YAKIMA BASIN POINT SOURCE WATERSHED ASSESSMENT

Report to the South Central Washington Resource Conservation & Development Council

By James L. Barnard, Ph.D.,D.Ing.h.c., PE. BCEE WEF Fellow and H. David Stensel, Ph.D., PE, BCEE

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Yakima Basin Clean Water Partnership – RC&D Committee
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1. Introduction

The work reported here is in response to needs identified by the South Central Washington RC&D Council (RC&D) for implementing a holistic approach to water quality management in the Yakima River Basin. In the Yakima River Basin, significant investments have been made to improve water quality and overall watershed function. Today the river is still impaired with nutrient concentrations in the lower Yakima River, which have been found to be high enough to periodically support high levels of periphytic algae and macrophytes, causing significant daily fluctuations in dissolved oxygen and pH. These conditions likely impact migrating salmon, undermining efforts to increase access and improve habitat upstream.

The most common approach to mitigating nutrient-related water quality problems are regulatory efforts to define very stringent effluent nutrient discharge levels from publically owned wastewater treatment plants (WWTPs). However, regulations alone for point source dischargers do not fully address the range of ecosystem services, such as water quality, fish habitat, in-stream flow, upland and riparian habitat, and agricultural best management practices that all play a role in protecting and improving the water resources in the Yakima River Basin. A watershed level approach requires the development and adaptation of tools that will quantify the benefit of innovative nutrient management practices and resource restoration, develop credits for those benefits, and move potential buyers and sellers of those credits closer to the point where they can participate in an Ecosystem Services Market in the Yakima River Basin.

Organizations across the Yakima River Basin have worked both individually and collaboratively for years to restore and protect streams, wetlands, floodplains, and riparian habitat. But it is becoming critical to increase the scale, rate, and effectiveness of limited restoration dollars. The project lead is proposing to collaboratively facilitate pollution reduction and ecosystem restoration, with market driven conservation as a tool that can help achieve those goals.

This watershed level approach requires the development and adaptation of tools that will quantify the benefit of innovative nutrient management practices and resource restoration, develop credits for those benefits, and move potential buyers and sellers of those credits closer to the point where they can participate in an Ecosystem Services Market in the Yakima River Basin. As a first step, a base-line analysis is needed for point source dischargers to identify relatively simple, low cost approaches that can be implemented within their wastewater treatment facilities to move to higher levels of phosphorus and nitrogen removal.

2. Objectives and Approach

Phosphorus has been identified as the main nutrient of concern, but cost effective technology used for phosphorus removal will also remove over 50% of the nitrogen in a WWTP. The major goals of this project were to (1) gather specific treatment process information about the participating WWTPs to allow an assessment of phosphorus reduction methods that could be implemented by operational changes and/or with moderate costs, (2) identify a range of cost effective plant retrofit approaches for phosphorus reduction, and (3) carry out workshops with WWTP operators and managers and their consultants to identify the most promising options for nutrient reduction at their respective facilities. These alternatives could be developed further in the facility plan of each WWTP.

The following tasks were carried out to meet the project objectives.

Task 1. WWTPs Survey

In Task 1, we gathered the information needed for the assessment of possible methods to improve phosphorus removal at the existing WWTPs in the Yakima River Basin. Twenty one WWTPs were initially identified, and process design and performance information was obtained for 17 of these. Information for three facilities was not pursued after an initial screening, as the existing processes offered little opportunity for the type of cost effective phosphorus methods identified. Information for a fourth facility was not obtainable within the time and resources of the project, after efforts to obtain it in the Washington Department of Ecology files and consultant contacts.

Task 2. WWTP Analyses and Nutrient Removal Workshop Preparation

In Task 2, we independently evaluated each WWTP to identify cost-effective phosphorus and nitrogen removal options. Our findings were shared and reviewed with each other. We then develop preparation materials about the facilities and nutrient removal options for use in the workshops with the WWTP managers and designers. A nutrient removal Technology Toolbox was developed for discussion at the workshops.

Task 3. Workshops for WWTP Assessments

In Task 3, we planned and carried out two separate full-day workshops, which were held with the WWTP managers and designers to assess and demonstrate the potential for cost-effective nutrient removal for representative facilities. They were held in Yakima, WA. on October 17th and in Grandview, WA. on October 18th. Materials covered in these workshops were (1) a review of key fundamentals related to enhanced biological phosphorus removal, (2) presentation and discussion of the nutrient removal tool box and how to apply it to identify options available to make a first level improvement in nutrient removal, and 3) group discussion of options for in-plant improvement for nutrient for selected WWTPs and identification of feasible and preferred approaches. The agenda for these workshops was as follows:

8:30 – 9:00 **Introduction**

Purpose and goals of workshop
Source, impacts, and general methods for phosphorus removal

9:00 – 10:00 **Enhanced Biological Phosphorus Removal (EBPR)**

What is it and how does it work?
What is required to make it work at a WWTP?
How do EBPR designs relate to nitrogen removal?
Dos and don'ts of EBPR
What factors affect the effluent phosphorus concentration?

10:15 – 11:15 **Implementation of EBPR at wastewater treatment facilities**

What process steps need to be considered?
What is a good check list for evaluating EBPR?
What methods would be part of an EBPR retrofit toolbox?

11:15 - Noon **EBPR retrofit examples**

Examples of retrofit methods used to improve phosphorus removal

1:00 – 2:00 **Review of the Yakima River basin WWTPs**

Types of plants
Existing permits
Identify plants with potential for EBPR

2:00 – 3:30 **Break out session into working groups to discuss methods of applying EBPR tools to existing Yakima River Basin WWTPs***
Groups review plants
List retrofit alternatives
Select one or two preferred approaches

3:45 – 4:30 **Presentation of results of WWTPs evaluations and discussion**

A third, 1/2 day workshop was held on October 19 in Yakima, Wa. to review the results of the prior two workshops and to provide technology transfer on cost-effective nutrient removal methods identified for regulators and WWTP managers. The agenda for this workshop was as follows:

8:30 – 9:00 **Introduction**

Purpose and goals of workshop
Source, impacts, and general methods for phosphorus removal.

9:00 – 9:30 **Enhanced Biological Phosphorus Removal (EBPR)**

What is it and how does it work?

9:30 – 10:15 **Methods that can be used to implement EBPR at WWTPs**

10:30 – 11:00 **Review of the Yakima River basin WWTPs**

11:00 – 11:30 **Review of workshop findings on implementing EBPR at existing facilities**

11:30 – 12:30 **Discussion**

This report provides (1) a background on cost effective phosphorus removal methods, (2) a description of the technology tool box and its application for different types of WWTP processes, (3) a summary of the WWTPs survey, and (4) the results of the WWTP analyses given at the first two workshops to identify operational or plant modifications methods for cost-effective phosphorus removal.

3. Background On Cost Effective Nutrient Removal Technology

The phosphorus concentration in influent wastewater to WWTPs treating mainly domestic wastewater is in the range of 4 to 8 mg/L. About half of that is as orthophosphate. The remainder is found in organic and polyphosphate compounds, which mostly converted to orthophosphate by biological reactions. Phosphorus is a conservative element and exits the WWTP in the treated effluent or in waste sludge. Moving the phosphorus from the influent to the waste sludge is accomplished by enhanced biological phosphorus removal (EBPR) and/or chemical precipitation (Figure 1). EBPR relies on unique biological process reactor designs, the availability of the wastewater Biochemical Oxygen Demand (BOD), and operating conditions to select and maintain bacteria that have a remarkable capacity for phosphorus uptake and cellular storage. The phosphorus content of these bacteria, on a dry weight basis, may range from 20 to 30 percent as compared to about 1.5 percent for the bacteria typically grown in a biological wastewater treatment system. The phosphorus-rich biomass grown is removed from the EBPR system in the daily excess sludge wasting.

