WRF Secondary Improvement Project was conducted by CH2M HILL for the City of Bend.

The VE orientation meeting was held at the Portland, Oregon, office of CH2M HILL on Tuesday morning, June 23, 2009. Objective VE team members from CH2M HILL who have not been involved in Bend WRF planning or design to date participated in the study. Design representatives from CH2M HILL discussed the existing plant conditions and provided an overview of the Water Reclamation Facilities Plan prepared by Carollo Engineers for the City of Bend in April 2008. City of Bend representatives provided an overview of the project history, plant conditions, and need for improvements regarding treatment effectiveness and expansion to meet growth in the community. The study continued on Wednesday, June 24 and Thursday, June 25, 2009, at CH2M HILL's Portland office.

The proposals and observations from the original VE study were included in a preliminary VE Report that was provided for the City's review and input. The CH2M HILL design team then coordinated with the City of Bend to determine the final disposition of the VE proposals and observations. The VE team has now documented the VE study results in this Final VE Report and plans to incorporate critical proposals and observations into the scope of the upcoming predesign work.

For further information about the content and schedule of the VE orientation meeting and study, please refer to the copies of the *VE Study Agenda* in the *Attachments* section of this report, which was distributed to participants in advance of the VE study.

VE Participants

The VE team members who participated in the 3-day VE study are identified below.

VE Team Members, June 23 through June 25, 2009

Full-Time CH2M HILL VE Team Members:
Paul Johnson, CVS, VE Team Leader
Steve Goodwin, P.E., Mechanical Process Engineer
Bruce Johnson, P.E., Principal Technologist (Wastewater Process)
Dimitri Katehis, P.E., Principal Technologist (Sidestream Process)
Stan Smith, P.E., Plant Operations Consultant

City of Bend Representatives Who Participated in the Live Meeting Conference Call on June 23:
Jim Wodrich, P.E., Project Manager
Scott Thompson, WRF Manager
Greg Mooney, WRF Operations Leader
Steve Simpson, Utilities Maintenance Supervisor
Steve Prazak, WRF Laboratory Manager
Peggy Spencer, Project Assistant

Design Team Members Who Presented Information to the VE Team on June 23:
Dave Green, P.E., Principal Project Manager
Brady Fuller, P.E., Predesign Manager
Bill Leaf, P.E., Lead Process Engineer (Secondary Treatment)
Michelle Burkhart, P.E., Lead Process Engineer (Primary/Solids Treatment)
Adrienne Menniti, PhD., Process Engineer

Project Description

The basis for the current project is defined in the 2008 Facilities Plan prepared by Carollo Engineers for the City of Bend. Figure 7.2, Table 7.2, and Table 7.3 from that Facilities Plan report are attached to this section of the VE Report to provide an understanding of the basis for the VE Study. Figure 7.2 shows the 2030 process flow schematic proposed in the 2008 Facilities Plan. Tables 7.2 and 7.3 show the scope of the Secondary Improvement Project, the estimated costs for major elements of the work, and the phasing of improvements proposed in the Facilities Plan.

In May 2009, City of Bend staff refined the cash flow (and implementation schedule) for the Facilities Plan Phase 1 and Phase 2 projects, modifying the phasing of the proposed improvements. City staff presented this refined cash flow schedule as the basis for the rate increases for the next 5 years, and this new cash flow schedule provided a targeted basis for the cost evaluations and phasing evaluated during the VE Study:

	FY10	FY11	FY12	FY13	FY14
WRF Secondary Improvement Project	$3.3M	$2.7M	$5.8M	$3.0M	$7.9M

The current capital costs estimate for the Bend WRF project is on the order of $20 million to $25 million for the fiscal year 2010 through 2014 expansion; and $15 million to $20 million for WRF improvements beyond 2014. Cost saving proposals were compared (in a relative manner) against this capital cost baseline, and projects will ultimately need to be phased to fit within the City's projected cash flow schedule.

General Approach

Since this project has completed facilities planning and no predesign has commenced, this VE study was intended to review work by others, and to validate the recommended approach or suggest alternative recommendations that provide more value or improved performance with reduced costs. An additional objective for this VE study is to provide value improvement to enhance the project, and improve the potential for reducing both the initial cost and the future cost of treatment requirements. Additionally, the VE study effort offers initial cost reduction options for consideration, if needed, to meet budget constraints, and help in the process of making informed decisions on design alternatives as the design process continues.

Study Methodology

During the VE study, the VE team moved through the following phases, as outlined in the attached *Agenda for Value Engineering Study at Conceptual Design.*

Information Phase

At the beginning of the study, the conditions and decisions that have influenced the development of the project must be reviewed and understood. For this reason, the VE team spent the first several hours of the study listening to the City of Bend and the CH2M HILL design team explain the various elements of the project. Items discussed included overview of the project's mission, functional requirements, content of the 2008 Facilities Plan that had been prepared by Carollo Engineers, existing process treatment concerns, capacity issues, and review of materials.

The VE facilitator then led the VE team through a discussion of team focus questions and answers, and identification of treatment process functions on a unit process basis through the WRF. These functions are documented and included in the VE Study Results section at the end of this section.

This effort allowed the VE team to be briefed on pertinent issues at the WRF, and brought the VE team up to speed on the functions of the project and where the significant improvements (and related expenses) are expected for this project.

Creative Phase

This VE study phase involved the creation and listing of ideas. During this phase, the VE team brainstormed alternates and developed as many ideas as possible to provide the necessary functions within the project at a potentially lower cost to the owner, or to improve the quality of the project within the budget limitations. Judgment of the ideas was restricted at this point. The VE team was charged with developing a large quantity of ideas and to identify associations between ideas. This phase also included the establishment of process treatment criteria on a unit process basis through the WRF.

Analysis Phase

During this phase of the VE study, the VE team judged the ideas generated during the creative phase. Therefore, each idea was compared with the present design concept in terms of how well it met the design intent. Advantages and disadvantages were discussed and recorded and the ideas were rated pass or fail.

Those that represented potential for cost savings were passed (approved for further study) and given a designation of “P” for “passed.”

Each “passed” proposal was then given a priority rating of high, moderate, or low (P1, P2, or P3) based on the VE team’s overall feeling about proposal viability.

Each idea was given a “treatment effectiveness” rating of high, moderate, or low (T1, T2, or T3) to indicate its potential for treatment effectiveness.

Each idea was also given a “cost” rating based on cost saving potential as follows: C1 for high potential savings over $1 million; C2 for moderate cost savings between $250,000 and $1 million; and C3 for cost savings less than $250,000.

In other cases, the designation of Observation for a design suggestion or recommendation was used. In most cases, these Observations were not intended as alternatives to the Facilities Plan, but, rather, design features that the VE Team recommends for incorporation into the upcoming design work.

This phase of the VE Study also included initial screening and ranking of alternative concepts for the proposed treatment options area by area through the plant. Criteria included:

- Applicability in Existing Plant
- Treatment Effectiveness
- Ease and Consistency of Operation
- Design Team Acceptance
- City of Bend Acceptance
- Sustainability and Energy Footprint
- Contractor Capability to Construct
- Future Operations and Maintenance

- Initial Cost Saving Potential
- Future Cost Saving Potential
- Net Life Cycle Cost Saving Potential
- Responds to Existing Significant Plant Deficiency
- Alternative Links to Other Processes
- Overall VE Team Recommendation for Design Team Follow-up

There was no effort to establish the relative importance of these criteria, because each criterion is considered an important topic for consideration against major treatment alternatives.

Development Phase

An evaluation of alternative ideas for the Bend WRF Project included narrative statements generated by the VE team, and a rating (high, moderate, or low) of how well the alternative appears to meet the criteria statement. A final recommendation was then made concerning design team follow-up in the predesign effort. In general, the alternatives (also called VE proposals) with P1 or P2 ratings were recommended for further study by the design team in the preliminary design phase. P3 (low priority) proposals were deemed by the VE team as possibilities for consideration, but were not recommended for further evaluation by the design team because other proposals rated P1 or P2 were rated higher and have a higher probability of improving technical performance, or economically addressing necessary capacity improvements at the plant. The VE Team recommends that the City and the CH2M HILL design team consider all proposals rated P1 or P2 as the VE study is reviewed and the results incorporated into the upcoming predesign and design work.

The data developed during the June 23-25 workshops are presented in the section of this report titled Proposal Development Data.

Presentation Phase

The compilation of ideas, observations, and cost analysis is presented in this report. The City of Bend and the CH2M HILL design team have reviewed this report, and met in July 2009 to discuss the proposals in further detail with City staff.

Implementation Phase

The final phase of the VE study is implementation. Owing to the abbreviated nature of this VE Study, this implementation phase will be incorporated into the upcoming predesign and design work. Through the course of the predesign and design work, the City and CH2M HILL design team will determine if the proposal items will be incorporated into the design, modified in some manner, or rejected. The final disposition of the VE study recommendations will be documented in the Predesign report.

Study Results

Introduction

The recommendations are the major feature of a VE study since they represent the benefits, or results, which can be realized on the project by the City. Results can be measured quantitatively in terms of accepted cost savings, and qualitatively in terms of accepted functional enhancements and mitigation of risk.

Expected Outcomes from the VE Study

- Generate independent, technically qualified recommendations to validate or adjust the Facilities Plan recommendations for technical solutions, process by process through the plant.
- Evaluate cost-effective solutions for plant unit processes, in order to show good stewardship and allow any reasonable savings to be directed to other priority projects within the City, such as collection system improvements.
- Focus on the 5-year plan through 2013, and also beyond as the current recommendations are expected to impact future capital improvement planning.
- Focus on life-cycle cost saving potential, with the appropriate capital cost investment in the current 5-year plan.

Team Focus Questions and Answers

What is the problem we are about to discuss?

a) Plant capacity is limited by both hydraulics and process.

b) The City would like more consistent nitrogen removal throughout the year.

c) Enhanced disinfection during the summer of the entire plant flow is inefficient.

d) There is limited redundancy through the solids processing train, for example in the waste activated sludge (WAS) process.

e) Cash flow is limited based on reduced system development charges (SDCs) and minimizing rate impacts over the next 5 years.

Why do we consider this a problem?

a) Limits the plant's ability to accept additional flow.

b) Consistent performance will reduce the likelihood of permit violation (and potentially reduce future regulatory risk) with regard to nitrogen removal.

c) Money is wasted on chemicals for disinfection during the summer re-use period.

d) Need reliability in producing thick digester feed solids.

e) Limited cash flow requires prioritization of plant components and phasing/staging over time to meet cash flow.

Why do we believe a solution is necessary?

a) If the plant capacity is not improved, it will limit economic development in the community.

b) To optimize plant operations for nitrogen removal to reduce the likelihood of a permit violation.

c) City would like to save money, and reduce the cost of reuse water production.

d) Good feed solids will offset the need to build additional digesters that may not be necessary.

e) City must remain within budgetary constraints of City's capital plan.

What are the top cost drivers on this project?

The budget for the current (initial) project for fiscal years 2010 through 2014, and the budget for improvements beyond FY 2014 are outlined in the table below (summarized from Facilities Plan Table 7.3).

Recommended Project Phasing Plan, Water Reclamation Facilities Plan, City of Bend

Project Element	Budget for FY 2010 through 2014	Budget beyond FY 2014
Influent piping and contact stabilization modifications	$1.52	
Primary clarifiers	$2.69	$2.32
Sidestream aeration basins	$3.29	
Aeration Basins		$3.93
Blowers	$1.42	$1.68
Secondary clarifiers and piping upgrades	$5.45	$3.12
Upgrade RAS pumps	$2.46	
Upgrade WAS pumps		$1.64
SVI Control	$0.51	
Disinfection	$2.04	
Solids handling	$1.25	$3.30
Site piping and improvements	$3.00	$1.74
TOTALS	**$23.63**	**$17.73**
Evaporation pond repairs (not included)		$1.31
Support facilities (not included)	$9.38	

Risk Areas

Following the design team's presentation, the VE team undertook a discussion of project risks in order to more fully understand the particular goals of this VE study. The following risks are believed to apply to the Bend WRF project:

- Not keeping up with plant capacity upgrades could limit the ability of the area to accommodate new development and/or industry.
- If City does not consistently meet nitrogen removal requirements, that could place the City in the position of having to implement more expensive upgrades in the future to meet more stringent nitrogen removal requirements.
- The treatment plant needs to continue to operate and meet treatment requirements while the plant is being upgraded.

The goal of the VE study is therefore to identify cost-saving measures that fully respect the treatment requirements within plant processes, which will help to deliver this project within budget.

Basic Functions of the Existing Project Components

During the Function Analysis Phase (part of the Information Phase), the VE team identified basic functions for each of the major project components included in the 2008 Facilities Plan. This exercise is helpful in bringing the VE team to a more complete level of understanding of the project goals, drivers, and purpose. Basic functions are described in simple verb–noun definitions, and are limited to the boundaries of the VE study. Basic functions are those addressing key areas of the project where opportunities for VE savings or performance improvements appear to exist. These functional categories provided the basis for organizing the Brainstorming phase of the VE Study, and the resulting proposals are grouped within these functional categories. The basic functions generated by the VE team are identified below.

Preliminary Treatment

Remove Trash
Protect Equipment
Screen Raw Sewage
Settle Grit
Dewater Screenings
Control Odor
Distribute Flow

Primary Treatment

Remove Solids
Settle Solids
Reduce BOD Load (to secondary treatment)
Remove Scum
Minimize Foam
Control Odor
Thicken Solids
Distribute Flow
Pump Solids

Activated Sludge Using a Modified Ludzack-Ettinger (MLE) Process

Remove Contaminants (BOD, Nitrogen, TSS)
Treat Wastewater
Meet Regulatory Requirements
Grow Biomass
Utilize Oxygen
Inject Oxygen
Mix Raw Sewage & Activated Sludge

Blowers

Provide Oxygen
Mix Activated Sludge

Secondary Clarifier

Remove Solids
Settle Solids
Thicken Solids
Clarify Effluent
Return Sludge to Process
Remove Scum
Waste Sludge from Process
Distribute Flow

Disinfection

Remove Pathogens
Prepare Effluent for Reuse
Measure Flow
Feed Disinfectant

Tertiary Filtration

Remove Solids
Pump Backwash
Reduce BOD
Prepare for Discharge
Meet Regulatory Requirements
Attain Turbidity Goal

Discharge to Infiltration/Seepage Ponds and/or Water Reuse System

Dispose of Effluent
Introduce Effluent into Environment
Water Golf Course

Primary Sludge Thickening

Remove Liquids
Reduce Volume of Solids

Improve Primary Treatment Capacity
Control Odors
Ferment Solids
Pump Solids
Equalize Solids

Waste Activated Sludge (WAS) Thickening

Remove Liquids
Reduce Volume of Solids
Control Odors
Pump Solids
Equalize Solids

Digestion

Stabilize Solids
Reduce Volume of Solids
Produce Biogas
Reduce Pathogens
Feed Solids
Burn Gas
Heat Sludge
Mix Sludge
Collect Foam

Biosolids Dewatering

Remove Liquids
Reduce Volume of Solids
Control Odors
Pump Solids
Equalize Solids
Store Solids
Dry Solids

Filtrate Treatment (Sidestream Process)

Handle Filtrate
Remove Nitrogen
Pump Filtration
Remove Phosphorus
Increase Nitrogen Capacity Removal
Add Oxygen
Equalize Nutrient Return

Land Application of Biosolids

Solids Disposal
Beneficial Reuse
Solids Storage

Solids Transport

Support Facilities

Plant Drainage
Plant Water
Plant Administration
Analyze Samples
Control Process
Comply with Permits
Maintain Plant

Overall Plant Improvements

Increase Plant Capacity
Promote Economic Development
Comply with Permit
Prevent Disease
Consistent Treatment
Accommodate Community Growth
Protect Environment
Improve Sustainability
Reuse Resources (Biogas, Reclaimed wastewater, Biosolids)
Reduce Consumables (Energy, Chemicals)
Stage Construction

VE Proposals and Observations

The VE team generated numerous ideas for change during the Creative Ideas phase of the VE job plan. The evaluation of these ideas during the Analysis and Development phases was based upon their potential for process improvements, perceived acceptability by the design team and City, cost savings potential, ease of future operations, constructability, and other criteria identified above. The VE team worked together to evaluate each of the ideas coming out of the Creative Ideas phase, ranking each proposal, and categorizing them for further consideration.