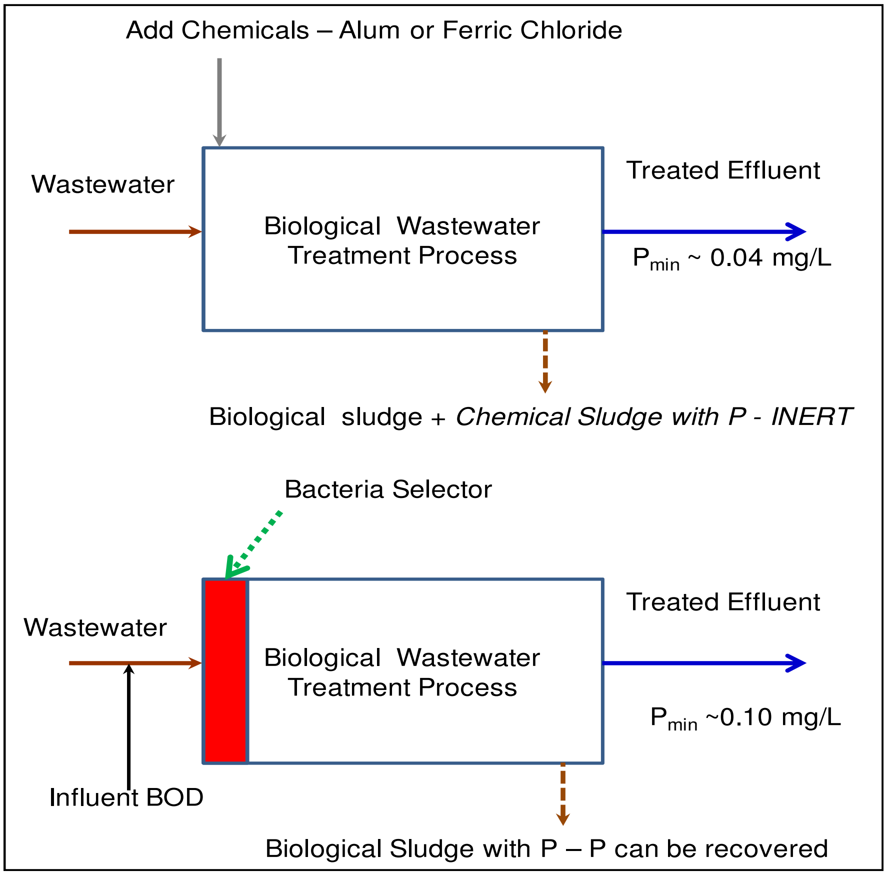

FIGURE 1. SCHEMATIC OF TWO PHOSPHORUS REMOVAL ALTERNATIVES FOR BIOLOGICAL WASTEWATER TREATMENT FACILITIES: CHEMICAL PRECIPITATION AND ENHANCED BIOLOGICAL PHOSPHORUS REMOVAL (EBPR).

The other removal mechanism, chemical precipitation, is accomplished by adding metal salts (alum or ferric chloride) to the wastewater treatment process to form aluminum or iron phosphorus precipitates, which are then removed via the waste sludge. This method involves the manufacturing and transport of the chemicals to the plant and more sludge production at the wastewater facility. In comparison, the EBPR process uses a free chemical contained in the influent wastewater, which is a portion of the influent organic material or BOD.

The advantage of the chemical precipitation method is that a very low effluent phosphorus concentration can be achieved, with minimal concentrations between 0.03 and 0.05 mg/L possible. However, the wastewater treatment plant capital and operating costs increases, and more rapidly for lower effluent P concentrations, due to the chemical and sludge handling costs as indicated in Figure 2. On the other hand, an EBPR process represents a more sustainable technology at lower costs. It generally requires some modest plant modifications and/or operating changes, but cannot achieve the very low effluent phosphorus concentrations by chemical precipitation. However, a combination of biological and chemical processes can achieve low effluent concentrations with low chemical dosages and reduced sludge production. Phosphorus removal is also dependent on the wastewater characteristics and can range from 50 to 90 percent. Another important advantage of the EBPR process is that most of the phosphorus removed can be recovered in struvite recovery processes (e.g., one is currently in operation in the Yakima Basin at the Yakima WWTP) and recycled. This is especially important as we recognize that phosphorus is an essential and globally finite resource.

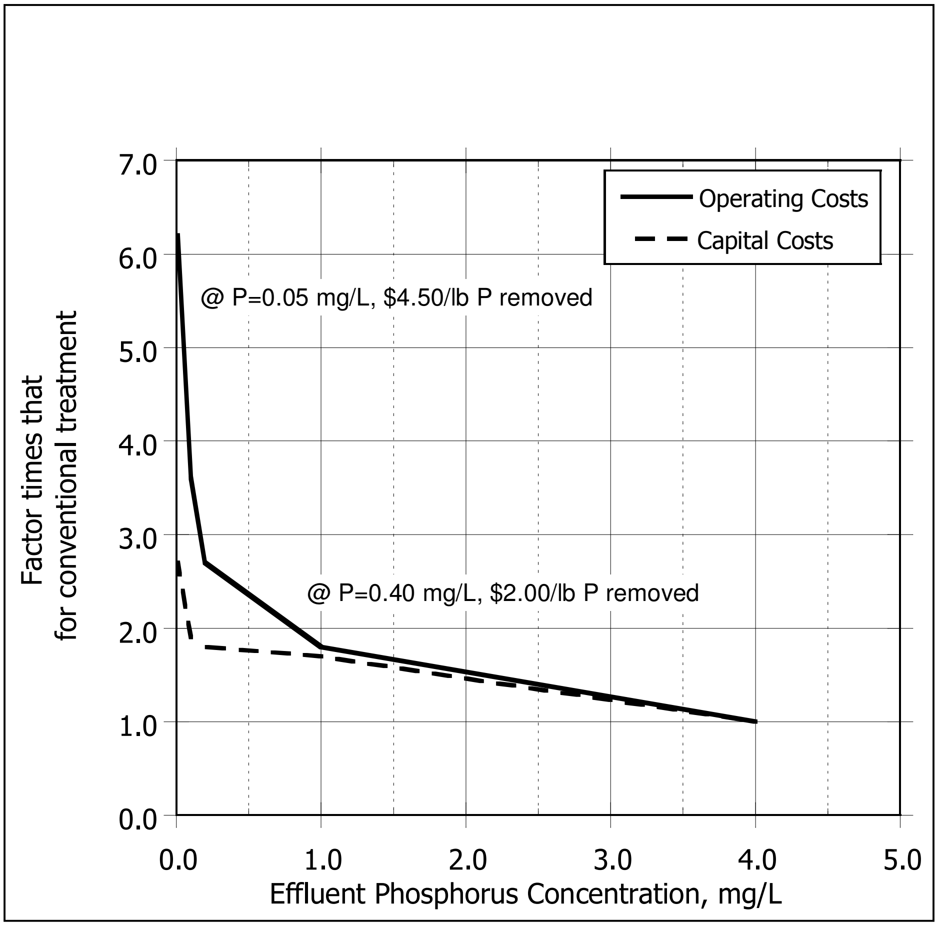

FIGURE 2. REPRESENTATION OF THE IMPACT OF CHEMICAL ADDITION FOR PHOSPHORUS REMOVAL BY CHEMICAL PRECIPITATION. THE RATIO OF THE WWTP CAPITAL AND OPERATING COSTS COMPARED TO CONVENTIONAL TREATMENT INCREASES WITH LOWER EFFLUENT PHOSPHORUS CONCENTRATION.

With the goal of identifying cost effective plant modifications to improve nutrient removal, the WWTP assessment focused on methods that could be used to implement EBPR technology for the different WWTPs in the Yakima Basin. For a few WWTPs, EBPR processes were in place and thus the facility review was intended to find ways to optimize P removal performance at no or little additional costs. There are many factors that affect the phosphorus removal efficiency with EBPR technology, and thus site specific factors for each wastewater treatment plant were considered and reviewed with the wastewater treatment plant workshop attendees to determine the most appropriate and feasible approaches to provide EBPR. The next section provides a further background on the fundamentals of EBPR and methods for incorporating it into existing WWTPs.

3.1 Enhanced Biological Phosphorus Removal

Biological phosphorus removal involves the selection of phosphorus accumulation organisms (PAOs) and the incorporation of phosphorus in the PAOs produced in the treatment system and subsequently the removal of the biomass and phosphorus during sludge wasting. The key to the process is providing an anaerobic condition prior to an aerobic condition (Figure 3). In the anaerobic zone, acetate and propionate (volatile fatty acids or VFAs) are produced by fermentation of soluble, readily biodegradable carbon (as measured by chemical oxygen demand), which is referred to as rbCOD. The VFAs are then taken up and stored as complex carbon compounds by the PAOs in the anaerobic zone. In subsequent anoxic (nitrate or nitrite present, but no oxygen) and aerobic zones, the PAOs oxidize the stored carbon, which results in energy production and the uptake of orthophosphate with minimal soluble phosphorus remaining in the treated effluent.

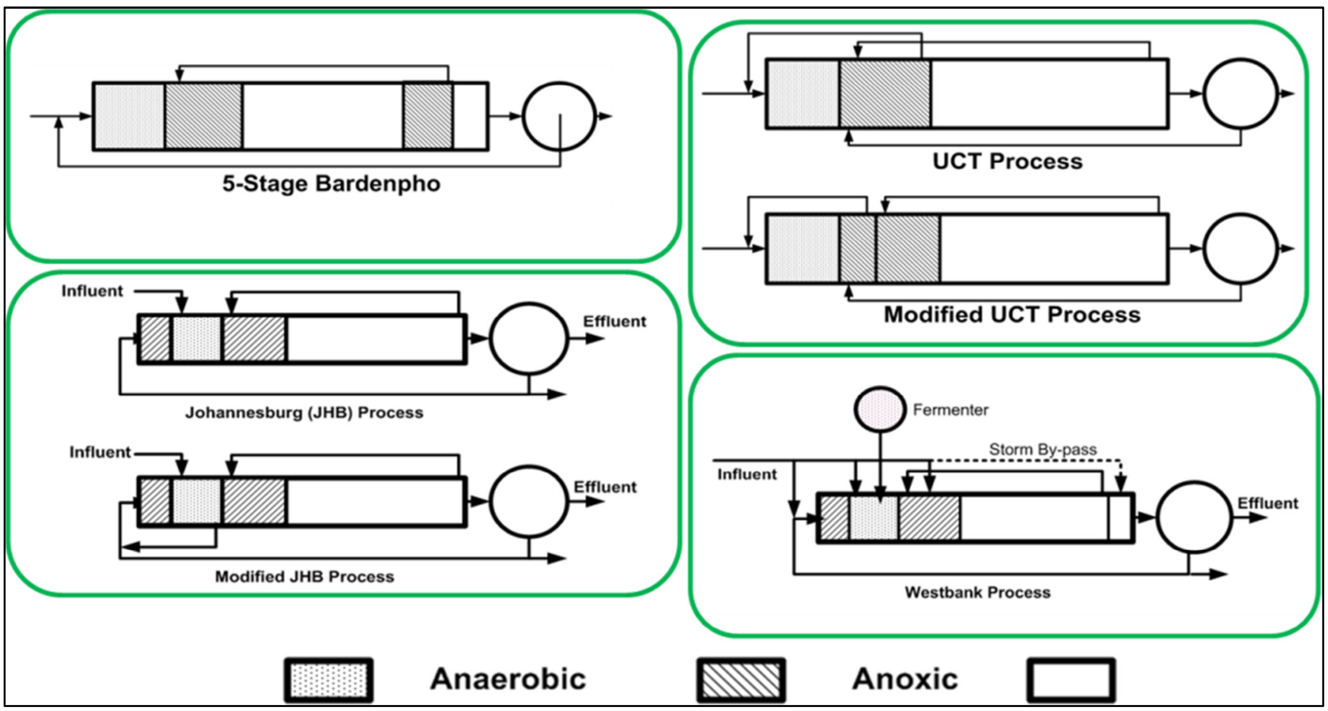

FIGURE 3. SOME CONVENTIONAL FLOW SHEETS FOR BIOLOGICAL PHOSPHORUS REMOVAL.

While the mechanism of biological phosphorus removal and the need for VFAs have been well researched and documented to the point where it is now possible to design a plant with a very reliable phosphorus removal process using formal flow sheets, as shown in Figure 3. However, biological phosphorus removal is still observed in a number of plants that have no designated anaerobic zone, which has been considered essential for phosphorus removal. In such unconventional plants, mostly mixed liquor or return sludge is fermented, whether in separate vessels or on the floor of the main basins. Exploiting these new approaches to old technologies has encouraged many plant operators to experiment with these originally observed technologies, sometimes at little or no increase in cost and with remarkable results.

When the theory for biological phosphorus removal were developed after the initial observations in plants that could now be described as "unconventional", the importance of VFA was emphasized in that the PAOs could take up VFA under anaerobic conditions, using previously stored phosphorus as an energy source while releasing the phosphorus, then taking up the released phosphorus and all surplus phosphorus in the influent upon aeration of the mixed liquor in the next stage to where most of the phosphorus in solution is taken up in the biological cells. When sludge is wasted the phosphorus is removed from the liquid stream. Most wastewater does not contain enough VFA and it was necessary to achieve some fermentation in an anaerobic zone free of nitrates and oxygen to supply the needed VFA. This led to some of the formal flow sheets, shown in Figure 3, that were considered necessary to avoid nitrates being discharged to the anaerobic zone which would stop fermentation of readily biodegradable COD to VFA.

Even when designed according to such conventional flow sheets, some of these plants did not perform well since there was just not enough fermentable material in the influent to sustain phosphorus removal. It was then necessary to ferment some of the primary sludge to produce enough VFA to sustain the process. This added additional BOD to the plant which would increase sludge production.

Barnard (1974) noticed release of phosphorus in the second anoxic zone of a 4-stage Bardenpho plant when testing the process in a 100 m^3/d pilot plant for nitrogen removal. Phosphorus was released in the second anoxic zone to more than 30 mg/L as P, with rapid uptake in the re-aeration zone, achieving soluble effluent phosphorus concentrations of less than 0.2 mg/L. The layout of the pilot plant is shown on Figure 4. The pilot plant was formed by partitioning an existing set of two tanks. A dead zone was created inadvertently in an effort to establish four zones with predetermined volumes. The circled numbers in the sketch on Figure 4 show the soluble phosphorus concentrations in the mixed liquor in each zone. In this case there was no anaerobic zone and it was realized much later that some mixed liquor passed to a fermenter (Dead Zone) and was returned, which confirmed that more than an anaerobic zone, anaerobic conditions are required to form somewhere in the plant.