During this evaluation process, a variety of implementable cost-savings and design enhancement opportunities were found. The recommendations of this study are presented as alternates for further evaluation in the preliminary design phase, or reminders to the design team of certain functional or risk issues to keep in mind as the design progresses. The VE Team recommends that all Priority 1 (P1) and Priority 2 (P2) proposals are reviewed with City staff for consideration as alternatives for evaluation during the Predesign phase of the project. All of the proposals studied are described below in the *Proposal Development* section of this Preliminary Value Engineering Report.

Cost Estimating

The VE team reviewed the Facility Plan cost estimates, focusing on high-cost components where there is the opportunity for VE savings or functional enhancements to the project.

These estimates, dated April 2008, total almost $24 million through FY2014, expressed in year 2008 costs.

Given the planning level status of the cost estimates, the abbreviated VE study period, the VE team did not produce detailed cost estimates for each of the individual proposals, but they did identify the potential cost savings, categorizing each proposal with the following ratings: C1 for high potential savings over $1 million; C2 for moderate cost savings between $250,000 and $1 million; and C3 for cost savings less than $250,000.

Figure from 2008 Facilities Plan

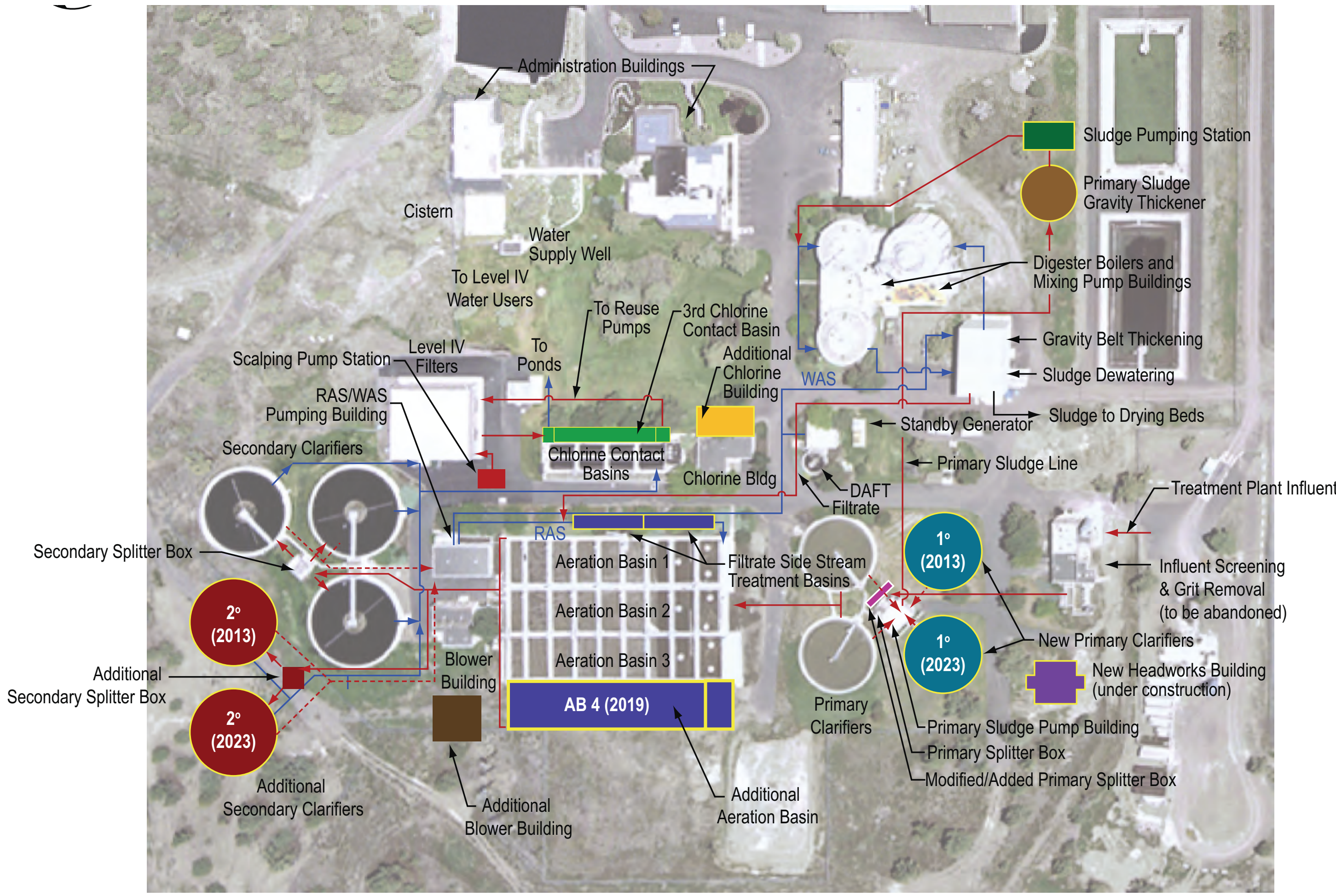


Figure 7
Recommended Facilities Expansion
WATER RECLAMATION FACILITIES PLAN

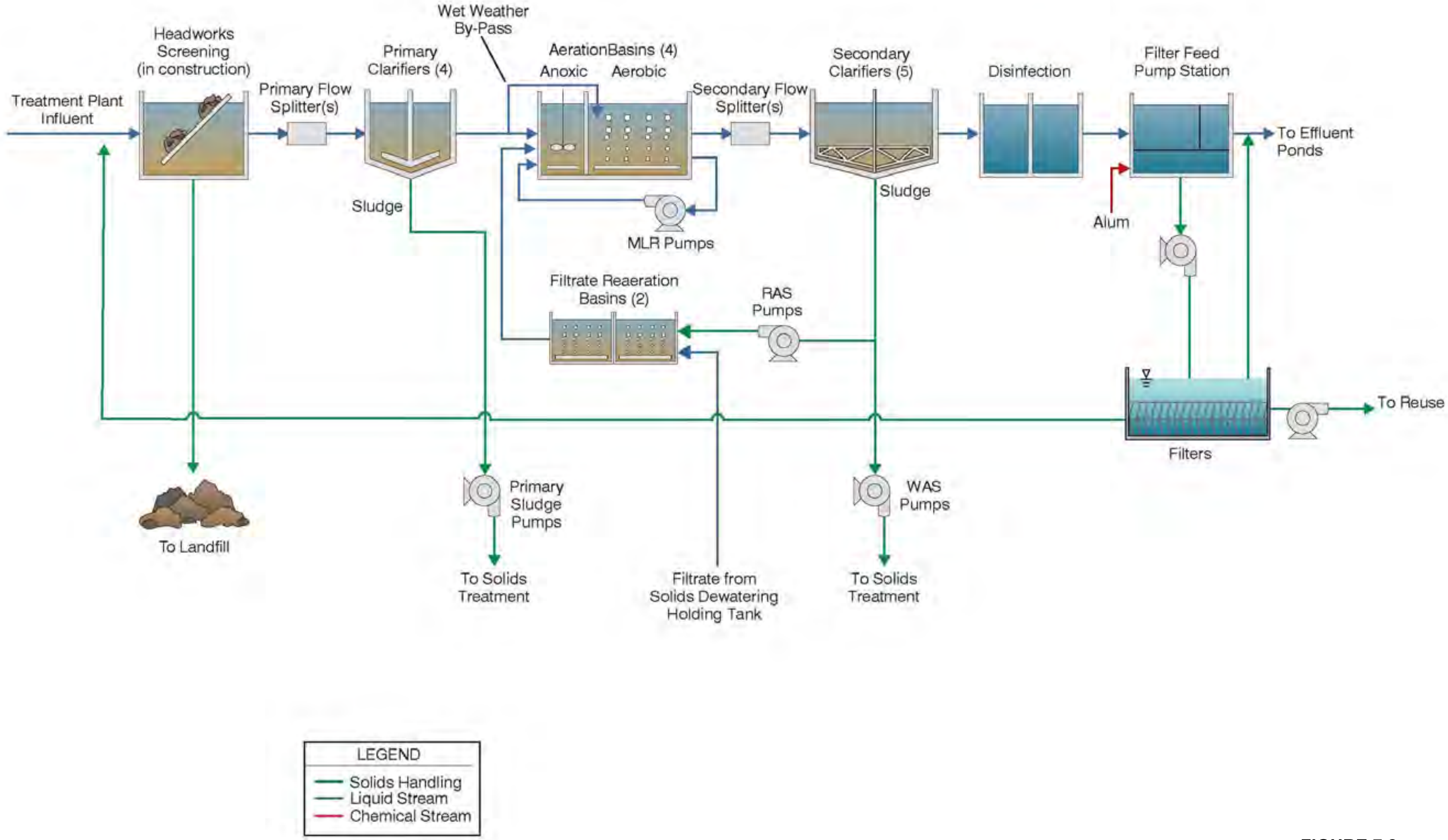


FIGURE 7.2
PROCESS FLOW SCHEMATIC
WATER RECLAMATION FACILITIES PLAN
CITY OF BEND

Table 7.2 Capital Improvements Phasing Schedule
Bend WRF Facilities Plan

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

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

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

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

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

Proposal Development Data

The development, creation, and analysis phases of the value engineering (VE) study resulted in the data presented in this section. The data were produced during the June 23 to 25, 2009, workshops conducted by CH2M HILL for the City of Bend in Portland, Oregon.

Preliminary Treatment

Proposal No. PT-O-1 Comment on new preliminary treatment processes and headworks facility at the plant. Observation: No upgrade viewed as necessary for next plant upgrade.

Primary Treatment

Proposal No. PT-12 Facility Plan: Add a Primary Clarifier in the current project, and another in the future 2014+ project. P1, T1, C3 This is the base facility plan approach, and is a workable solution. The VE proposals generated compare to this base facility plan approach. Comments are provided in each of those proposals as to treatment effectiveness, O&M issues, cost, and other factors comparing the alternatives against the base approach.		
Advantages		Disadvantages
• Conventional approach. • Very reliable technology.		• Higher initial capital cost.
Overall Recommendation for Design Team Followup	High	VE team strongly recommends that this Base Facility Plan proposal be carried forward for further evaluation by the design team.

Proposal No. PT-1 Chemically enhanced primary treatment (CEPT) in lieu of one or both of the new clarifiers. P1, T1, C2		
Advantages		Disadvantages
• Improved BOD removal. • Possible benefits for Microthrix reduction. • Improved aeration capacity. • Improved digester biogas production. • Can be used intermittently.		• Higher operating cost, but probable overall life-cycle cost saving. • Increases load to digesters. • Adding a chemical feed unit process.
Criteria	Rating	Comment
Applicability in Existing Plant	High	Plant arrangement lends itself to applying CEPT.
Treatment Effectiveness	High	CEPT results in high capability for treatment effectiveness in the primary treatment process.
Ease and Consistency of Operation	High	Can use a highly automated chemical feed control system pace the dose. System can be readily turned off and on. Consider running system in the winter to enhance nitrification. May not need to be on in the summer when it is easier to nitrify.
Design Team Acceptance	Moderate	CEPT is a departure from the addition of a primary clarifier. This represents a departure from the current design approach, and will require further evaluation by the design team.
City of Bend Acceptance	Moderate to Low	CEPT requires operation of a new chemical feed system. Staff members are not yet familiar with this process.
Sustainability and Energy Footprint	Moderate	CEPT required ongoing energy related to production and hauling of chemical relative to the one-time costs associated with energy associated with construction of additional clarifier volume. For each alternative consider: chemical production and hauling; Primary Sludge

		pumping; Digester mixing, heating, solids processing; Solids disposal. Also consider avoided cost of clarifier construction and related impacts. Also consider any improvements to digester performance and maintenance.
Contractor Capability to Construct	High	Construction is straightforward with a chemical feed building and small diameter pipe.
Future Operations and Maintenance	Moderate	Future O&M will increase due to the addition of a new chemical process.
Initial Cost Saving Potential	Moderate	Requires further evaluation. Savings is in how long the City can defer the construction of a new third clarifier. CEPT system can still be used even after the addition of the third clarifier which then defers or eliminates the addition of a fourth clarifier.
Future Cost Saving Potential	Moderate	Requires further evaluation. CEPT represents future chemical cost, offset by other aeration costs in the secondary system.
Net Life Cycle Cost Saving Potential	Moderate	Requires further evaluation.
Responds to Existing Significant Plant Deficiency	Moderate	CEPT contributes to flexibility in options the city needs to deal with in uncertain community growth patterns, depending upon the economy and resulting rate of growth.
Alternative Links to Other Processes	Moderate	Reduced aeration requirements. CEPT creates a beneficial sludge mix going to the digesters.
Overall Recommendation for Design Team Followup	High	VE team strongly recommends this proposal for further evaluation during Predesign by the design team.

Proposal No. PT-F-1

Salsnes Filters (fine screen filters) in lieu of new primary clarifiers.

Fail

Advantages	Disadvantages
• Small and inexpensive. • Provides equivalent removal compared to primary clarifiers.	• Not a well-proven technology. • Results in head loss through pumping. • Two parallel primary clarifier technologies.

Proposal No. PT-13 Partial primary treatment, with bypass of remainder to secondary treatment process. P3, T3, C2		
Advantages		Disadvantages
• Would bypass high wet weather flows directly to the secondary treatment process. • Possibly saves cost of adding a third primary clarifier. • Improves hydraulics through primary treatment.		• Bypasses a treatment step which may create a regulatory concern. • Increased loading on secondary process. • Need to provide a more complicated control step for bypassing from primary to secondary processes.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Low P3 Rating	The VE team has proposed other alternatives that appear more favorable than this concept for primary treatment. This alternative can be eliminated from further consideration.

Proposal No. PT-2 Add the gravity thickener to improve capacity, in lieu of new clarifiers. P1, T1, C2	
Advantages	Disadvantages
• Improved wet weather capacity. • Reduced opportunity for odor issues. • Improved primary treatment performance. • More uniform feed to digesters.	• Adds another unit process. •

• Thicker feed to digesters. • Overall savings by omitting a clarifier, compared to added cost to bring the gravity thickener into the current project.		
Criteria	Rating	Comment
Applicability in Existing Plant	High	VE team believes gravity thickener will increase primary clarifier capacity while providing thicker and more consistent feed to the digesters.
Treatment Effectiveness	High	Moving the thickening process to the gravity thickeners allows clarifiers to operate at a lower sludge blanket, and also achieves a higher concentration feed to the digesters compared to thickening in the primary clarifiers themselves.
Ease and Consistency of Operation	High	Gravity thickening is fundamentally a simple operation. It is primary sludge which does not typically exhibit compaction problems.
Design Team Acceptance	High	Gravity thickeners are commonly employed in treatment plants for this purpose.
City of Bend Acceptance	Moderate	Gravity thickening was proposed in the facilities plan, but at a later stage than is currently proposed by the VE team.
Sustainability and Energy Footprint	Moderate	Small gravity thickener saves requirement for more total clarifiers. Small motor load on thickener mechanism, and incremental increase in pumping power (double pumping required) from clarifer to digester.
Contractor Capability to Construct	High	Straightforward construction operation.
Future Operations and Maintenance	Moderate	Adding new gravity thickeners are simple to operate, but add additional pumps and equipment to operate and maintain.
Initial Cost Saving Potential	Moderate	Proposal defers the cost of a third clarifier, and a thickener costs less to build than a clarifier.
Future Cost Saving Potential	Moderate	Proposal defers the cost of a future fourth clarifier, and a thickener costs less to build

		than a clarifier.
Net Life Cycle Cost Saving Potential	Moderate	See above.
Responds to Existing Significant Plant Deficiency	High	Additional primary capacity is required, and gravity thickening addresses this concern.
Alternative Links to Other Processes	Moderate	Gravity thickeners will send thicker and more consistent feed to digesters.
Overall Recommendation for Design Team Followup	High	VE team strongly recommends this proposal for further evaluation during Predesign by the design team. Design team needs to evaluate thickener capacity versus future primary clarifier capacity to optimize the initial size.