Since that time many observations were made of "unconventional" processes that removed phosphorus and it was established that in all cases, some of the mixed liquor was fermented

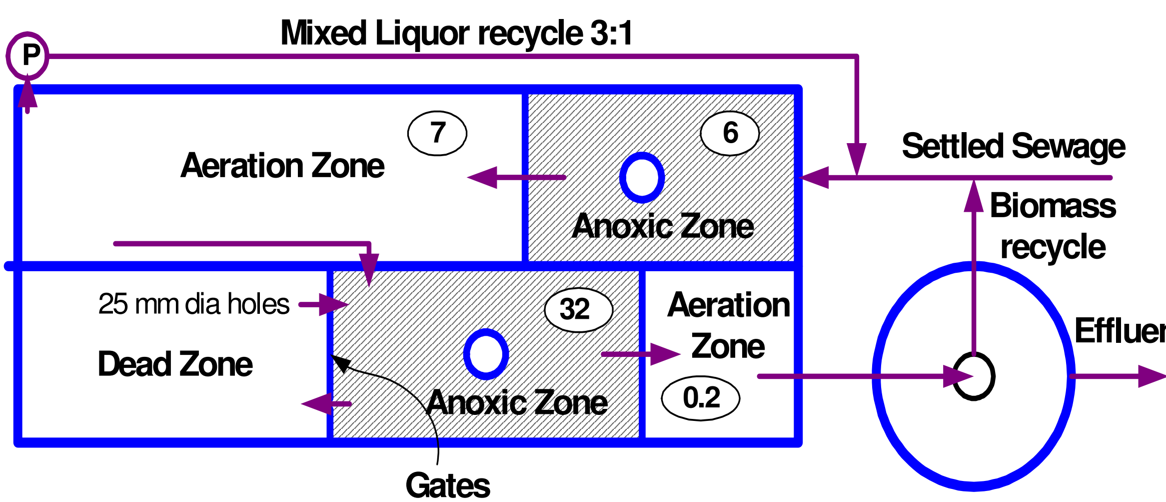

FIGURE 4 ORIGINAL BARDENPHO PILOT PLANT WITH PHOSPHORUS REMOVAL.

either in a separate zone or on the floor of the tanks when mixers were switched off or even where aeration was switched off. Oxygen and nitrates were soon depleted and the redox potential lowered sufficiently to promote fermentation of solids to VFA. It was possible to achieve phosphorus removal in an experiment in which mixed liquor was pumped from the anoxic zone of a small MLE (anoxic/aerobic) plant at the Iowa Hill plant in Colorado to an unmixed basin, where the mixed liquor was fermented and passed back to the anoxic zone. Even with no anaerobic zone it was possible to achieve effluent phosphorus removal to levels of 0.03 mg/ℓ ortho-phosphorus. In many plants that were designed for phosphorus removal, but where the influent wastewater characteristics were not favorable, it was possible to reduce the phosphorus by switching off a mixer in the anaerobic zone, allowing mixed liquor to ferment on the floor. The thickening of the sludge in the basin allows fermentation to take place and the new mixed liquor seems to float over the thicker sludge while exchanging VFA and fresh sludge.

The Henderson NV plant treats an average flow of 21.5 Mgal/d. Regulations required that effluent total phosphorus concentrations be limited to 0.14 mg/L. Two existing Carousel plants were upgraded to high-rate operation and retrofitted with anaerobic and anoxic basins to treat 12 Mgal/d each. A new parallel biological phosphorus removal (BNR) plant (Figure 5) was constructed to treat an additional 6 Mgal/d. There are no primary sedimentation tanks. The combined effluent from the old and new plants is pumped to rapid mixing, chemical clarifiers, and sand filters. During plant construction, long pumping mains and wastewater temperature ranging from 20 to 28 ºC produced sufficient VFA in the influent for achieving good biological phosphorus removal and no additional acid fermentation units were provided. Both the Carousel and the BNR plants are operated in the Johannesburg (JHB) configuration. A pre-anoxic zone was provided for denitrification of the return activated sludge in all the parallel trains.

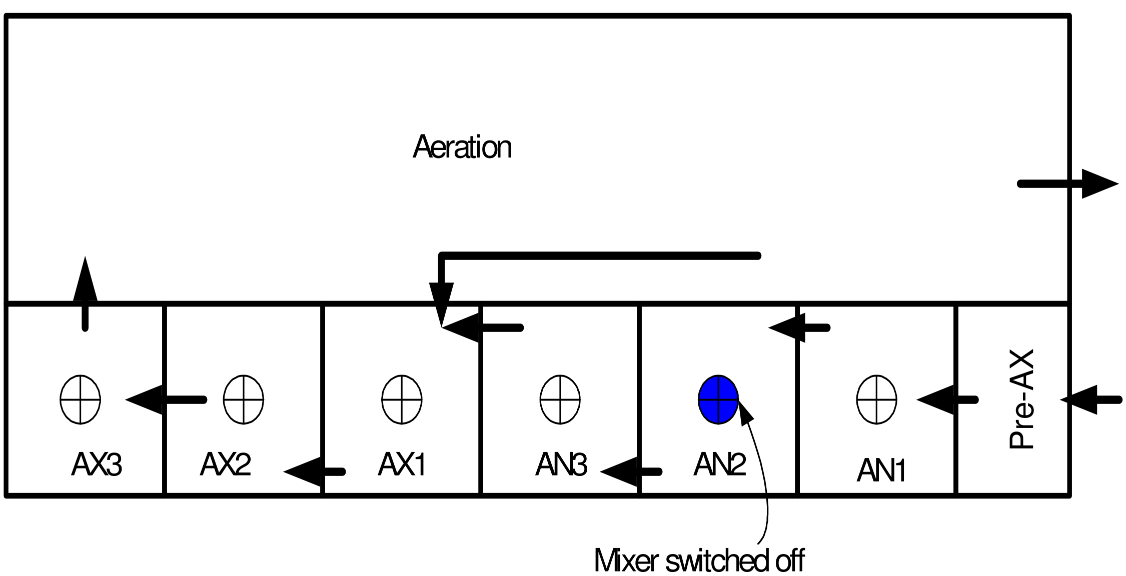

FIGURE 5. LAYOUT OF THE HENDERSON BNR PLANT.

During startup of the plant, the concentration of the VFA in the influent was about 5 mg/L which was not sufficient to sustain biological phosphorus removal. It appeared that a nitrate solution that was added to the sewer system to combat odors, also oxidized the VFA or prevented their formation. It was decided to operate the second anaerobic zone of each of the three plants as in-basin fermenters by stopping the mixers for all but 15 minutes each day. The short mixing period was needed to prevent permanent accumulation of solids on the basin floor or in the corners away from the main flow. Biological phosphorus removal was greatly improved. Effluent ortho-phosphorus concentration averages 0.1 mg/ℓ.

The success of these plants and many others has encouraged operators to experiment in their own plants and the purpose of this workshop was to convey this experience to the Yakima communities for possible pro-active measures to reduce phosphorus to the receiving stream.