Proposal No. PT-14 Do nothing alternative: do not add any new clarifiers. P3, T3, C2		
Advantages		Disadvantages
• Cost saving.		• Reduced primary removal capacity. • Higher aeration cost. • Needs full scale testing to assess performance.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Low P3 Rating	The VE team believes that viable alternatives to enhance primary clarification will provide needed capacity and improved performance. The do-nothing alternative is not recommended.

Proposal No. PT-15 Ferment primary sludge to improve nitrogen removal. P3, T2, C-neutral	
Advantages	Disadvantages

• Improved nitrogen removal. • Inexpensive and straightforward to implement.		• Increased odor control requirements. • Reduced biogas production. • Reduced secondary capacity due to increased BOD load.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Low P3 Rating	The VE team recommends the design team evaluate this proposal only if the wastewater characterization study shows primary effluent is unfavorable for nitrogen removal.

Proposal No. PT-16 Thicken primary sludge in gravity belt thickener (GBT) in lieu of deploying the gravity thickener. P3, T1, C1, or C2		
Advantages		Disadvantages
• Cost saving. • Thicker overall feed to digester. • Increased digester capacity. • Lower polymer consumption.		• Substantially increased odor control requirement. • Possible resistance from operations staff.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Low P3 Rating	This proposal is not a high priority recommendation by the VE team. It can represent a cost savings, but has significant operational short-comings. This alternative can be eliminated from further consideration.

Activated Sludge Process, and Sidestream Process

Proposal No. AS-1 Existing Plan: To add Filtrate/RAS re-aeration, and to defer future aeration basin to 2017. P2, T2, C2

Advantages	Disadvantages
• Modest cost saving potential. • Easy to add this process while keeping existing plant in service.	• Uncertain methods of operation. • Large scale pilot testing would be required.

Criteria	Rating	Comment
Applicability in Existing	Questionable	Other VE proposals compare to this approach. The VE team does not feel that enough information was provided in the facilities plan to establish the likelihood of success for Filtrate/RAS re-aeration.
Treatment Effectiveness		See above comment regarding treatment effectiveness. VE team recommends that this Base Facility Plan proposal be carried forward into Predesign for comparison to other alternatives.
Ease and Consistency of Operation	Moderate	New unit process at WRF. Requires additional monitoring, pumping
Design Team Acceptance	Moderate	Other VE proposals compare to this approach.
City of Bend Acceptance	Moderate	City recognizes history of operating experience in select locations, but open to other effective proposals from VE team.
Sustainability and Energy Footprint	Low	Only defers impact of additional aeration basin. (does not add
Contractor Capability to Construct	High	Can construct and commission off-line from rest of treatment process. Limited cut-ins required.
Future Operations and Maintenance	Moderate	New unit process requires additional O&M.
Initial Cost Saving Potential	High	Defers aeration basin.
Future Cost Saving Potential	Low	Defers, but does not eliminate required aeration basin capacity.
Net Life Cycle Cost Saving Potential	Moderate	
Responds to Existing Significant Plant	Moderate	Addresses peak ammonia loads and total N removal, but does not address fundamental

Deficiency		secondary capacity increase.
Alternative Links to Other Processes	Low	Limited effect on other processes.
Overall Recommendation for Design Team Followup		Carry forward in predesign and compare to alternative VE proposals. See above comment in treatment effectiveness.

Proposal No. AS-2 High efficiency diffusers versus conventional membrane diffusers. P2, T1, C2 or C3		
Advantages		Disadvantages
• Life-cycle cost saving. • Reduced greenhouse gas production. • Reduced energy usage.		• Relatively new technology.
Criteria	Rating	Comment
Applicability in Existing Plant	Moderate	Consider effects of conventional membrane and high efficiency diffusers operating on same headers. Include this in energy incentive application to Central Electric Cooperative.
Treatment Effectiveness	High	No fundamental changes in aeration basin operation.
Ease and Consistency of Operation	High	No fundamental changes in aeration basin operation.
Design Team Acceptance	High	Experience in North America.
City of Bend Acceptance	Moderate	Unsure of City knowledge of equipment.
Sustainability and Energy Footprint	High	Improves overall efficiency of oxygen transfer, reducing blower loads.
Contractor Capability to Construct	Moderate	Requires sequentially taking basins out of service. Retrofit is straightforward.
Future Operations and	High	No fundamental changes in aeration basin

Maintenance		operation.
Initial Cost Saving Potential	Low	Have to make capital investment. Eligible for efficiency incentives from BPA/Central Electric.
Future Cost Saving Potential	High	If this proposal is combined with the turbo blowers, then a significant energy savings may be realized.
Alternative Links to Other Processes	High	If this proposal is combined with the turbo blowers, then a significant energy savings may be realized.
Overall Recommendation for Design Team Followup	High	This is a straightforward energy cost comparison that should be completed during Predesign in order to select the appropriate type of aeration diffuser. If this proposal is combined with the turbo blowers, then a significant energy savings may be realized.

Proposal No. PT-3

Step feed in lieu of:

a) Sidestream treatment

b) Aeration basin

c) Secondary clarifier

d) Ammonia addition (common to all step feed processes)

e) Aeration basin and secondary clarifier.

P1, T1, C1

Advantages	Disadvantages
• Provides more treatment capacity out of a given volume of bioreactor. • Can adjust step feed to give needed ammonia to effluent. • Could eliminate ammonia feed at disinfection process. • Save power cost. • Process is done effectively at Rock Creek	• More complicated operation but automation simplifies operation. •

AWTF with support of operations staff. • More efficient nutrient removal. • More flexibility for sludge volume index (SVI) control.	

Criteria	Rating	Comment
Applicability in Existing Plant	High	VE team believes that incorporating step feed into current and future aeration basin arrangements can provide numerous benefits and increased operational flexibility.
Treatment Effectiveness	High	Step feed arrangement can enhance nitrogen removal and wet weather treatment.
Ease and Consistency of Operation	Moderate	More complicated flow split within basins, but automation can be utilized to control the splits.
Design Team Acceptance	Moderate	Relatively new application to northwest.
City of Bend Acceptance	Low	City's experience with step feed has not been positive; therefore, the design team needs to explain how this step feed system under consideration overcomes previous short-comings.
Sustainability and Energy Footprint	High	Maximizes function of existing basins. Limited additional infrastructure or power required.
Contractor Capability to Construct	Moderate	Step feed involves modifications of existing basins while keeping other elements of the plant in service during construction.
Future Operations and Maintenance	Moderate	There will be a learning curve for staff, but ultimately the VE team believes that the step feed system will overcome current capacity limitations.
Initial Cost Saving Potential	Moderate	Step feed system could potentially eliminate or defer the construction of a secondary clarifier, and sidestream treatment.
Future Cost Saving Potential	High	Over the long run a step feed system could eliminate or defer a future aeration basin.
Net Life Cycle Cost	High	Significant opportunity for eliminated or

Saving Potential		deferred capital cost requirements.
Responds to Existing Significant Plant Deficiency	High	Step feed system addresses nitrogen removal capacity and wet weather treatment issues. Future design should accommodate very quick wet weather flow peaks.
Alternative Links to Other Processes	High	See also blower, SVI control, and other secondary process-related proposals.
Overall Recommendation for Design Team Followup	High	Step feed system addresses nitrogen removal capacity and wet weather treatment issues. VE team strongly recommends this proposal for further evaluation during Predesign by the design team. Future design should accommodate very rapid increases in wet weather flows.

Proposal No. PT-4

Wet weather (high flow) contact stabilization, versus current wet weather mode. Upsize the existing 12" line and valve (or add second parallel line and valve) that leads to the first aerobic zone, and extend it to the most downstream aerobic zone.

P1, T1, C1

Advantages	Disadvantages
• More efficient inventory management. • Reduced likelihood of washout. • Essentially the same as RAS re-aeration without filtrate.	• Intermittent operation. • May be a need to augment the air diffuser grid.

Criteria	Rating	Comment
Applicability in Existing Plant	High	This option is common to all proposed basin configurations and represents an upgrade above what the existing plant has now.
Treatment Effectiveness	High	Modifications will improve treatment effectiveness under high flow conditions.
Ease and Consistency of Operation	High	Operation is on/off, and is straightforward.
Design Team Acceptance	High	Straightforward idea to implement.
City of Bend	High	Proposal is a direct improvement over an

Acceptance		existing plant component.
Sustainability and Energy Footprint	High	Low energy use. Limited new infrastructure requires (pipe, valves, controls).
Contractor Capability to Construct	High	Just adding pipe and valves, electrical, and instrumentation.
Future Operations and Maintenance	High	Proposal adds future O&M flexibility, similar to what the plant has now.
Initial Cost Saving Potential	Savings is reflected in step feed proposal.	Cost saving is primarily reflected in the step feed proposal, through elimination or deferral of a future aeration basin and clarifier.
Future Cost Saving Potential	Savings is reflected in step feed proposal.	See above.
Net Life Cycle Cost Saving Potential	Savings is reflected in step feed proposal.	See above.
Responds to Existing Significant Plant Deficiency	High	Existing 12" pipe arrangement is undersized.
Alternative Links to Other Processes	Moderate	This proposal for contact stabilization would be provided whether the step feed system or parallel flow system is selected. This proposal is limited to the aeration basin.
Overall Recommendation for Design Team Followup	High	Regardless of other secondary improvements, the VE team recommends incorporating this feature into the selected aeration basin arrangement.

Proposal No. PT-5

Evaluate the conversion of third anoxic zone to swing zone in winter, as an option to baseline process, in lieu of filtrate re-aeration.

P1, T1, C1

Advantages	Disadvantages
• Cost saving. • Increased treatment flexibility.	• Cost

Criteria	Rating	Comment
Applicability in Existing Plant	Moderate	Relatively minor modification to existing plant would be needed to implement.
Treatment Effectiveness	Moderate	There may not be enough volume in the anoxic zone for this alternative to be possible. Design team is requested to investigate further.
Ease and Consistency of Operation	High	Operation involves turning a mixer on and off, and opening/closing air line isolation valves.
Design Team Acceptance	Moderate	Acceptance of proposal will be based on further evaluation of merits of this proposal.
City of Bend Acceptance	Moderate	Design team would only recommend this proposal if upon further evaluation they find it to have technical merit.
Sustainability and Energy footprint	High	Maximizes use of existing basins.
Contractor Capability to Construct	High	Straightforward construction.
Future Operations and Maintenance	High	Simple process upgrade.
Initial Cost Saving Potential	High	Cost savings is high, but contingent upon further research as to technical merit, and successful application of this proposal.
Future Cost Saving Potential	High	Cost savings is high, but contingent upon further research as to technical merit, and successful application of this proposal.
Net Life Cycle Cost Saving Potential	High	Cost savings is high, but contingent upon further research as to technical merit, and successful application of this proposal.
Responds to Existing Significant Plant Deficiency	Low	Proposal is more of an enhancement than an opportunity to address an immediate plant priority.
Alternative Links to Other Processes	High	Dovetails with step feed proposal.
Overall Recommendation for Design Team	High	Design team is requested to evaluate technical feasibility of this proposal, based on winter nitrification rates. If the proposal

Followup		is technically feasible it could potentially save a lot of money. VE team strongly recommends this proposal for further evaluation during Predesign by the design team.

Observation No. PT-O-2 Flow-pace or nitrate-pace mixed liquor recycle pumping.		
Advantages		Disadvantages
• More effective nitrogen removal. • Pumping cost savings, because matching recycle with flow that needs to be denitrified. • Reduced greenhouse gas production potential from denitrification process.		• Somewhat more complicated system with an automation requirement; involves nitrate analyzers.
Discussion The VE team recommends providing a pacing mechanism for the mixed liquor recycle pumps. Pacing based on nitrate exiting primary anoxic zones is preferred, because it establishes the actual treatment taking place in those zones. Flow pacing could be used as a backup method. The value in pacing comes from saving energy from pumps that are transferring up to 400% of the plant influent flow, and treating only that flow for which the anoxic zones have capacity.		
Overall Recommendation for Design Team Followup	Operational Recommendation	VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal as part of plant operations.

Proposal No. PT-6 Provide bio-augmentation (seeding nitrifiers from sidestream treatment) in lieu of filtrate re-aeration. P1, T1, C1 or C2	
Advantages	Disadvantages
• Increased nitrification capacity at low temperature and lower solids retention time (SRT). • Rapid recovery from potential nitrification process.	• An additional process to monitor and run. • Operations buy-in may require a full scale pilot test.

• Potentially reduces the number of aeration basins. • Works with, and provides benefits to, all proposed secondary treatment processes.		
Criteria	Rating	Comment
Applicability in Existing Plant	High	This is an enhancement of the base Facilities Plan sidestream re-aeration proposal.
Treatment Effectiveness	High	See advantages.
Ease and Consistency of Operation	Moderate	An additional process to monitor and run. Operations buy-in may require a full scale pilot test.
Design Team Acceptance	Moderate	This is a relatively new treatment process in the northwest.
City of Bend Acceptance	Moderate to Low	May require full scale testing for full acceptance.
Sustainability and Energy Footprint	Moderate	Requires additional unit process with limited treatment capacity, but improves efficiency and capacity of existing process tanks.
Contractor Capability to Construct	High	Implementation of bio-augmentation system could be done independent of aeration basin modifications.
Future Operations and Maintenance	Moderate	Bio-augmentation is not a difficult process to operate, but it is an additional one.
Initial Cost Saving Potential	High	High cost saving potential, if the design team's analysis shows that the additional basin can be deferred or eliminated.
Future Cost Saving Potential	High	See above.
Net Life Cycle Cost Saving Potential	High	See above.
Responds to Existing Significant Plant Deficiency	High	Responds to capacity limitation issues, relating to nitrogen removal.
Alternative Links to	High	Bio-augmentation can be used with a number of other proposed options, such as

Other Processes		CEPT, step feed, contact stabilization, and swing zone.
Overall Recommendation for Design Team Followup	High	VE team strongly recommends this proposal for further evaluation during Predesign by the design team.

Proposal No. AS-3 Add one aeration basin in lieu of filtrate re-aeration plus one secondary clarifier. P2, T1, increased cost	
Advantages	Disadvantages
• Greater capacity potential. • Simpler operations. • Well understood process.	• Could cost more, due to larger unit process. • Reduced nitrification capacity at low temperatures (for part a). • Uses more air, resulting in higher power cost.

Criteria	Rating	Comment
Applicability in Existing Plant	High	This is an extension of the baseline facilities plan recommendation. It should serve as a basis against which other cost saving and functional proposals are compared, such as sidestream plus one aeration basin, or step feed, or IFAS.
Treatment Effectiveness	High	Known unit process.
Ease and Consistency of Operation	High	Adds more of existing process at WRF.
Design Team Acceptance	High	Straightforward to design.
City of Bend Acceptance	High	Known unit process.
Sustainability and Energy Footprint	Moderate	Compared to some of the VE team proposals for sidestream treatment, may require more infrastructure for buildout conditions.
Contractor Capability	High	Construct and commission off-line from

to Construct		existing operation. Requires typical tie-ins and shutdowns to make it work.
Future Operations and Maintenance	Moderate	More of the same unit process.
Initial Cost Saving Potential	Low	Probably the most expensive secondary process alternative.
Future Cost Saving Potential	Moderate	A new basin is needed eventually.
Net Life Cycle Cost Saving Potential	Moderate	
Responds to Existing Significant Plant Deficiency	High	Plant needs secondary capacity now.
Alternative Links to Other Processes	Moderate	A number of other proposals for secondary process would interact with this base case (methods for SVI control for instance).
Overall Recommendation for Design Team Followup	Moderate	This is an extension of the baseline facilities plan recommendation. It should serve as a basis against which other cost saving and functional proposals are compared, such as sidestream plus one aeration basin, or step feed, or IFAS.

Proposal No. PT-7

High intensity air rate in the first aerobic zone for bulking control in lieu of a secondary clarifier in the current project.

P1, T2, C1

Advantages	Disadvantages
• Potentially reduces microthrix. • Significant cost-saving potential. • Can avoid a future secondary clarifier.	• May need a full scale pilot test to prove process. • Modifications to existing basins' aeration system required.

Criteria	Rating	Comment
Applicability in Existing Plant	High	Includes creation of a high intensity aeration grid to create aerobic selector to combat microthrix.

Treatment Effectiveness	High	New selector arrangement shows promise, but may need further investigation. Its goal is to biologically prevent SJG - No, reduce is the correct term – unlikely to actually prevent its growth, just want to control it to manageable levels. microthrix.
Ease and Consistency of Operation	High	Involves application of a high intensity aeration grid, with very little additional operator attention required.
Design Team Acceptance	High	Requires further development of specific design details by the design team.
City of Bend Acceptance	High	Involves application of a high intensity aeration grid, with very little additional operator attention required.
Sustainability and Energy footprint	Moderate	VE team thinks this solution is likely to reduce SVI problem, but does require a high level of aeration to make it work. (ie, provide more air than process needs at this location)
Contractor Capability to Construct	Moderate	Will require taking a train down for construction implementation while keeping remainder in operation.
Future Operations and Maintenance	High	If it effectively controls microthrix, then operations will be enhanced considerably.
Initial Cost Saving Potential	High	If the process is proven to work effectively, it could eliminate or defer a secondary clarifier and could reduce or eliminate RAS chlorination.
Future Cost Saving Potential	High	See above.
Net Life Cycle Cost Saving Potential	High	See above.
Responds to Existing Significant Plant Deficiency	High	Is part of an overall plan to significantly reduce microthrix caused sludge bulking problems.
Alternative Links to Other Processes	High	This proposal links to all other aeration basin and SVI control proposals.
Overall Recommendation for	High	The VE team recommends further investigation of this proposal because of the

Design Team Followup		value which could be realized if shown to be successful in reducing microthrix. VE team strongly recommends this proposal for further evaluation during Predesign by the design team.

Proposal No. PT-8 Biological foam removal (optimized skimming system on aeration basin) for microthrix filament control (surface waste). P1, T1, C1		
Advantages		**Disadvantages**
• Good design practice. • Dovetails with other processes to achieve desired treatment benefits. • High cost saving potential. • Positively removes microthrix from mixed liquor.		• Potentially increases hydraulic load to gravity belt thickeners (GBT's).
Criteria	**Rating**	**Comment**
Applicability in Existing Plant	High	Requires some construction within basins, so it may be most applicable if/when high intensity air proposal is implemented.
Treatment Effectiveness	High	Positively removing microthrix foam from basin surface will reduce microthrix population in the activated sludge.
Ease and Consistency of Operation	High	Would involve a straightforward skimming operation, and pumping of scum to solids handling system.
Design Team Acceptance	High	Would involve a straightforward design.
City of Bend Acceptance	High	Potentially alleviates a significant operations difficulty at the existing plant.
Sustainability and Energy footprint	High	Limited investment and energy required.
Contractor Capability to Construct	Moderate	May require taking down treatment trains for construction implementation.

Future Operations and Maintenance	High	Straightforward operation of skimming and pumping.
Initial Cost Saving Potential	High	Alleviation of sludge bulking may defer or eliminate additional secondary clarifier, and may reduce or eliminate RAS chlorination requirement.
Future Cost Saving Potential	High	See above.
Net Life Cycle Cost Saving Potential	High	See above.
Responds to Existing Significant Plant Deficiency	High	Is part of an overall plan to significantly reduce microthrix caused sludge bulking problems.
Alternative Links to Other Processes	High	This proposal links to all other aeration basin and SVI control proposals.
Overall Recommendation for Design Team Followup	High	Regardless of other secondary improvements, the VE team recommends incorporating this feature into the selected aeration basin arrangement. The VE team recommends further development of this feature by the design team (as to how to implement in the aeration basins, i.e. need for baffle walls, actual skimming device, etc.).

Proposal No. PT-F-2

Provide enhanced biological phosphorus removal (EBPR), by converting first anoxic zone to an anaerobic zone, for filament control.

Fail

Advantages	Disadvantages
• Potential SVI control.	• Phosphorus limit is not in permit. • Potential struvite issues in the digester. • Potentially reduced nitrogen removal. • Won't work well with chemically enhanced primary treatment (CEPT).

Proposal No. PT-9 Optimize RAS chlorination to enhance bulking control. P1, T1, C1		
Advantages		Disadvantages
• Straightforward to implement. • No capital cost required. • Immediate ease of implementation. • Eliminates need for additional clarification.		• Increased chemical usage and cost. • Requires operational adjustments, but the chemical requirements are consistent.
Criteria	Rating	Comment
Applicability in Existing Plant	High	This proposal addresses a suggested optimization of current plant practice.
Treatment Effectiveness	High	Plant staff has already demonstrated that RAS chlorination can reduce mixed liquor SVI values. Further operation may be enhanced by routinely reducing SVI down to 120 mL/g, while maintaining SVI's less than 150 mL/g.
Ease and Consistency of Operation	High	This is an extension and reinforcement of a practice that plant staff realizes is necessary, but changes the target to 120 mL/g from current target of 200 mL/g.
Design Team Acceptance	High	Theoretically does not involve any design change.
City of Bend Acceptance	High	Relatively simple change in current operations.
Sustainability and Energy footprint	High	Additional chemical application required, but limited incremental energy increase.
Contractor Capability to Construct	High	Would not involve any construction to implement.
Future Operations and Maintenance	Moderate	May require higher chlorine consumption.
Initial Cost Saving Potential	High	Alleviation of sludge bulking may defer or eliminate additional secondary clarifier, and may reduce or eliminate the need for in

		basin SVI control methods.
Future Cost Saving Potential	High	See above.
Net Life Cycle Cost Saving Potential	HIgh	See above.
Responds to Existing Significant Plant Deficiency	High	Is part of an overall plan to significantly reduce microthrix caused sludge bulking problems.
Alternative Links to Other Processes	High	This proposal links to all other aeration basin and SVI control proposals. Specifically, this proposal may be implemented immediately along with chlorine spray, and modifying current scum disposal methods.
Overall Recommendation for Design Team Followup	High Operational Recommendation	VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal as part of plant operations. The VE team also recommends that current scum disposal practices be modified such that scum is not re-introduced to RAS or other plant recycle streams.

Proposal No. PT-18 Current plan: Polyaluminum chloride (PAX) addition for bulking control. P2, T2, C1		
Advantages		Disadvantages
• Straightforward to implement. • Relative ease of implementation. • Eliminates need for additional clarification.		• Increased chemical usage and cost. • Requires operational adjustments, but the chemical requirements are consistent. • Need to add a chemical feed system. • Process not yet piloted or tested.
Criteria	Rating	Comment
Applicability in Existing Plant	Moderate	New chemical feed/storage facility required.

Treatment Effectiveness	High	Expected to work as described.
Ease and Consistency of Operation	High	Chemical dosing is simple to set and turn ON/OFF>
Design Team Acceptance	Low	Other methods are expected to be as effective and are good design practice.
City of Bend Acceptance	Low	Recognize potential cost implications of new chemical feed process.
Sustainability and Energy Footprint	Moderate	Improved SVI control reduces need for clarification infrastructure, but new chemical feed infrastructure is required.
Contractor Capability to Construct	High	Chemical feed facility can be constructed and commissioned off-line from other processes.
Future Operations and Maintenance	Moderate	New chemical feed facility will require additional O&M. PAX is a relatively expensive chemical.
Initial Cost Saving Potential	Low	New facility required.
Future Cost Saving Potential	Moderate	See comments on sustainability. New chemical facility impacts offset savings from eliminated clarification needs.
Net Life Cycle Cost Saving Potential	Low	Life Cycle costs are expected to be higher than other VE team recommended SVI control approaches.
Responds to Existing Significant Plant Deficiency	High	Addresses high SVI conditions.
Alternative Links to Other Processes	Low	Limited other interactions.
Overall Recommendation for Design Team Followup	Moderate	The VE team recommends that the design team carry this Facility Plan recommendation (PAX for microthrix control) forward for further evaluation during Predesign. If the Predesign evaluation recommends PAX for microthrix control, a demonstration scale study should be conducted to prove

		performance.

Proposal No. PT-19 Reduce fats, oils, grease (FOG) into aeration basins to enhance bulking control. P2, T2, C2		
Advantages		Disadvantages
• Achieve by enforcing current local ordinance. • Reduces growth of microthrix.		• Some uncertainty due to difficulty in source control (restaurants, etc.). • Need to add a measurement component to determine effectiveness.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Moderate Operational Recommendation	VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal as part of plant operations. The VE team believes that plant treatment effectiveness can be improved through reduction of FOG. CH2M HILL can provide additional assistance, as needed, for source control of FOG. The FOG program could entail enhanced digester gas production through the direct digestion of collected FOG material.

Proposal No. PT-17 Mixed liquor ozonation for filament control and sludge reduction. P3-, T1, C2 or C3		
Advantages		Disadvantages
• Supplier of technology has data showing effectiveness of system. • Reduces SVI. • Reduces WAS production. • Ease of implementation.		• Increased operating cost. • Additional process. • Liquid oxygen storage facility required. • Questionable economics of overall system.
Criteria	Rating	Comment

Applicability in Existing Plant	Low P3 Ranking	

Proposal PT-10 Chlorine surface sprays for filament control. P1, T1, C1		
Advantages		Disadvantages
• Good design practice. • Dovetails with other processes to achieve desired treatment benefits. • High cost saving potential. • Positively removes microthrix from mixed liquor.		• May increase chlorine usage within aeration basins.
Criteria	Rating	Comment
Applicability in Existing Plant	High	This proposal provides a recommendation to heavily chlorinate the surface of the activated sludge.
Treatment Effectiveness	High	Heavily chlorinating biological foam removes the filaments from the system.
Ease and Consistency of Operation	High	Operation consists of applying a chlorine solution spray along each aeration basin train. Operation then consists of monitoring the amount of foam on the basins.
Design Team Acceptance	High	Involves the design of a separate chlorine solution delivery and spray system. The design chlorine concentration may be in the range of 1,000 to 2,000 mg/L.
City of Bend Acceptance	High	Relatively simple change in current operations.
Sustainability and Energy footprint	High	Limited infrastructure, chemical, and energy costs.
Contractor Capability to Construct	High	Minor retrofit to add solution lines and nozzles.
Future Operations and Maintenance	Moderate	May require higher chlorine consumption.

Initial Cost Saving Potential	High	Alleviation of sludge bulking may defer or eliminate additional secondary clarifier, and may reduce or eliminate the need for in basin SVI control methods.
Future Cost Saving Potential	High	See above.
Net Life Cycle Cost Saving Potential	High	See above.
Responds to Existing Significant Plant Deficiency	High	Is part of an overall plan to significantly reduce microthrix caused sludge bulking problems.
Alternative Links to Other Processes	High	This proposal links to all other aeration basin and SVI control proposals. Specifically, this proposal may be implemented immediately along with RAS chlorination, and modifying current scum disposal methods.
Overall Recommendation for Design Team Followup	High	Regardless of other secondary improvements, the VE team recommends incorporating this feature into the selected aeration basin arrangement. VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal. The VE team also recommends that current scum disposal practices be modified such that scum is not re-introduced to RAS or other plant recycle streams.

Observation No. PT-0-3

Increase mixed liquor recycle (MLR) and direct supplemental carbon for nitrogen removal.

Observation. Consider only if discharge requirements become more stringent.

Observation No. PT-O-4

Four-stage Bardenpho for nitrogen removal.

Observation. Consider only if discharge requirements become more stringent.

Observation No. PT-0-5 Denitrification filters. Observation. Consider only if discharge requirements become more stringent.

Proposal No. PT-F-3 Simultaneous nitrification/denitrification (SNDN) for nitrogen removal. Fail	
Advantages	Disadvantages
	• Potential for increased bulking.

Proposal No. PT-F-4 Intermittent aeration in lieu of current process arrangement. Fail	
Advantages	Disadvantages
	• Microthrix can thrive in an intermittent air environment.

Proposal No. PT-11 Integrated fixed film activated sludge (IFAS), in lieu of current arrangement. P1, T1, C3 or neutral		
Advantages		Disadvantages
• Increased capacity in existing basins. • Well understood technology. • Multiple options. • Enhanced cold weather nitrification.		• Fairly complicated re-fit of aeration basins. • Modest increased energy requirement for process aeration.
Criteria	Rating	Comment
Applicability in Existing Plant	High	This proposal involves modifying existing aeration basins to utilize IFAS media within the activated sludge.

Treatment Effectiveness	High	By using fixed film and suspended growth activated sludge, we enhance treatment capacity and cold weather operations.
Ease and Consistency of Operation	Moderate	This proposal represents a significant departure from current operations. Screens and baffles are required so that the media doesn't wash out. Scum control becomes somewhat more complicated.
Design Team Acceptance	Moderate	This is a relatively new technology, and represents an extensive retrofit.
City of Bend Acceptance	Moderate	This is a relatively new technology, and represents an extensive retrofit.
Sustainability and Energy footprint	High	Maximizes capacity of existing basins.
Contractor Capability to Construct	Moderate	This is a relatively new technology, and represents an extensive retrofit.
Future Operations and Maintenance	Moderate	There will be a learning curve utilizing a new technology.
Initial Cost Saving Potential	Moderate to Low	Potentially increases basin capacity, but may require small increase in aeration system energy usage.
Future Cost Saving Potential	Moderate to Low	Potentially increases basin capacity, but may require small increase in aeration system energy usage.
Net Life Cycle Cost Saving Potential	Moderate to Low	Potentially increases basin capacity, but may require small increase in aeration system energy usage.
Responds to Existing Significant Plant Deficiency	High	Responds to increasing basin treatment capacity.
Alternative Links to Other Processes	High	This IFAS proposal links with CEPT and bio-augmentation. This IFAS proposal is mutually exclusive with step feed and contact stabilization proposals.

Overall Recommendation for Design Team Followup	High	The VE team recommends that the design team evaluate this proposal further during Predesign. Performance enhancements and cost effectiveness of IFAS versus step feed systems needs to be evaluated, with the optimal proposal selected.

Proposal No. PT-F-5 Add floating high purity oxygen (HPO) aerators in lieu of current diffuser system. Fail	
Advantages	Disadvantages
	• Complexity and cost of process.

Proposal No. PT-F-6 Ammonia stripping of filtrate in lieu of biological treatment. Fail	
Advantages	Disadvantages
• Lower power usage.	• Higher capital cost due to stripper and absorber towers. • Higher chemical usage and cost.