4. Technology Toolbox for Plant Modifications for EBPR

The potential for converting existing WWTPs to incorporate an EBPR process depends on the existing process and the plant layout. The biological process treatment technology at the 17 Yakima River Basin WWTPs evaluated fit into one of 3 basic process types: (1) activated sludge, (2) sequencing batch reactor (SBR), or (3) oxidation ditch. To provide a roadmap for the evaluation of retrofitting these types of facilities to an EBPR process, a technology toolbox that considered the various aspects of the EBPR process and conditions to optimize its performance was developed (Table 1).

The toolbox considered the basic process functions for a successful EBPR system. First, it is necessary to have an anaerobic contact zone in which the VFAs are provided for the population selection of PAOs. There are various ways to do this, depending on the type of biological process. Activated sludge plants with no unaerated zones and having a plug-flow arrangement are better suited for manipulation, as some phosphorus removal is possible even by switching off aerators at the front end. In more complete mixed tanks this is not possible and the strategy would be to look for external tanks that could be used for fermentation of mixed liquor. In activated sludge plants with un-aerated zones, some may be designed for phosphorus removal but have difficulty in achieving EBPR; it may merely be a case of switching off some mixers. The same applies to oxidation ditches, while SBRs have the flexibility of re-arrangements of various cycles to create the necessary conditions for phosphorus removal. Even here some outside vessel could be used for side-stream fermentation of mixed liquor.

Successful EBPR performance depends on having a minimal amount of nitrate fed to the anaerobic contact zone. All of the WWTPs in the study were showing successful nitrification, and thus nitrate was in their aerobic treatment zones, which could be fed to an EBPR contact zone by the addition of necessary return activated sludge. Thus different methods to remove nitrate were identified for the different types of processes. These methods employed biological denitrification and conversion of nitrate to nitrogen gas. Thus, nitrogen removal was also an important part of evaluating methods for conversion of the existing WWTPs to EBPR facilities.

TABLE 1. TECHNOLOGY TOOLBOX FOR IMPLEMENTATION OF EBPR IN EXISTING WWTPS.

Function	Tools	Process Type*		
		AS	SBR	Ditch
Anaerobic Contact	Turn off some aerators	x		
	Divide/baffle tanks	x		
	Add external tank		x	x
	React/fill is anaerobic		x	
Minimize NO3 to Anaerobic Tank	Aeration on/off	x	x	x
	Aeration low DO	x	x	x
	Convert to anoxic/aerobic tanks	x		
	Convert to Bardenpho	x		
	Add anoxic contact tank	x	x	
	Provide anoxic zone for RAS (JHB)	x	x	x
	Step feed SBR		x	
Minimize DO to Anaerobic Tank	Check influent head drop/aeration	x	x	x
Optimize SRT	Sludge wasting control	x	x	x
Get more food for PAOs	Create settling periods in anaerobic	x		x
	Industrial sources	x	x	x
	Onsite fermentation of waste solids	x	x	x
Minimize P in recycle	Keep waste sludge aerobic	x	x	x
	Off-site sludge processing	x	x	x
	Composting	x	x	x
	Anaerobic digester struvite recovery	x	x	x
Optimize P uptake	Provide sufficient aerobic time	x	x	x
	Provide sufficient DO	x	x	x
	Modify to staged kinetics	x		
	Waste sludge from aerobic zone	x	x	x

*AS = Activated Sludge, SBR = Sequencing Batch Reactor, Ditch = Oxidation Ditch.

The technology toolbox also points out the need to minimize the amount of dissolved oxygen added to the anaerobic contact zone, as this also hinders the efficiency of the PAOs in EBPR systems. The biological process, solids retention time (SRT) is also critical to the level of performance of an EBPR system. Systems with longer SRTs result in more time for biomass reduction due to endogenous decay. The less biomass or PAOs produced, the less is the phosphorus removal via the waste sludge. To maximize EBPR system performance, it is best to operate at SRT values that are above that are just above that needed for complete nitrification.

The amount of PAO growth and thus the amount of phosphorus removed in an EBPR system is dependent on how much readily degradable BOD is fed to the PAOs under an anaerobic contact condition. Thus the technology toolbox points out the need to consider any other sources of food that could be added to the retrofitted EBPR system. For the Yakima River Basin WWTPs, there are some opportunities for the use of food processing wastewater to provide more VFAs to improve the efficiency of an EBPR system.

If more phosphorus is fed to an EBPR system without increasing the readily available BOD, a higher effluent P concentration will result. Thus, recycle streams that have a high amount of phosphorus are of concern. Such recycle streams originate from aerobic or anaerobic sludge digestion. A final function shown in a technology toolbox is to optimize the conditions for phosphorus uptake by the PAOs. There must be sufficient time under aerobic conditions. The toolbox indicates that the reactor configuration, dissolved oxygen concentration, and methods of sludge wasting should be considered to optimize phosphorus uptake.

5.0 WWTP Survey

For the purpose of this study, 21 WWTPs were identified. Three of these were eliminated from further evaluation because their existing designs were not compatible for a retrofit to EBPR. These were (1) Buena which has a recirculating gravel filter, (2) Wapato with a rotating biological contactor (RBC) system, and (3) Richland with a Biolac system. Nothing can be done with attached growth systems like trickling filters and Moving Bed Biofilm Reactor (MBBR) plants or pond systems. In addition, information for the City of Sunnyside was not made available within the study time frame, leaving 17 WWTPs for review. The remaining WWTPs had biological treatment process designs that fit one of the three basic process types mentioned in the previous section (Oxidation Ditch, Activated Sludge, SBRs), which have potential for modification to EBPR treatment.

A list of these facilities with their design flows is given in Table 2 (next page). A plant survey summary was prepared for these systems to provide the necessary background for process evaluation. The summaries are provided in Appendix A of this report and the information is organized under each of the three basic process types. Information was obtained from available engineering reports (many were made available by the Department of Ecology, Yakima office) and one year of monthly Discharge Monitoring Reports (DMRs) giving average influent and effluent measurements. The survey summaries in Appendix A include information on the existing discharge permit requirements, the average performance for one year up to May 2012, the WWTP layout with unit processes and relevant design sizing, and the WWTP design flow and loads, and additional observations regarding plant observations related to the potential for conversion to EBPR. Site visits were made to about 12 of the 17 WWTPs.

6. Results of Evaluations for Retrofit of WWTPs to EBPR

Representative WWTPs were selected during the two full-day workshops to assess the methods from the technology toolbox for facility modification to provide EBPR, or to improve the performance of EBPR where the process already existed or was part of a new design. WWTPs were selected to represent the three types of biological systems listed above, and priority was given to workshop attendee WWTPs. The plant evaluations are presented in this section in the same order of the WWTPs plant surveys given in Appendix A. The recommended modifications are given in the order of those methods that have the greatest impact or need for EBPR. Where possible, operational changes were identified to create conditions for EBPR. The methods preferred for each type of biological treatment system can also be considered for other WWTPs under the same category, but not specifically covered in the workshops. Implementation of these recommendations would require in many cases design consultation and/or consultation on procedures for instituting operational changes and necessary monitoring and data collection.

Table 2. List of 17 WWTPs in plant surveys in Appendix A.