Proposal No. PT-F-7 Struvite precipitation in lieu of filtrate re-aeration. (Only viable with BPR which was 'failed'.) Fail	
Advantages	Disadvantages
	• Need phosphoric acid and magnesium hydroxide addition. • Much higher operating cost.

Observation No. PT-O-6 Optimize the equalization of filtrate, which is the current plant operational standard. Observation. Detailed wastewater characterization required to optimize filtrate management.		
Advantages		Disadvantages
• Simple process.		• There is a limitation to optimization.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Operational Recommendation	VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal as part of plant operations. Detailed wastewater characterization is required to optimize filtrate management.

Blowers

Observation No. B-O-1 Consider utilizing blower manufacturer to front-fund blower system improvements, with payback over time. Observation	
Advantages	Disadvantages
• Allows flexibility in cash flow to fund additional improvements. Pays for improvements out of efficiency gains.	• Contract terms from blower manufacturer may not be preferred to other funding sources.

Observation No. B-O-2 Baseline: Continue to utilize existing blowers, and add new to match existing blower type.	
Advantages	Disadvantages
• Operations staff familiarity. • Lower capital cost requirement.	• Higher operational cost. • May require additional blower building at an earlier stage.

Proposal No. B-1 Replace existing multi-stage blowers with turbo blowers. P1, T1, C2		
Advantages		Disadvantages
• Reduced energy cost. • Avoids need to expand blower building for current project. • Quieter operation. • Reduced maintenance. • Potential for overall life-cycle savings.		• Newer, less proven technology. • Likely higher initial cost depending upon condition of existing blowers and blower building modifications.
Criteria	Rating	Comment
Applicability in Existing Plant	High	High speed turbo blowers can be much more efficient and provide higher turndowns compared to multi-stage blowers.
Treatment Effectiveness	High	High speed turbo blowers are available in a wide range of capacities.
Ease and Consistency of Operation	High	Simpler to operate and maintain than multi-stage blowers. Also more quiet.
Design Team Acceptance	High	Straightforward design application.
City of Bend Acceptance	High	Likely to show short payback period. Eligible for energy incentive funding.
Sustainability and Energy footprint	High	Short payback expected. Combine with high efficiency diffusers for more improved efficiency. Eligible for BPA/Central Electric incentives.
Contractor Capability to Construct	High	Straightforward construction application.
Future Operations and Maintenance	High	Simpler to operate and maintain than multi-stage blowers. Also more quiet.
Initial Cost Saving Potential	Moderate to Low	Initial cost of high speed turbo blowers may be higher than replacement with multi-stage blowers, but high efficiency provides a very short payback period.

Future Cost Saving Potential	High	High efficiency results in lower future energy usage.
Net Life Cycle Cost Saving Potential	High	Moderate due to blending initial higher cost against future energy savings.
Responds to Existing Significant Plant Deficiency	High	Addresses plant aeration capacity issues.
Alternative Links to Other Processes	High	This proposal links to all aeration basin capacity proposals.
Overall Recommendation for Design Team Followup	High	The VE team recommends evaluation of high speed turbo blowers during Predesign to provide additional aeration capacity.

Observation No. B-O-3 Improve air delivery control system to optimize energy usage.		
Advantages		Disadvantages
• Reduce energy cost.		• Requires additional minor construction coordination and sequencing constraints to implement.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Operational Recommendation	VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal as part of plant operations.

Proposal No. B-2 Separate process aeration and mechanical mixing energy in last aerobic zone. P2, T1, C3		
Advantages		Disadvantages
• Reduced energy usage. • Improved nitrogen removal.		• Increased complexity of operations.
Criteria	Rating	Comment
Applicability in	Moderate	Requires retrofit of all three existing basins.

Existing Plant		
Treatment Effectiveness	High	No change in fundamental treatment process, but provides only air required for treatment needs.
Ease and Consistency of Operation	High	Conventional aeration and mixing equipment used. Automatic controls.
Design Team Acceptance	High	Typical equipment used.
City of Bend Acceptance	Moderate	Change to existing process will require demonstration of effectiveness.
Sustainability and Energy Footprint	Moderate	Clearly will show efficiency improvements. New equipment required which offsets savings in footprint.
Contractor Capability to Construct	High	Requires sequential basin modifications to all existing basins.
Future Operations and Maintenance	High	New mixer required in each last aerobic zone. Aeration air savings is good value.
Initial Cost Saving Potential	Low	Air piping modifications and new mixer needed. Upfront costs.
Future Cost Saving Potential	High	Aeration air savings is good value.
Net Life Cycle Cost Saving Potential	High	Aeration air savings is good value.
Responds to Existing Significant Plant Deficiency	Moderate	This is more of an efficiency project, than process improvement.
Alternative Links to Other Processes	Low	Low. This is just in-basin work.
Overall Recommendation for Design Team Followup	Moderate	The VE team recommends this proposal be evaluated further by the design team for future aeration basins, to explore the potential for energy savings at the plant. Economics likely do not promote the retrofit of existing aeration basins.

Observation No. B-O-4 Evaluate performance of different dissolved oxygen (DO) concentrations in aerobic zones, to minimize energy usage.		
Advantages		Disadvantages
• Reduced energy usage. • Improved nitrogen removal.		• Potential for greater bulking problems in the activated sludge process.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Operational Recommendation	VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal as part of plant operations.

Proposal No. B-3 Add variable frequency drives (VFDs) to multistage blowers. P3, T2, C3		
Advantages		Disadvantages
• Lower initial capital cost. • Reduced energy cost.		• Less flexible than turbo blowers.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Low P3 Ranking	The VE team suggests that this proposal be considered only if multi-stage centrifugal blowers are found to be more cost effective than high speed turbo blowers.

Secondary Clarifier

Proposal No. SC-3 Optimize existing clarifiers by replacing existing mechanisms. Coordinate with other secondary clarifier improvement options. P3, T3, Cost increase.	
Advantages	Disadvantages
• Improved sludge removal. • Improved scum removal.	• Higher capital cost. • No bulking reduction benefit.

• Proposal only makes sense if existing mechanisms are slated for replacement anyway.		• Existing clarifier equipment is not slated for near-term replacement.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Low P3 rating	Acceptance of this proposal would be based on the City's need to replace the clarifier mechanisms. The design team should work with the City to confirm the condition assessment of the plant.

Observation No. SC-O-1 Evaluate need for baffles to improve clarifier performance. Coordinate with other clarifier improvements.		
	Rating	Comment
Overall Recommendation for Design Team Followup	Operational Recommendation	VE team recommends that the Design team work with Bend Operations staff to further evaluate this proposal as part of Predesign.

Observation No. SC-O-2 Evaluate current clarifier inlet and replace with better floc well design. Coordinate with other clarifier improvements.		
Advantages		Disadvantages
• Improved settleability • Higher likelihood of lower TSS.		• None noted.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Operational Recommendation	VE team recommends that the Design team work with Bend Operations staff to further evaluate this proposal as part of Predesign.

Proposal No. SC-1 Direct connect RAS suction line to pumps to bypass the RAS wet well. Coordinate with tank drain piping modifications. P1, T1, C3

Advantages	Disadvantages
• Improved RAS control. • Should achieve higher RAS solids concentration. • Better solids management in each clarifier. • May avoid re-introduction of filaments to activated sludge.	• None noted.

Criteria	Rating	Comment
Applicability in Existing Plant	High	Current RAS piping arrangement limits RAS pumping capacity.
Treatment Effectiveness	High	Proposed improvements will provide more positive control over RAS pumping operation and ability to control solids in the secondary clarifiers.
Ease and Consistency of Operation	High	Proposal will operate much like current operations, but will provide enhanced process control.
Design Team Acceptance	High	Will require addressing how to connect RAS suction lines to clarifier discharge lines.
City of Bend Acceptance	High	Will provide enhanced process control of secondary clarifiers.
Sustainability and Energy footprint	Low	No measureable change in energy requirements, but will improve solids removal from clarifiers
Contractor Capability to Construct	Moderate	Extensive retrofit of piping required while keeping existing plant in operation.
Future Operations and Maintenance	High	Proposal will enhance future operations by providing more positive process control.
Initial Cost Saving Potential	Moderate to Low	Enhanced process control at expense of extensive modifications to existing system.
Future Cost Saving Potential	Moderate to Low	Enhanced process control at expense of extensive modifications to existing system.
Net Life Cycle Cost Saving Potential	Moderate to Low	Enhanced process control at expense of extensive modifications to existing system.
Responds to Existing	High	Proposal will provide more positive means

Significant Plant Deficiency		of removing solids from secondary clarifiers.
Alternative Links to Other Processes	High	This proposal links to any of the secondary treatment alternatives.
Overall Recommendation for Design Team Followup	High	Regardless of other secondary improvements, the VE team recommends incorporating this feature into the selected RAS arrangement. VE team recommends that the Design team work with Bend Operations staff to further evaluate and implement this proposal.

Observation No. SC-O-3

Flow-pace RAS.

Observation. Works primarily with direct connection of RAS pumps to secondary clarifier.

Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Moderate	VE team recommends that the Design team work with Bend Operations staff to further evaluate this proposal as part of Predesign.

Proposal No. SC-2

Full radius skimmer and removal of scum from RAS/WAS in lieu of existing configuration or a new, smaller conventional scum trough. Coordinate with other clarifier improvements. Current full-radius skimmer does not remove scum from RAS/WAS flowstream.

P1, T1, C3

Advantages	Disadvantages
• More positive scum removal. • Reduced bulking potential.	• May collect more water in the scum system. • Requires coordination with existing clarifier mechanism that may be incompatible with fixed full-radius skimmer.

Criteria	Rating	Comment
Overall Recommendation for	High	VE team recommends that the Design team work with Bend Operations staff to further

Design Team Followup		evaluate this proposal as part of Predesign.

Observation No. SC-O-4 Provide weir cleaning method. Observation. Check with plant staff about need.

Surface wasting versus revamping of waste activated sludge pumping. Combined with earlier proposal.

Observation No. SC-O-5

Separate scum from sludge lines per the current operation. Review record drawings for comments to RAS piping routing. Coordinate with tank drain piping modifications.

Observation. High priority for design team follow-up.

Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	High	VE team recommends that the Design team work with Bend Operations staff to further evaluate this proposal as part of Predesign.

Disinfection

Observation No. DI-O-1

Baseline recommendation from facilities plan: Convert to Sodium Hypochlorite, in lieu of chlorine gas.

Observation. Concur.

Advantages	Disadvantages
• Improved safety. • Reduced liability and training costs.	• Costs for conversion.

Observation No. DI-O-2 Support continued use of high energy mixing device (Waterchamp).

Observation.

Proposal No. DI-1 Expand disinfection with UV disinfection rather than hypochlorite. Recommend UV for seepage pond water. Retain chlorine for reuse. P2, T1, C2 or C3		
Advantages		Disadvantages
• Reduced chemical handling. • Flexibility in expanding reuse flow. • Achieves disinfection goals.		• High power usage. • Two types of disinfection systems versus one.
Criteria	Rating	Comment
Applicability in Existing Plant	Moderate	New UV facility would be needed in lieu of new hypo storage and new contact basin.
Treatment Effectiveness	High	Proven technology.
Ease and Consistency of Operation	High	Automated and easy to operate.
Design Team Acceptance	High	Common technology.
City of Bend Acceptance	Low	New treatment process and requires continued operation of separate process.
Sustainability and Energy Footprint	High	Perceived high electricity use required. Unsure how footprint compares to hauling, using hypochlorite.
Contractor Capability to Construct	High	Common technology. Can construct and commission off-line and tie in.
Future Operations and Maintenance	Moderate	More operator attention required than in chlorination. True but more automation provided.
Initial Cost Saving Potential	Low	Signficant capital investment
Future Cost Saving Potential	Moderate	Electricity and lamp replacement vs. chlorine purchase.
Net Life Cycle Cost	Low	Not yet sure of final costs, but Facility Plan

Saving Potential		did not recommend it.
Responds to Existing Significant Plant Deficiency	Moderate	Addresses need for increase disinfection and optimization of re-use disinfection with other effluent.
Alternative Links to Other Processes	Moderate	Connection to effluent filtration requires coordination.
Overall Recommendation for Design Team Followup	High	The VE team recommends that the Design team evaluate the costs and potential for UV process implementation. This is a combination of processes that apparently was not evaluated in the facilities plan. There is a potential for a life-cycle cost benefit to the City.

Observation No. DI-O-3

Address need for split disinfection with the chlorine contact basins. Need improved understanding of how the facilities plan team came to this recommendation. Coordinate with current re-use regulations.

Observation

Advantages	Disadvantages
• Potential operational cost savings through reduced chemical usage.	• May represent higher capital cost. • More complicated hydraulics.

Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	High	The VE team recommends a design study to evaluate cost and potential for UV process implementation. This is a combination of processes that apparently was not evaluated in the facilities plan. There is a potential for a life-cycle cost benefit to the City. VE team recommends that the Design team work with Bend Operations staff to further evaluate split flow for reuse water as part of Predesign.

Observation No. DI-O-4

Automatic diversion for non-spec reuse water.

Observation		
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Moderate	VE team recommends that the Design team work with Bend Operations staff to further evaluate the need for automatic diversion of non-spec water as part of Predesign.

Tertiary Treatment

Observation No. TT-O-1 Current plant appears to have adequate capacity with current technology for tertiary treatment. Observation: No change recommended.

Discharge to Infiltration/Seepage Ponds and/or Water Reuse System

Observation No. DIS-O-1 Comment on current plans for increased capacity of current infiltration/seepage pond system. Observation	
Advantages	Disadvantages
• Opportunities for phasing in increased capacity	

Primary Sludge Thickening

Gravity thickener in lieu of building a new primary clarifier for thickening. Combined with earlier proposal in Primary Treatment group.

Proposal No. PST-1 Refit centrifuge for primary sludge thickening, in lieu of gravity thickener. P3, T2, C1	
Advantages	Disadvantages
• Low capital cost requirement.	• Much higher power cost.

• Centrifuge runs all the time, for consistent operations. • Improved odor control. • Higher solids concentration.	• Higher maintenance cost. • May result in primary sludge being too thick. • Determine effect of grit on the centrifuge.

Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Low P3 Rating	Followup by the design team should be undertaken as part of the evaluation of overall solids handling alternatives.

Ferment primary sludge in the gravity thickener to enhance nitrogen removal. Combined with earlier proposal in Primary Treatment.

Observation No. PST-O-1 Pump style (diaphragm pump) appears to be appropriate for sludge pumping. Observation	
Advantages	Disadvantages
• Pump style works well with new headworks facility: – no liquid stream grit removal – fine screens	

Proposal No. PST-F-1 Fournier Press to thicken primary sludge in lieu of gravity thickener. Fail	
Advantages	Disadvantages
• Reduced footprint in plant building.	• Requires extensive pilot testing. • Works best with highly fibrous sludge.

Observation No. PST-O-2 Use gravity thickening to equalize primary sludge load to digesters, to improve gas production when gas is in demand.		
Advantages		Disadvantages
• Increased gas utilization and energy production.		
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Moderate	VE team recommends that the Design team work with Bend Operations staff to further evaluate this proposal as part of Predesign.

Observation No. PST-O-3 Co-thicken in the gravity thickener or centrifuge in lieu of the hybrid gravity belt thickener/belt filter press. Observation – suggest design team evaluate to provide backup capability.		
Advantages		Disadvantages
• Ease of implementation. • Dovetails with any of the alternative primary sludge thickening proposals.		
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Moderate	VE team recommends that the Design team further evaluate this proposal as part of Predesign.

Proposal No. PST-F-2 Rotary drum thickener. Failed	
Advantages	Disadvantages
	• Substantially increased odor issues. • Substantially increased maintenance.