WWTP	Annual Average Design Flow, Mgal/d	Comments
Oxidation Ditch		
Grandview	1.5	Carrousel -existing tankage for EBPR
Granger	0.3	Brush- new parallel ditch to be built
Mabton	0.25	Brush –new design - provide EBPR potential
Naches	0.14	Shallow trapezoidal brush ditch design
Zillah	0.42	As external tank, brush design
Activated Sludge		
Toppenish	1.2	Has an operating EBPR process
Yakima	11.3	Is being modified to an EBPR process
Benton City	1.0	Waste sludge lagoon
Ellensburg	5.0	Square aeration tanks, sloped walls
Richland	8.9	Surface aerators in aeration basins
Kennewick	6.6	Secondary system design information sought
Selah	1.5	Square aeration tanks, sloped walls
Sequencing Batch Reactors (SBRs)		
Kittitas	0.5	2 tanks, waste sludge lagoon
Cowiche	0.25	4 tanks, waste sludge lagoon
Cle Elum	3.6	2 tanks, waste sludge lagoon
Prosser	0.63	2 tanks, preceded by trickling filter
Port of Sunnyside	0.55	2 tanks, Industrial wastewater treatment

6.1 *Oxidation Ditch WWTPs*

Oxidation ditch designs are used for secondary treatment at Grandview, Granger, Mabton, Naches, and Zillah.

City of Grandview

The Grandview facility has 2 mixed, unaerated tanks before the oxidation ditch, which can serve as anaerobic and anoxic contact zones (Figure 6). The anaerobic zone provides conditions necessary for EBPR. The amount of phosphorus removal for the facility is not well known as it is currently not a permit parameter. Excellent EBPR performance may be expected for the facility in view of the fact that it has a fairly strong wastewater due to a high level of industrial waste food processing sources.

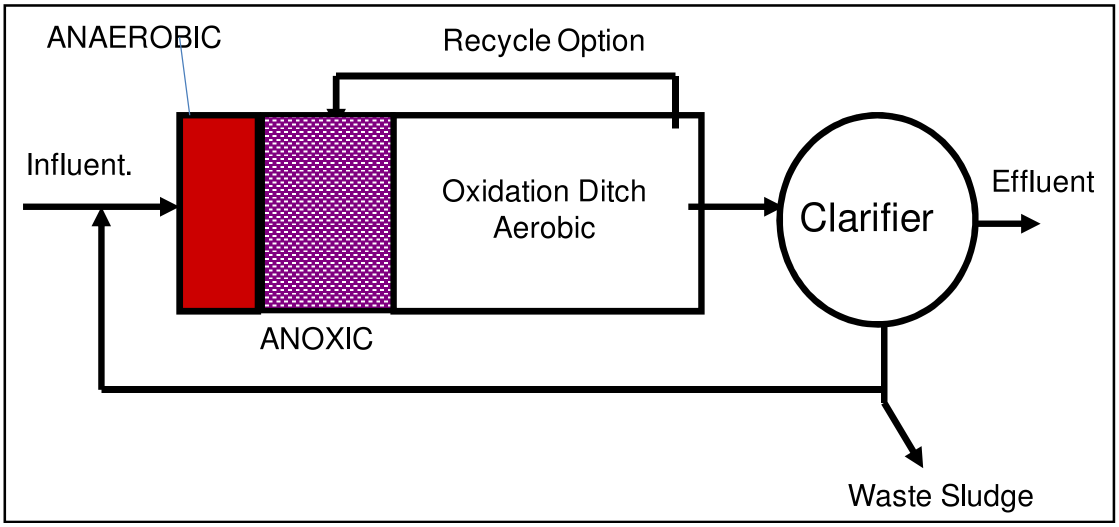

FIGURE 6. SCHEMATIC OF GRANDVIEW OXIDATION DITCH PROCESS WITH ANAEROBIC AND ANOXIC ZONES.

The following recommendations are made concerning the implementation and optimization of EBPR at the Grandview WWTP:

- Use internal recycle tool to maximize nitrate removal.
- Provide more monitoring information to assess the level of phosphorus removal.

City of Granger

The Granger facility has an existing shallow oxidation ditch with two brush aerators. A new parallel ditch is to be built. Currently the waste sludge from the oxidation ditch is sent to an aerobic digester before decanting and sludge removal. We recommend that the new facility design consider the addition of an anaerobic contact tank and that and Oxidation Reduction Potential (ORP) probe and mixer be installed at the Granger facility to control nitrogen removal in the ditches. Alternatively, the design engineer could add an anoxic contact tank with the new external anaerobic tank.

City of Mabton

The Mabton facility is to be modified with the installation of anaerobic, anoxic, and aerobic zones prior to the existing oxidation ditch process (Figure 7). These modifications provide an excellent opportunity for EBPR. The following recommendations were made for the new installation.

- Use mixers in anaerobic contact and anoxic contact zones instead of air for mixing.
- Optimize performance by obtaining more readily degradable BOD.
  - Turn off mixer(s) in anaerobic zone.
- Use staged aerobic zones in the aerobic tank before the oxidation ditch to improve phosphorus uptake rates.
- Control digester supernatant return flow rates.
- Use minimal SRT to improve phosphorus removal efficiency.

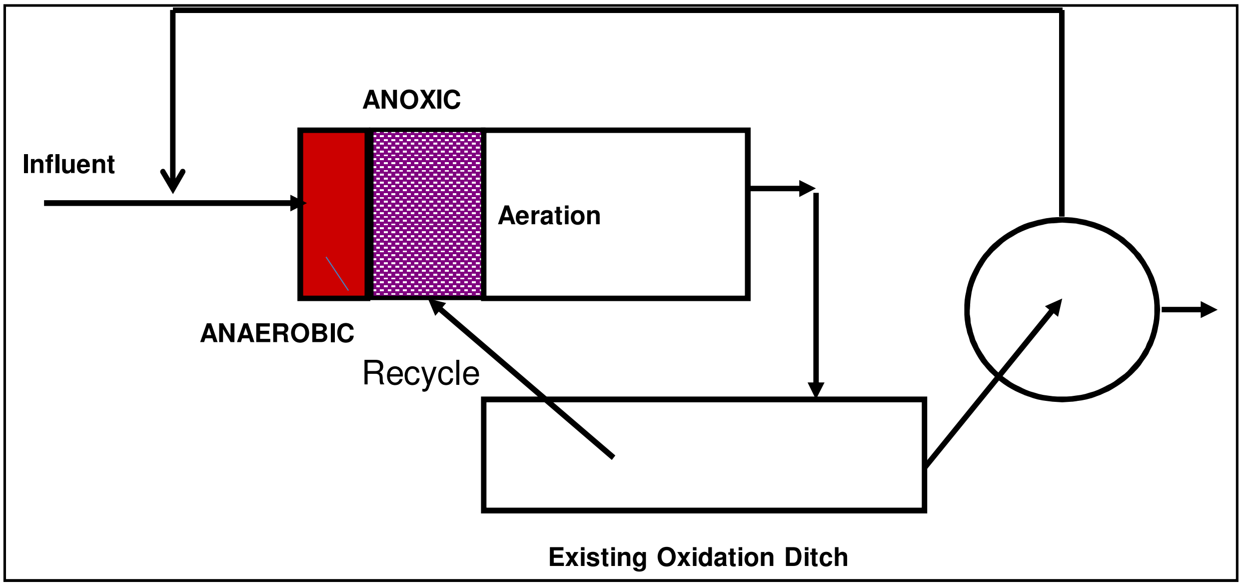

FIGURE 7. MODIFICATIONS PLANNED FOR ADDITION OF ANAEROBIC, ANOXIC, AND AEROBIC STAGES BEFORE THE MABTON EXISTING OXIDATION DITCH SYSTEM.