Waste Activated Sludge (WAS) Thickening

Proposal No. WAS-1 Direct WAS to de-gassing basins as a redundancy measure, in lieu of new gravity belt thickener/belt filter press (GBT/BFP). P3, T2-T3, C1 or C2	
Advantages	Disadvantages
• Low cost, best use of existing facilities. • Consider in conjunction with a decant system for a lower level of emergency thickening.	• Reduced volume would be available for filtrate equalization. • Potential for increased odor issues. • More operational cleanup requirements.

Criteria	Rating	Comment
Applicability in Existing Plant	High	Simple to re-plumb WAS to de-gassing basin.
Treatment Effectiveness	High	Storage of sludge until equipment repaired. No change in process.
Ease and Consistency of Operation	High	Storage is simple
Design Team Acceptance	High	Storage is simple
City of Bend Acceptance	Moderate	Storage requires cleanup, and more operator attention to resolve/repair problem.
Sustainability and Energy Footprint	High	No new equipment purchase or operation required. (Need to investigate how to return WAS to thickening)
Contractor Capability to Construct	High	Pipe and valves (maybe degass bed level sensors) are all that's required.
Future Operations and Maintenance	Low	No new equipment to maintain.
Initial Cost Saving Potential	High	No equipment purchase or installation required. Pipe and valves are inexpensive.
Future Cost Saving Potential	High	No equipment purchase or installation required. Pipe and valves are inexpensive.
Net Life Cycle Cost	High	No equipment purchase or installation

Saving Potential		required. Pipe and valves are inexpensive.
Responds to Existing Significant Plant Deficiency	High	Redundancy needs would require new WAS thickener.
Alternative Links to Other Processes	Moderate	Degass beds proposed for use by VE team for PS thickening, WAS thickening, and/or filtrate storage. Can't do all of these simultaneously with 2 degass beds.
Overall Recommendation for Design Team Followup	Moderate	VE team recommends that the Design team work with Bend Operations staff to further evaluate this proposal as part of Predesign. There is the potential for operational efficiencies and cost savings.

Proposal No. WAS-F-1 Provide WAS storage ahead of thickening. Failed	
Advantages	Disadvantages
• Helps with plant operations.	• Not a cost saving proposal.

Proposal No. WAS-2 Provide thickened WAS storage, ahead of digestion. P3, T2, Cost increase		
Advantages		Disadvantages
• Equalizes loads to digestion. • Increased ability to manage foaming of the digesters.		• Requires additional process and structure. • Increased odor control requirements.
Criteria	Rating	Comment
Applicability to Existing Plant	Low P3 Rating	A storage tank provides improved opportunity to store WAS. This would normally be provided in a new plant. Not highly recommended for follow-up by the design team.

Digestion

Proposal No. DG-1 Utilize acid gas digestion to reduce foaming concerns. P3, T3, Cost increase		
Advantages		Disadvantages
• Reduces foaming in digesters. • Possible improved volatile suspended solids (VSS) removal.		• Increased cost through significant capital investment.
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Low P3 Rating	This alternative was not considered a high priority by the VE team.

Proposal No. DG-F-1 Utilize WAS pre-treatment to reduce foaming, such as: sonication; biogest; biolysis. Failed	
Advantages	Disadvantages
• Reduces foaming in digesters. • Possible improved volatile suspended solids (VSS) removal.	• Increased cost through significant capital investment. • Increased energy cost. • Newer, as-yet unproven technology.

Observation No. DG-O-1 Heat recovery for building heat.	
Advantages	Disadvantages
• Good utilization of digester gas.	

Observation No. DG-O-2
Divert high strength waste directly to digester.
Observation

Advantages	Disadvantages
• More biogas. • Addresses City's desire for sustainable solutions. • Reduced operational cost.	• Conveyance and delivery of high strength waste is complicated.

Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Operational Recommendation	VE team recommends that the Design team work with Bend Operations staff to further evaluate this proposal as part of Predesign.

Observation No. DG-O-3

Address degree to which industrial waste can be treated at industry prior to discharge to plant. Review benefits of waste from these sources, such as high BOD waste that the plant benefits from.

Observation

Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Operational Recommendation	VE team recommends that the Design team work with Bend Operations staff to further evaluate this proposal as part of Predesign.

Proposal No. DG-1

Implement post-aerobic digestion for nitrogen removal.

P2, T1, Cost neutral

Advantages	Disadvantages
• Higher VSS destruction. • Nitrogen removal from digested sludge. • Prevents struvite formation. • Lower overall energy usage. • Potential for augmentation of nitrifiers.	• Increased odors. • New tankage and equipment required.

Criteria	Rating	Comment

Applicability in Existing Plant	Moderate	Requires new tankage.
Treatment Effectiveness	High	Addressed nitrogen removal.
Ease and Consistency of Operation	High	Limited operator attention required. Aerators, DO probes, and level sensors.
Design Team Acceptance	High	Conventional equipment.
City of Bend Acceptance	Low	New unit process. Increased odors.
Sustainability and Energy Footprint	Moderate	New tankage and equipment and aeration air required, but could eliminate/reduce other sidestream and secondary process improvements for N removal.
Contractor Capability to Construct	High	Conventional equipment. Can construct and commission offline from other process tanks.
Future Operations and Maintenance	Moderate	Another unit process, requires operator attention. Sludge mixing is harsh on submerged equipment.
Initial Cost Saving Potential	Low	New tankage, equipment required. Need to compare to initial investment for other alternatives that remove N.
Future Cost Saving Potential	High	Could save secondary improvements designed to remove N which would otherwise be recycled back into plant.
Net Life Cycle Cost Saving Potential	Moderate	Significant investment needed for post aerobic digestion. Need to evaluate cost for alternatives to know if savings exist.
Responds to Existing Significant Plant Deficiency	High	Responds to N removal need.
Alternative Links to Other Processes	High	This is alternative or in combination with to other secondary process improvements.
Overall Recommendation for Design Team Followup	Moderate	The VE team recommends this proposal for further evaluation by the design team. Successful application of this proposal may eliminate the need for sidestream treatment alternatives.

Observation No. DG-O-4 Consider fill and spill conversion for foam control in digesters.

Observation No. DG-O-5 Insulate digesters to avoid heat loss.

Biosolids Dewatering

Proposal No. BD-2 Use existing centrifuge as backup to belt press, in lieu of new belt press. P3, T1, C1

Advantages	Disadvantages
• Reduced capital cost.	• May need an upgraded polymer system. • Operational complexity – need to maintain two systems. • Centrifuge can not easily double as a gravity belt thickener.

Criteria	Rating	Comment
Applicability in Existing Plant	High	Existing equipment can provide function.
Treatment Effectiveness	High	Centrifuge dewatering is proven and effective.
Ease and Consistency of Operation	Moderate	Centrifuge startup/shutdown requires operator attention.
Design Team Acceptance	Moderate	Condition of centrifuge is uncertain.
City of Bend Acceptance	Low	Preference for avoiding use of centrifuge is understood.
Sustainability and Energy Footprint	Low	Centrifuge uses lots of energy. But this is backup operation and performance equal to belt press should be achieved with less polymer than typical centrifuge dewatering.
Contractor Capability to Construct	High	Nothing to construct

Future Operations and Maintenance	High	Centrifuge requires significant O&M, but intermittent operation mitigates this.
Initial Cost Saving Potential	High	Potentially no capital costs (check for polymer system)
Future Cost Saving Potential	Moderate	Centrifuge expected to use more power/polymer than belt press.
Net Life Cycle Cost Saving Potential	High	No capital expenditure needed for redundancy.
Responds to Existing Significant Plant Deficiency	High	Redundant equipment needed (and already present)
Alternative Links to Other Processes	Low	No apparent linkages (check polymer system capacity).
Overall Recommendation for Design Team Followup	Moderate	The VE team recommends that the Design team evaluate this alternative during Predesign as an alternative method of providing backup to a single belt filter press.

Proposal No. BD-1

Use existing drying beds to back up the belt press, in lieu of adding a new belt press for dewatering solids.

P3, T1, C1

Advantages	Disadvantages
• Substantial capital cost reduction. • Simplified operations.	• Potential for odors. • Seasonal limitations. • City preference is to avoid time-consuming and difficult clean-up of drying beds

Criteria	Rating	Comment
Applicability in Existing Plant	High	Drying beds are currently available for this use.
Treatment Effectiveness	High	Drying beds are a simple and effective sludge drying technology, particularly in the desert environment around Bend.
Ease and Consistency	High	Drying beds are simple to operate and staff can easily monitor the thickness of dried

of Operation		solids.
Design Team Acceptance	High	Selecting this proposal may require very little new facility design.
City of Bend Acceptance	TBD	Design team is requested to explore this idea further with the City.
Sustainability and Energy footprint	High	No new equipment needed. Pipes, valves, level sensors needed. No new motor loads.
Contractor Capability to Construct	High	Selecting this proposal may require very little new facility construction.
Future Operations and Maintenance	High	Simple operation and very little mechanical equipment to maintain.
Initial Cost Saving Potential	High	This proposal could avoid the need for a new belt press, resulting in a significant initial cost saving.
Future Cost Saving Potential	Low	Both processes are approximately equal to operate in the future.
Net Life Cycle Cost Saving Potential	Moderate	Need to evaluate the initial and future cost savings in present worth.
Responds to Existing Significant Plant Deficiency	High	A backup is required for solids dewatering capability.
Alternative Links to Other Processes	High	This proposal could be used with any of the plant expansion/improvement proposals.
Overall Recommendation for Design Team Followup	High	The VE team suggests that given the current climate of limited funding, this proposal provides an opportunity for savings and directing those savings to other plant priorities.

Proposal No. BD-3

Use storage in degas basin as backup to belt filter press.

P3, T1, C1

Advantages	Disadvantages
• Low cost, best use of existing facilities.	• Reduced volume would be available for filtrate equalization.

		• Potential for increased odor issues. • More operational cleanup requirements.
Criteria	Rating	Comment
Refer to Proposal BD-1 (drying beds as backup for belt press) for other critiera.		
Overall Recommendation for Design Team Followup	Moderate to Low	The VE team recommends this alternative as another method of providing backup to a single belt filter press. The VE team's preference would be the drying beds or centrifuge as backup to the filter press.

Observation No. BD-O-1

Comment on current plan for second belt press. There is a lot of redundancy in this process compared to other processes.

Observation.

Proposal No. BD-F-1

Use electrical fields to assist dewatering.

Failed.

Advantages	Disadvantages
• Dryer cake. • Lower polymer consumption.	• Newer technology, not yet fully proven. • Higher energy cost.

Land Application of Biosolids

Observation No. LAB-O-1

Existing land application process appears cost-effective.

Observation.

Support Facilities

Observation No. SF-O-1 Concur with current approach to defer support facilities upgrades in favor of other priorities. Observation.

Overall Plant Improvements

Observation No. OPI-O-1 Conduct a wastewater characterization study for influent, flow within the plant, and effluent, which are important for design and prioritization of the design package. Observation priority 1.		
Advantages		Disadvantages
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	High	The VE team recommends that the Design team evaluate this alternative during Predesign as an alternative method of providing backup to a single belt filter press.

Observation No. OPI-O-2 Confirm the current capacity analysis. Observation priority 2.		
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Moderate	The VE team recommends that the Design team evaluate the current capacity as part of Predesign.

Observation No. OPI-O-3 Evaluate need for immediate upgrades given the downturn in the economy. Observation, priority 3.		
Criteria	Rating	Comment

Overall Recommendation for Design Team Followup	Moderate	The VE team recommends that the Design team evaluate options for phasing and deferrable during Predesign.

Observation No. OPI-O-4 Comment on appropriate extent of automation within the plant.		
Criteria	Rating	Comment
Overall Recommendation for Design Team Followup	Moderate	The VE team recommends that the Design team clarify the appropriate level of automation prior to launching Predesign.

Attachments

Agenda for Value Engineering Study at Conceptual Design

Water Reclamation Facility
Bend, OR

Study Dates: Tuesday, June 23 through Thursday, June 25, 2009

Location Schedule

Days 1 - 3, Tuesday, June 23 through Thursday, June 25

- **CH2M HILL Portland Office.** 2020 SW 4th Avenue, Suite 300, Portland, OR 97201; Willamette Conference Room on Floor 7 (check in at the main desk on Floor 3 for a pass card).
- **Contact persons:** Janis Freeman, Administrative Assistant, (503) 736-4252; Dave Green, Program Manager, (503) 872-4440

Design Team Members

Team Member	Organization	Home Office	Role
Dave Green	CH2M HILL	Portland, OR	Program Manager
Brady Fuller	CH2M HILL	Bend, OR	Pre-Design Manager
Bill Leaf	CH2M HILL	Boise, ID	Lead Process Engineer (Secondary)
Michelle Burkhart	CH2M HILL	Portland, OR	Lead Process Engineer (Primary/Solids)
Jennifer Chang	CH2M HILL	Corvallis, OR	Lead Process Engineer (Disinfection)
Adrienne Menniti	CH2M HILL	Portland, OR	Process Engineer
Jim Griffiths	CH2M HILL	Corvallis, OR	Design Manager

VE Team Members

Team Member	Organization	Home Office	Role
Paul Johnson	CH2M HILL	Boise, ID	Certified Value Specialist and VE Study Leader
Steve Goodwin	CH2M HILL	Rahleigh, NC	Mechanical Process Engineer
Bruce Johnson	CH2M HILL	Denver, CO	Principal Technologist (wastewater process)
Dimitri Katehis	CH2M HILL	New York, NY	Principal Technologist (sidestream process focus)
Rob Edgerton	CH2M HILL	Portland, OR	Cost Estimating
Stan Smith	Consultant	Bellingham, WA	Operations Consultant

Client and Agency Contacts

Name	Organization	Home Office	Role
Paul Roy	City of Bend	Bend, OR	Utilities Operation and Maintenance Manager 541-322-6334
Jim Wodrich	City of Bend	Bend, OR	Project Manager 541-693-2190 (cell 541-408-1869)
Scott Thompson	City of Bend	Bend, OR	Wastewater Operations Manager (Plant) 541 322 6338
Steve Simpson	City of Bend	Bend, OR	Utilities Maintenance Manager 541-317-3057
Greg Mooney	City of Bend	Bend, OR	Wastewater Operations 541-322-6333
Shanna Olson	Oregon DEQ		SRF Project Officer/Permits

Detailed Agenda

Tuesday, June 23

Phase 1 – Information

Location: CH2M HILL Portland, OR Office

7:45 a.m. to 8:30 a.m.

INTRODUCTIONS and OVERVIEW OF STUDY AGENDA AND VE PROCESS - VE Team Leader

- Objectives of the VE Study:
  - ❖ Optimal value solutions for the project to meet wastewater capacity and treatment requirements.
  - ❖ Explore the Water Reclamation Facilities Plan (by Carollo) and determine if improvements can be made to the process, flexibility and components of the wastewater treatment systems.
  - ❖ Focus on the construction access/logistics and approach to the project.
  - ❖ Other priorities in the VE study

8:30 a.m. to 11:00 a.m.

CITY OF BEND and CH2M HILL DESIGN TEAM: OVERVIEW OF THE BEND WATER RECLAMATION FACILITY REQUIREMENTS

- Project history and regulatory drivers
- Permitting agency requirements
- Project background including history, existing plant characteristics, O&M concerns/deficiencies, and plant improvement requirements
- Design objectives
- Process treatment alternatives discussed in the WRF Plan:
  - – Liquids Treatment
  - – Disinfection
  - – Effluent Disposal
  - – Solids Processing
  - – Support Facilities
- Project funding/constraints/cash flow

- Scheduling requirements/commitments
- Community concerns
- Other sensitive issues
- General Comments

11:00 a.m. to 12:30p.m. *Working lunch from 12:00 to 12:30 p.m.*	**DESIGN TEAM PRESENTATION (by CH2M HILL)** *(Including Q/A for each topic)* • Process treatment alternatives discussed in CH2M HILL's proposal • Treatability study approach and results from WRF • Aerial Photographs • Record Drawings • Construction logistics and other considerations (for example, community, rights-of-way, utilities, other environmental factors) • Cost estimates • Design and implementation schedule
12:30 p.m. to 1:30 p.m.	**QUESTIONS, ANSWERS, REVIEW OF RECORD DRAWINGS AND WRF PLAN**

Phase 1 – Information (continued)

1:30 p.m. to 3:00 p.m.	**TEAM FOCUS QUESTIONS AND ANSWERS** • What is the problem we are about to discuss? • Why do we consider this a problem? • Why do we believe a solution is necessary? • What are the top cost drivers on this project? • What are the top risk areas on this project? • What are the expected outcomes from the VE study?
3:00 p.m. to 5:30 p.m.	**FUNCTIONAL ANALYSIS** • Identify significant project functions with opportunities for cost reduction or functional enhancement • Prepare FAST Diagram (this activity may continue as an evening session, to link the functions identified above into How-Why relationships)

Wednesday, June 24

Phase 1 – Information (Continued)

Location: CH2M HILL Portland, OR Office

Phase 2A - Criteria Development (for mechanical process alternatives)

7:45 a.m. to 10:00 a.m.	**ESTABLISHMENT OF WASTEWATER PROCESS TREATMENT EVALUATION CRITERIA** • Major project components: Liquids Treatment; Disinfection; Effluent Disposal; Solids Processing; Support Facilities • Brainstorm criteria • Prioritize criteria

Phase 2B – Creative (for potential cost-saving proposals)

10:00 a.m. to 1:00 p.m. *Working lunch from 12:00 to 12:30 p.m.*	**BRAINSTORMING** • Generate alternative solutions to current design • Generate observations of existing design and treatment process • Validation of design elements • Focus on high cost functions of project • Review area by area • Review discipline by discipline

Wednesday, June 24

Phase 3A - Ranking of Concepts (for major mechanical and process alternatives)

1:00 p.m. to 2:00 p.m.	**REVIEW & CREATE ALTERNATIVE TREATMENT CONCEPTS** • Review plant treatment concepts developed to date • Define any alternative concepts
2:00 p.m. to 3:00 p.m.	**SCREENING OF ALTERNATIVE CONCEPTS** • Key advantages and disadvantages of each concept • Are there any fatal flaws that preclude a concept? • Are there other concepts that should be considered? • Select several of the most promising concepts for further ranking and development
3:00 p.m. to 4:00 p.m.	**RANKING OF ALTERNATIVE CONCEPTS** • Rating of alternative concepts • Point values as indicators for relative comparisons • Determine top concepts for further refinement

Phase 3B – Analysis (for potential cost-saving proposals)

4:00 p.m. to 5:00 p.m.	**PASS/FAIL OF ALTERNATIVE SOLUTIONS** • Discussion of advantages and disadvantages • Pass/fail analysis • Selection and refinement of promising cost-saving proposals

Phase 4A - Refinement of Concepts (for major mechanical process alternatives)

5:00 p.m. to 5:30 p.m.	**REFINE AND ENHANCE TOP CONCEPTS** • Recap concerns or deficiencies of top concepts • Team refinement of top concepts • Order of magnitude cost opinions
5:30 p.m. to 6:00 p.m.	**IDENTIFICATION OF PREFERRED CONCEPT** • Re-rating of top concepts • Identification of preferred concept • List any areas for further refinement

Thursday, June 25

Phase 4B – Development (for potential cost-saving proposals)

8:00 a.m. to 8:30 a.m.	**VE STUDY PROPOSAL AND OBSERVATIONS FORMAT** *(Overview by VE Team Leader)*
8:30 a.m. to 11:00 a.m.	**PROPOSAL DEVELOPMENT** • Write-ups • Economic calculations • Supporting sketches
11:00 a.m. to 12:00 p.m.	**COMPLETE WRITE-UPS, AND CROSS CHECK PROPOSALS.**
Working lunch from 12:00 to 12:30 p.m. for those who do not need to leave at noon to catch flights	**PREPARE EXECUTIVE SUMMARY; COPY PRELIMINARY REPORT**

Phase 5 – Presentation	
Post-Study Conference Call (date and time TBD)	**EXECUTIVE SUMMARY PRESENTATION (OR CONFERENCE CALL) WITH CITY, DEQ, AND DESIGN TEAM** • Summary of VE study methodology • Preferred treatment alternatives from concept rating system • Cost saving and functional enhancement proposals • Observations (notes to design team and City/DEQ) • VE cost saving proposals • Project delivery/phasing/scheduling comments • Follow-up activities • Comments from City and DEQ • Comments from CH2M HILL design team
Phase 6 – Implementation	
Post-Study	The Implementation Phase will be subsequent to the VE Study. The City of Bend, DEQ, and the CH2M HILL design team will review the proposals during the predesign phase of the project and will advise the VE Team of acceptance, rejection, or modification of the VE proposals for incorporation into the design as appropriate. CH2M HILL will follow-up with a Final VE Report or a letter supplement to the Preliminary VE Report documenting the final disposition of the VE proposals.

Bend, Oregon, Water Reclamation Facility–Project Overview

PREPARED FOR: Bend WRF - VE Planning Team

PREPARED BY: Adrienne Mennitti/PDX
William Leaf/BOI

COPIES: Dave Green/PDX
Brady Fuller/BND
Michelle Burkhart/PDX

DATE: June 19, 2009

Introduction

This memorandum provides a brief overview of the Bend Water Reclamation Facility (WRF). A general description of the WRF is provided within along with some of the key project issues. This memorandum also refers to sections from the existing Facility Plan (FP), by Carollo Engineers, where additional information can be found. The FP is set up with Sections and includes technical memorandums (TM) in the appendix (i.e., TM 4 – Liquids Process Assessment). The key concepts from the CH2M HILL proposal are also presented.

Bend Water Reclamation Facility

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

- Preliminary treatment
- Primary clarification
- Activated sludge using a Modified Ludzack Ettinger (MLE) process
- Secondary clarification
- Chlorine disinfection
- Tertiary filtration (seasonal usage for production of Level IV reclaimed water)
- Discharge to infiltration/seepage ponds and/or water reuse system

And the following solids treatment processes:

- Primary sludge thickening
- Waste activated sludge (WAS) thickening

- Digestion
- Biosolids dewatering
- Land application of biosolids (on site)

The existing WRF began operation in 1981. Previous upgrades to the WRF include two new seepage ponds in 1983, construction of a new solids handling building in 1996, upgrades to the secondary treatment process in 2000, addition of the cloth media filters for reclaimed water production around 2000, and a new headworks facility in 2008. Effluent from the WRF is applied either to the existing seepage pond system or as reclaimed water. The treatment plant operates under a WPCF discharge permit (attached).

Process flow diagrams from previous designs are included along with this memorandum. The treatment plant has three equally sized basins that operate in parallel. Figure 6.1 from Carollo's FP shows the current configuration of the basins.

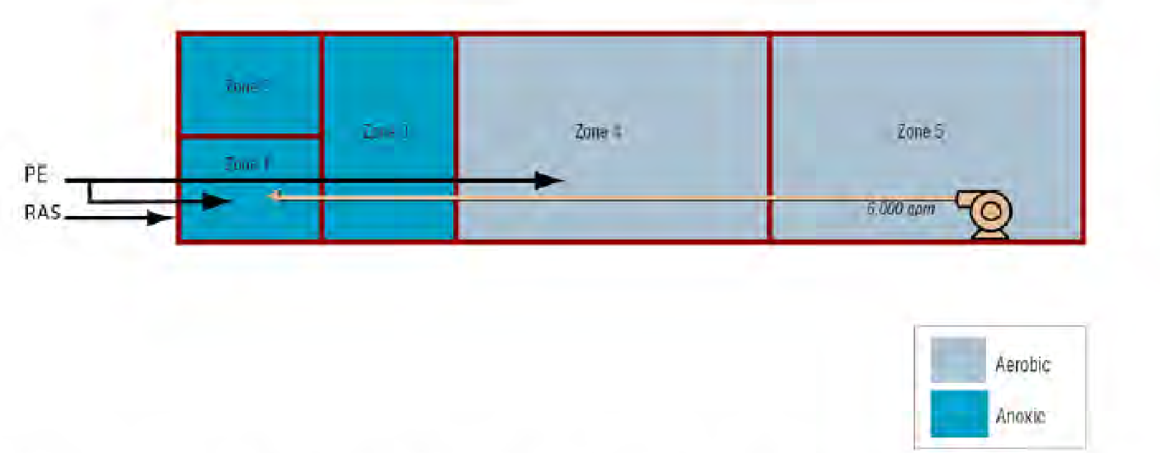


Figure 6.1 Existing Aeration Basin Configuration and Flow Distribution

The existing "step-feed" piping for peak wet weather treatment allows some primary effluent to be diverted to Zone 4 but the pipe is undersized at only 12 inches in diameter.

The bioreactor is alkalinity limited, pebble lime is added to provide alkalinity as required.

Key Project Drivers

(1) The current facility is at capacity, Table 1 provides the current influent flow rates and associated unit process capacities.

TABLE 1
Bend WRF – Current Influent Flow, Existing Unit Process Capacity

Influent Flow	
Current average daily average flow	5.9 MGD1
Current average daily maximum month flow	6.5 MGD[1]
Nominal unit process capacity	
Primary Clarification	6.2 MGD[2]
Aeration Basins	6.0 MGD[2]
Secondary Clarification	6.0 MGD[2]
Disinfection	5.5 MGD[3]

Facility Plan Table 4.1

Facility Plan Table 3.1, ADMM

Facility Plan Table 3.1, Average flow with one unit out of service

(2) The treatment facility currently has an annual monthly average total nitrogen discharge limit of 10 mg/L. Evaluations in the FP (TM 3) provide additional information on the effluent disposal criteria. It is noted that the current effluent limit along with the continued practice of water reuse is protective of ground water. However, there is the potential for reduced total nitrogen limits to 3 or 6 mg/L. (TM 5, Table 2)

(3) The treatment plant experiences severe seasonal bulking events attributed to *M. parvicella*. However, the FP recommends confirmation of the problem organism (TM 4, section 5.4). Relatively high SVIs are recorded at the facility (200-300). The treatment plant currently chlorinates to control bulking, which appears to be an effective approach.

(4) The current peak wet weather treatment infrastructure is lacking at the treatment facility. Contact stabilization is recommended by the Facilities Plan for peak wet weather treatment.

Other process information:

- The Deschutes Brewery contributes to the plant COD load. The COD limits are 1650 ppd daily, 1600 ppd weekly, 1575 ppd monthly. The current BOD loading to the treatment plant is 18,030 ppd (TM 1, Table 2). The BOD/COD ratio of brewery waste was characterized in 2004 (BOD/COD=0.67). The brewery also produces a high strength waste that is sent to another site for disposal.
- Bend currently nitrifies to low levels then adds ammonia back to the reuse water to generate chloramines for disinfection.

– The capacity rating of primary clarification from the facilities plan suggests that they are at capacity. The proposed primary clarifier addition would provide capacity along with the needed redundancy in the system.

– The treatment plant has a hydraulic bottleneck between the secondary clarifiers and chlorine contact basin that needs to be rectified.

– When reuse water is produced, all effluent flow must be treated to Level IV reuse standards.

– Eastern Region DEQ folks had some minimal comments about the City of Bend and their Facility Plan:

    - Oregon DEQ commented on concerns about expanded infiltration ponds and potential Nitrate impacts on groundwater. Memo is attached indicating that current and projected nitrate levels downgradient from the infiltration ponds are below the critical 5 mg/l level of concern by DEQ. The monitoring wells do show that nitrate levels are slightly higher downgradient of the infiltration ponds. If the levels reach or exceed 5 mg/l, then Bend will be required to upgrade their treatment process to achieve lower nitrogen levels.

    - DEQ concerns can be addressed by continued monitoring, improved existing monitoring wells, expanding monitoring when infiltration ponds are expanded, etc. Another approach that might add value would be improved plant performance that will consistently reduce the effluent Nitrate levels, minimizing the nitrate load to the infiltration ponds, and minimizing Bend's risk of ever exceeding the 5 mg/l trigger point for advanced nitrogen removal.

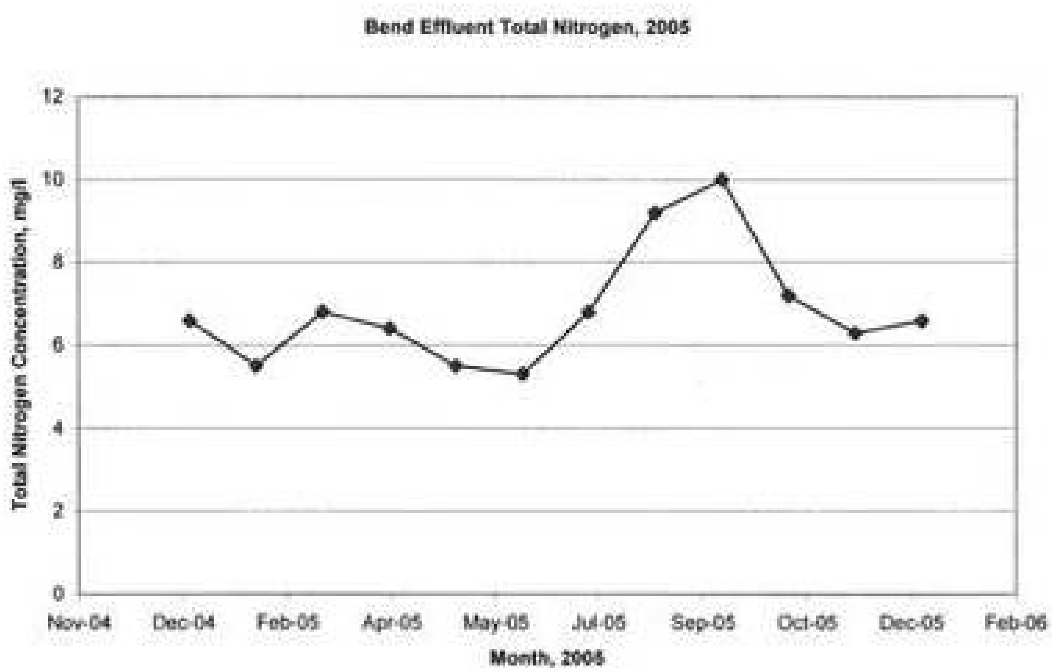


Figure 1 Bend WRF Effluent Total Nitrogen, 2005

Facility Plan Recommendations

Three process alternatives were compared and summarized in Facilities Plan Section 6.1.3.3:

Alternative1 – Existing Configuration: All future aeration basins designed with a configuration identical to the existing aeration basins (Figure 6.1 above).

Alternative 2 – Reduced Anoxic Zone: All aeration basins designed with a configuration identical to the existing aeration basins, except that the anoxic zone is decreased from 34% to 17% (Figure 6.2, Carollo). The existing aeration basins will also be reconfigured with the reduced anoxic zone. To implement this alternative, the existing anoxic Zone 3 would be converted to an aerobic zone with a target oxygen concentration of 2 mg/L. This configuration results in an increased aerobic volume for nitrification, while continuing to provide sufficient anoxic volume to denitrify.