City of Naches

The Naches facility is a conventional oxidation ditch system. For such systems, it is necessary to find an external tank to provide in anaerobic contact zone for EBPR. Fortunately, an old chlorine contact tank is available at the site for consideration for use as an anaerobic contact zone. Additionally, recommendations were made to improve the nitrate removal in the oxidation ditch by using either aeration or ORP control. The following summarizes the recommendations.

- Use external tank (abandon chlorine contact tank) for anaerobic contact zone.
- Control nitrates in the oxidation ditch by aeration and dissolved oxygen control.
- Add a mixer to the oxidation ditch for NO_3 removal with an ORP control system.
- Reduce the aeration rate to help NO_3 removal in oxidation ditch.

City of Zillah

The Zillah facility has a long narrow aerated tank before the existing oxidation ditch. The tank receives return activated sludge and the influent wastewater, and is aerated in three initial baffled zones with coarse bubble diffused aeration. Following that fine bubble diffused aeration is used in the rest of the tank with a detention time of about 4 hours. This tank provides an excellent opportunity for a simple conversion to provide EBPR by using methods to allow the initial contact zones in the existing narrow tank to be anaerobic. The following summarize the recommendations for progressive steps to reach this goal:

- Turn off air in the 3 initial coarse bubble zones or periodically turn the air on and off to provide an operational change for EBPR without capital investment.
- Insert baffles and mixers to turn the narrow tank into conventional anaerobic/anoxic zones.
- Use mixers instead of coarse air for the 3 initial contact zones.

- Add mixers and ORP control for NO_3 removal in the oxidation ditch.
- Optimize the SRT to maximize phosphorus removal.

6.2 *Activated sludge WWTPs*

Three activated sludge WWTPs were reviewed; Toppenish, Yakima, and Selah.

City of Toppenish

For the Toppenish facility, Figure 8 shows a schematic of the Toppenish design in which anaerobic and anoxic contact zones are in place to provide EBPR. The WWTP has reported periods of low effluent phosphorus concentrations, but there are periods with dilute influent wastewater strength when the P removal declines. Increasing the availability of readily biodegradable BOD should help improve performance and the following is recommended:

- Turn off some mixers in anaerobic zone.
- Lower the SRT at warmer temperatures.
- Ferment waste primary sludge in the smaller extra primary clarifier.
- Add additional outlet port in anoxic recycle line so that return activated sludge recycle only goes to the anoxic zone.

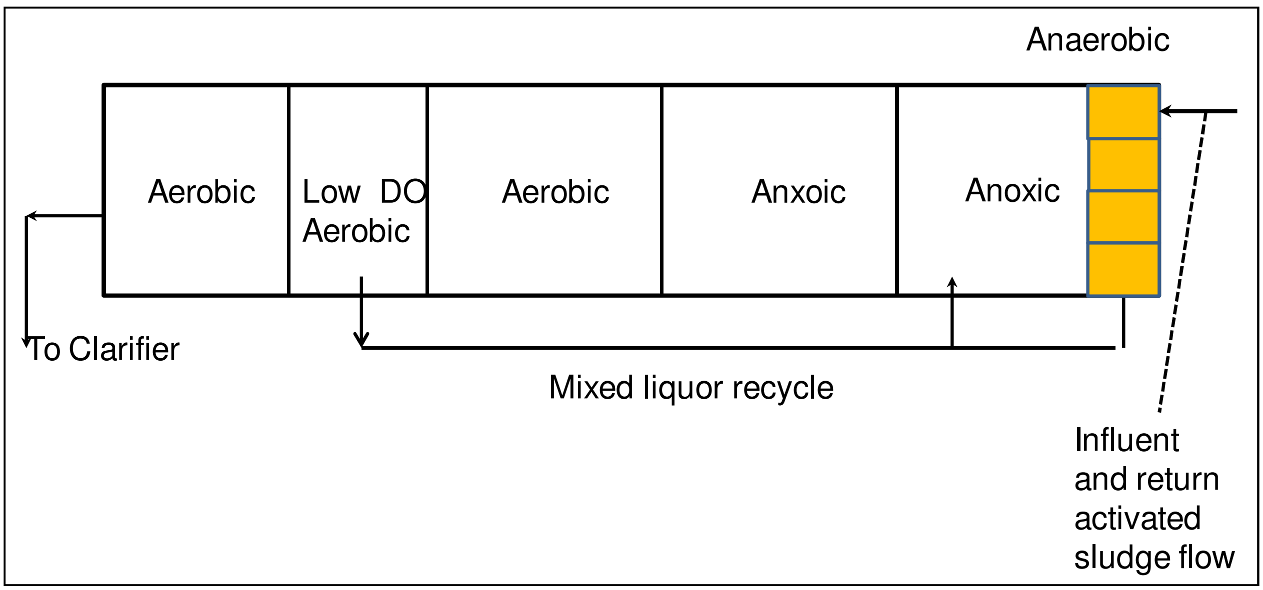

FIGURE 8. SCHEMATIC OF THE TOPPENISH BIOLOGICAL NUTRIENT REMOVAL DESIGN.

City of Yakima

The Yakima facility was designed as a conventional activated sludge system with nitrification capacity. A design and retrofit construction is underway to convert the system to an EBPR facility. The new process design to promote EBPR is shown in Figure 9. It is a version of the EBPR Johannesburg (JHB) process. The return activated sludge is directed to a designated anoxic zone in which the nitrate is reduce prior to the return sludge contacting the influent wastewater in the anaerobic zone. Aeration zones follow for phosphorus uptake and nitrification.