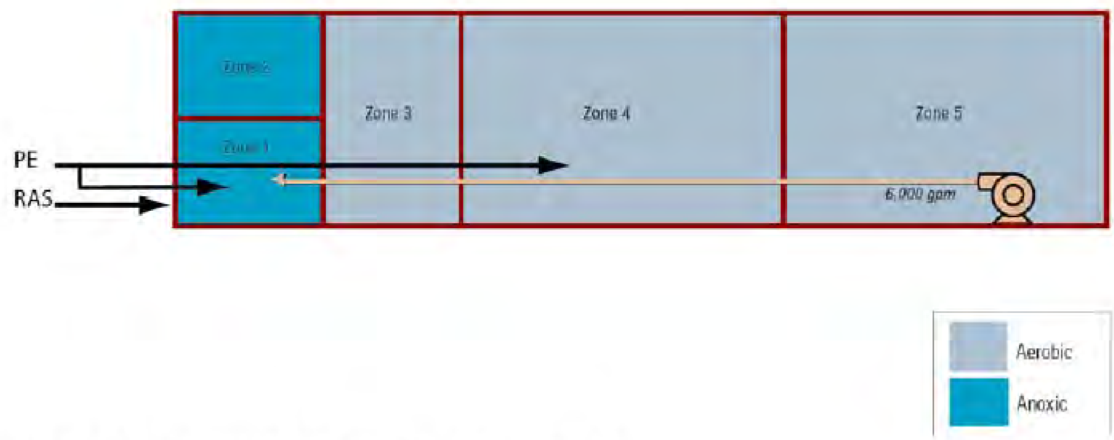


Figure 6.2 Alternative 2: Reduced Anoxic Zone

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

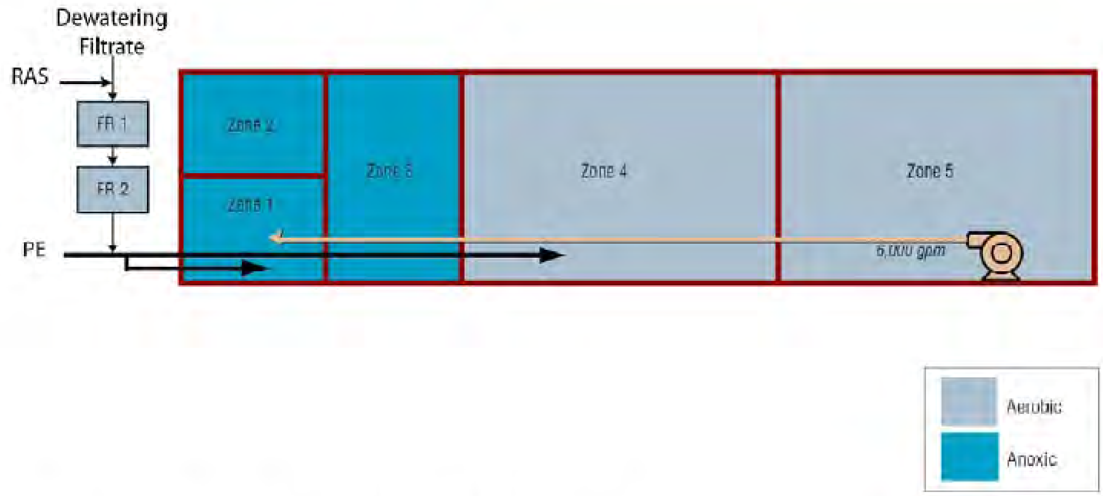


Figure 6.3 Alternative 3: Filtrate Reaeration

The facilities plan recommends filtrate reaeration. By incorporating two new filtrate re-aeration basins with a total volume of 0.4 MG, the treatment plant capacity can be increased to treat the 2010 flows without the construction of a new basin and without any modifications to the existing basins. Filtrate reaeration therefore provides capacity expansion with reduced construction. Filtrate reaeration also required fewer aeration basins (i.e. smaller aeration basin volume) to achieve the desired TN limit of 10 mg/L for 2030 projected flow and loads. Filtrate reaeration also results in a lower MLSS concentration in the aeration basins, reducing the secondary clarifier solids loading.

The Facilities Plan also recommends poly aluminum chloride (PAX) addition to control seasonal bulking problems, starting with an initial pilot of PAX additional prior to full-scale implementation. Current bulking issues are managed with the addition of chlorine.

FP TM 4 Section 7.0 provides the following phased recommendations:

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

- Conversion of chlorine gas system to hypochlorite system and construct one new chlorine contact basin

• 2013

– Construct one new secondary clarifier and secondary clarifier splitter box

• 2019

– Construct one new primary clarifier

– Construct one new aeration basin

– Add one blower

• 2024

– Construct one new secondary clarifier

– Add one blower

CH2M HILL Proposal Concepts

The general concept from our proposal was to work closely with the City to identify cost-effective projects that meet their treatment goals, while minimizing financial impacts with an effective phasing approach. The technical approaches we have, to be evaluated further with the City, are:

First-flush and grit removal.

Not mentioned in the proposal, (but VE team should understand) is the tendency for large amounts of grit to be discharged to the WRF during rare peak flow conditions. A large rain-on-snow event in December 2006 resulted in “filling” a primary clarifier with grit. Are there any methods of facilitating a more rapid recovery from major grit events in primary clarifier or splitter design?

Blower System Upgrade

An early-out project, to be implemented in the near-term, is to replace the existing blowers with high-speed, high efficiency blowers for improved energy efficiency and increase in system capacity. APSCO and K-Turbo are interested in fronting the capital costs for the blowers through a pay-back plan, allowing an expedited installation of the system.

SVI Control

A biological approach to controlling *M. parvicella* is proposed, with the goal of reducing the overall SVI within the system to improve secondary capacity. We would like to incorporate a system where a targeted aeration zone is utilized to control *M. parvicella* growth, based on the findings from WERF Project 01-CTS-4 and 4a (2006, 2008). Research has demonstrated that a selector, by itself, does not control *M. parvicella*; selectors remove dissolved organic matter, not particulate and colloidal matter. The region just downstream of the anoxic environment is typically low in dissolved oxygen because traditional aeration systems do not elevate this level fast enough. With the particulate and colloidal "food" passing through the selector, an ideal environment for the growth of *M. parvicella* is created.

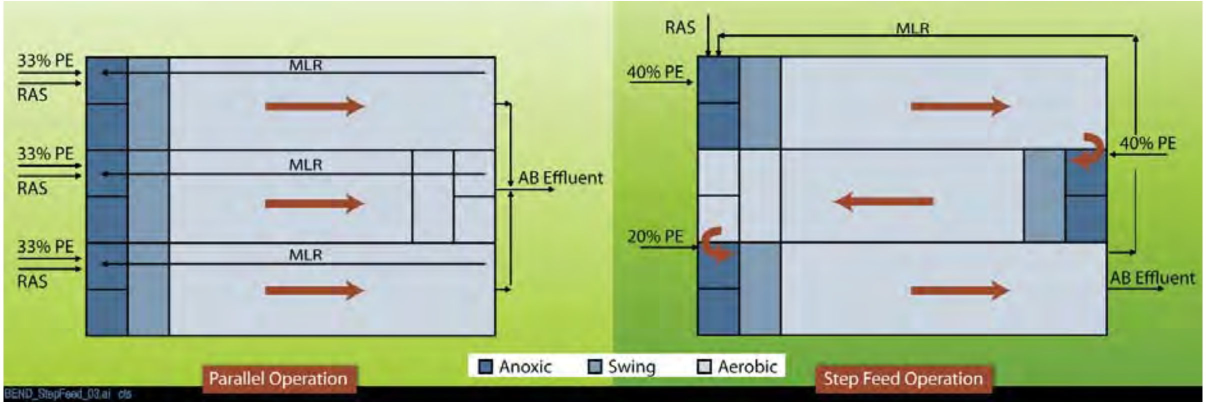
The aeration system in the bioreactors can be reconfigured to generate an independent aeration zone, having a consistent and relatively high aeration rate, just downstream of the anoxic zone. The aeration control system would be designed to provide the required dissolved oxygen to this independent aeration zone, and would not be affected by other oxygen demands in the system. This high aeration zone can be appropriately sized based on the predictability of biological growth, availability of particulate and colloidal organic matter, and correlations between organism respiration rate and required dissolved oxygen.

Contact Stabilization

As noted previously, the existing system allows for the conveyance of primary effluent to the first aerobic zone during wet weather events. Unfortunately this system is undersized, limiting the amount of primary effluent that can be transferred. An upgrade to this system is warranted, and could be implemented in the near term.

Step-Feed System

An incremental increase in capacity could be achieved with the conversion of the existing aeration basins to a step-feed system. This is an alternative that may be warranted if a relatively lower-cost approach is needed. As the original complete-mix aeration basin design did incorporate a step-feed system, we need to work with the City to make sure this is an alternative worth continued evaluation. The concept is that a new, automated step-feed system allowing for improved process control could be implemented. Below is the concept for this type of system. The system would be designed to provide flexibility, allowing continued operation with the current configuration but having the ability to operate in a step-feed mode when additional capacity is needed.



Side-stream Treatment

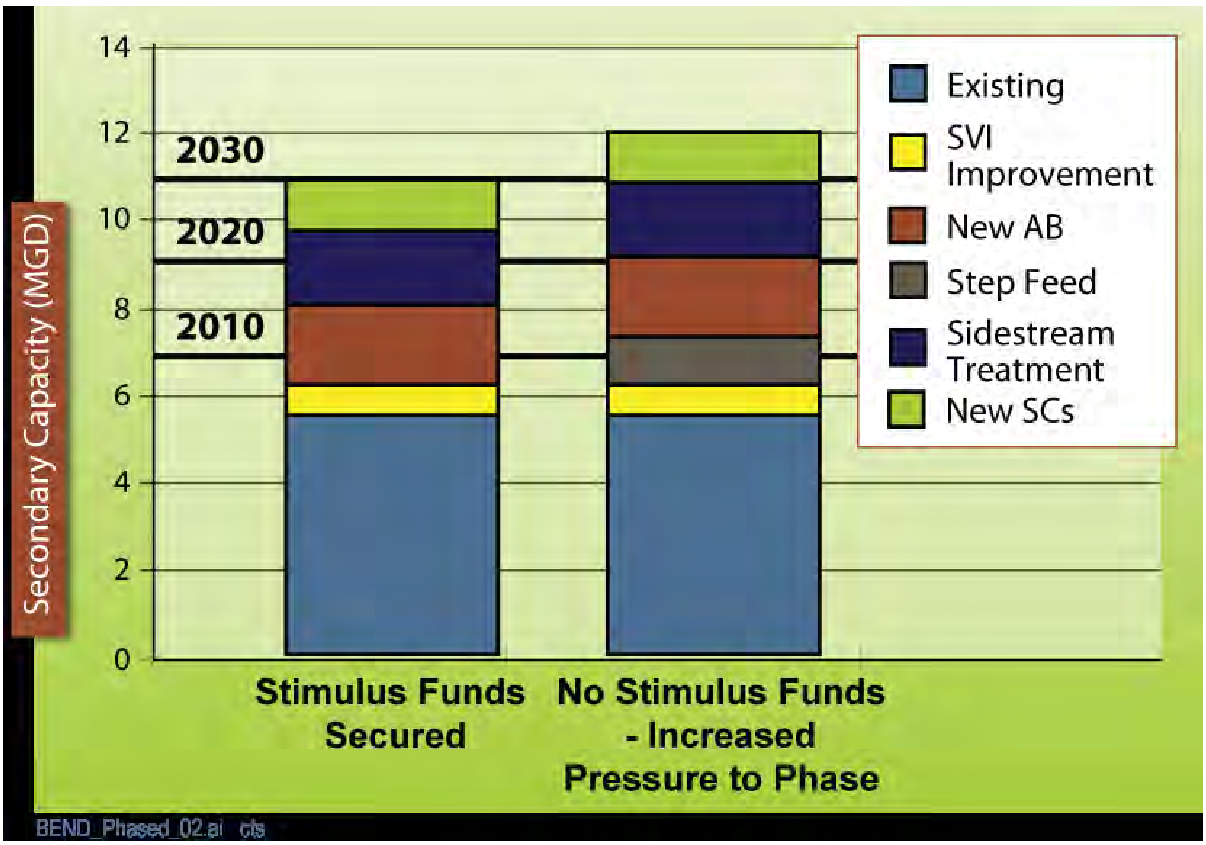
Sidestream treatment is a viable alternative for capacity improvements through the reduction in ammonia load and associated bioaugmentation available with some systems. There are a number of sidestream treatment configurations and technologies available. It was noted in the proposal that filtrate reaeration may or may not be the appropriate for the City. We will evaluate sidestream treatment technologies, and work with the City to determine the configuration best suited for the facility.

New Aeration Basin and Secondary Clarifier

It may be warranted to install a new aeration basin and secondary clarifier to provide the needed capacity in the system. A concept would be to optimize the existing system to the extent possible, with approaches similar to those stated above, deferring the capital investment required for a new aeration basin and secondary clarifier. However, depending on the associated financial viability, it may be warranted to proceed with a larger secondary system upgrade.

Capacity Increase Approach

As stated before, the goal of our approach is to provide a cost-effective, phased approach to expansion at the WRF. Below is figure that details on concept of how the systems above could be incorporated to provide the necessary system capacity.



Disinfection System

The FP recommends abandoning the gaseous chlorine system, and providing new liquid hypochlorite disinfection facilities. An additional concern that needs to be evaluated is to address the expected requirement for filtration prior to disinfection (a proposed Oregon Class A recycled water requirement per ORS 340-55). The preference is to maintain filtration downstream of disinfection due to costs but will need to assess direction from DEQ.

A cost-effective split flow disinfection system is a good approach to minimize chemical costs so that not all effluent is treated to Level IV reuse standards. Flexibility with this required flow split needs to be incorporated into the system. We will need to work with DEQ regarding the proposed Class A requirements and split flow disinfection, along with other reuse issues (different chlorine residual based on effluent disposal, etc.).

Chloramination requirements for the disinfection of Level IV reuse will be evaluated. If the City would like to replace the existing ammonia tote system, the 90-percent design completed by CH2M HILL in March 2004 for a permanent ammonia addition facility can be integrated into the design.

Note that per the FP the new, additional CCB has to be located hydraulically higher than the other 2 to provide for separation for re-use water with potential use of adjustable weir gates for operational flexibility. As such a pump station is required to pump to the new CCB. Maybe consider, addressing sustainability effects of chlorine storage, bulk delivery, air conditioning vs. sun shade and heat tracing, etc.

Hydraulic Improvements

A detailed evaluation of the hydraulic issues at the WRF will be completed, with the removal of hydraulic bottlenecks incorporated into the appropriate design project. It is our understanding that there are hydraulic concerns with some of the primary effluent basin piping and at the 21-in propeller flow meter. The secondary clarifiers back up in to the aeration basin splitter box too.

We are presently collecting water surface data using Isco level meters and dataloggers. We should have collected some flow associated with moderate storms the week of June 5th.

References

CH2M HILL (2009). Proposal for Secondary Expansion, City Project No. SW0802. Prepared for the City of Bend, OR.

Carollo Engineers, Inc. (February 2008). DRAFT – Executive Summary, Water Reclamation Facility Plan, City Project No. SW0701. Prepared for the City of Bend, OR.

Carollo Engineers, Inc. (April 2008). City of Bend Water Reclamation Facilities Plan – DRAFT. Prepared for the City of Bend, OR.

Water Environment Research Foundation (WERF, 2006). Develop and Demonstrate Fundamental Basis for Selectors to Improve Activated Sludge Settleability. IWA Publishing. WERF Project 01-CTS-4.

Water Environment Research Foundation (WERF, 2008). Develop and Demonstrate Fundamental Basis for Selectors to Improve Activated Sludge Settleability – Phase II Lab Investigation. IWA Publishing. WERF Project 01-CTS-4a.

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