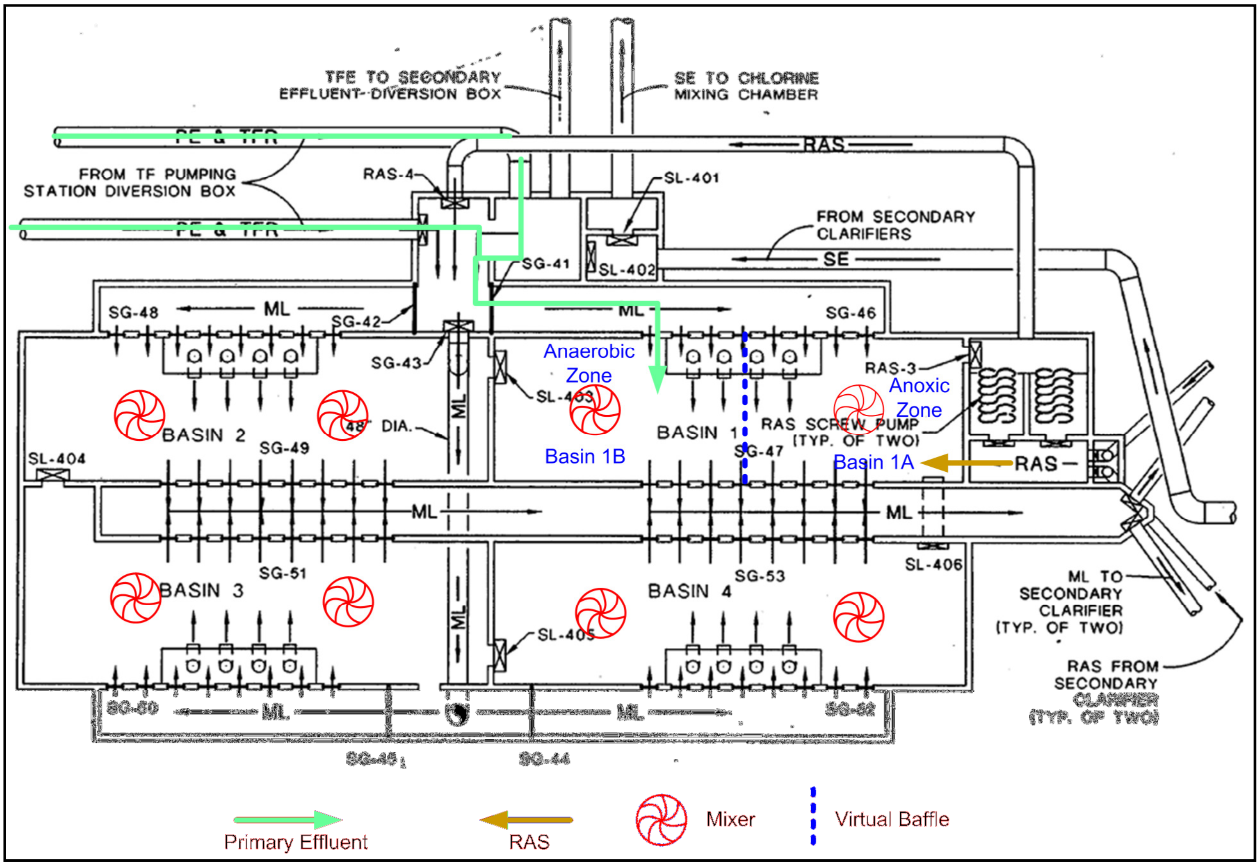

FIGURE 9. SCHEMATIC OF EBPR PROCESS IN RETROFITTED YAKIMA WWTP.

City of Selah

The Selah facility has a good source of readily available BOD from food processing industrial wastewater that goes to an aerated lagoon. The lagoon effluent is treated with domestic wastewater in the Selah activated sludge treatment system. By passing some of the industrial wastewater provides a higher influent BOD to phosphorus ratio to encourage good EBPR performance. A major challenge at the Selah facility was to develop conditions to provide an anaerobic contact zone. An operational method to vary the aeration in the activated sludge tank was the only logical option in lieu of building an anaerobic contact tank. Cycling the first aerator on and off would allow for periods of anaerobic contact to develop conditions favorable for the growth of PAOs and subsequent EBPR. The following was recommended for the Selah WWTP:

- By-pass some Sunripe wastewater.
- Turn down aeration to develop anaerobic contact.
- Turn off one aerator at night for anaerobic contact.
- Cycle aerators on and off for NO_3 removal.
- Use aerobic digester –partition a portion for fermentation of mixed liquor.
- Add some industrial waste to the digester ML fermentation zone.
- Cycle aeration in aerobic digesters for reducing nitrates.

6.3 Sequencing Batch Reactor WWTPs

Three sequencing batch reactor (SBR) designs were evaluated. These were for the Kittitas WWTP, which treats mainly domestic wastewater, the Prosser WWTP, which has a mixture of domestic and industrial food processing wastewater, and the Port of Sunnyside WWTP, which treats industrial wastewater from a dairy operation and seasonal food processing. All of these SBRs were not designed for EBPR and thus did not have any provision for in the anaerobic contact time. Mixing during the entire fill process of an SBR operation would provide an excellent anaerobic contact condition to promote EBPR. However, all of these designs only had a mixed, non-aerated period during about 15 to 25 percent of the fill time. This provides some nitrate removal, but is insufficient for an EBPR operation. Programming changes would be necessary to optimize existing systems for EBPR, but some operational changes were identified that relate to the aeration strategies that may help promote some degree of EBPR.

City of Kittitas

The following recommendations were provided for the Kittitas WWTP:

- Extend fill without aeration.
- Experiment with DO set points.
- Fill during decant.
- Post anoxic mixing towards end of recycle.
- Surface wasting of mixed liquor and scum.
- Add external or internal partition for mixed liquor fermentation.

City of Prosser

For the Prosser WWTP, the use of the trickling filter prior to the SBR is likely removing too much readily available BOD that is needed for the EBPR process. One of the recommendations is to bypass the trickling filter operation, but further information on the wastewater characteristics and design is needed to determine if the downstream SBR process has sufficient aeration capacity for this approach. Without the trickling filter in operation, the intermediate clarifier can also be used as a sludge fermentation tank to produce more VFAs for an optimal EBPR performance. The following recommendations were made for the Prosser WWTP:

- By-pass the influent flow around the trickling filter to be added directly to the SBR.
- Mix during fill without aeration for as long as possible.
- Obtain more information on the wastewater characteristics to determine aeration capacity needed in SBR without trickling filter in operation.
- Use the intermediate clarifier as a sludge fermenter when using the smaller trickling filter.
- Get more data on SBR operation.

Port of Sunnyside

The Port of Sunnyside has a challenging operation in terms of responding to changing wastewater characteristics from the various dairy and food processing sources. It also has a level of flexibility that could aid in EBPR operation. It is possible to bypass influent wastewater around the initial aerated lagoons and provide for BOD for the EBPR operation and it may also be possible to see the SBR over a shorter time so that the fill period can be used for an anaerobic contact time. The following recommendations are made for the Port of Sunnyside WWTP:

- Increase the mix fill time in the SBR cycle.
- By pass some feed around Lagoon 1.
- Fill the SBR faster to allow more anaerobic contact time after the fill.
- Use 3 cycles per day versus 2 cycles per day.

7. Summary and Conclusions

Information on 17 WWTPs in the Yakima Basin was obtained to evaluate design and/or operational process changes that would result in enhanced biological phosphorus removal (EBPR). EBPR is a cost effective method of providing modest to good levels of phosphorus removal without adding chemicals, which have significant costs and greenhouse gas implications. A technology toolbox was developed and applied in two separate one-day workshops to evaluate the potential for EBPR at representative facilities. The facilities were categorized under activated sludge treatment, oxidation ditch treatment, and sequencing batch reactors (SBRs). A third workshop was done to share the results of the first two-day workshops with regulators and utility attendees.

The WWTP evaluations revealed that EBPR is possible at many facilities and is being implemented at Toppenish, Yakima, and in the future upgrade to Mabton. It also may be occurring at the Grandview facility. More specific plant data collection and operational attention would be needed to fully quantify the phosphorus removal at these facilities.

The scope of this study did not allow for a full evaluation of the wastewater characteristics to more accurately determine the level of EBPR possible at the different facilities. However, we expect that the amount of phosphorus removal possible from these point discharges with full implementation of the study recommendations would result in improved phosphorus removal of 60 to 80 percent. Implementation will require demand on the operational staff and more sampling and analyses.

Appendix A-1. Oxidation Ditch Facilities

A-1.1. City of Grandview - WWTP

Type of Treatment Facility: Oxidation Ditch

FIGURE 10. GRANDVIEW WWTP – AERIAL VIEW.

TABLE 3. PERMIT REQUIREMENT - GRANDVIEW.

Parameter	Unit	Max Month	Max Week
BOD	mg/L	30	45
TSS	mg/L	30	45
NH_4-N			
Summer	mg/L	6	*N/A**
Winter	mg/L	15	*N/A*

*N/A = Not Available.

TABLE 4. DESIGN CRITERIA – GRANDVIEW.

Parameter	Unit	Value
Avg Flow	Mgal/d	1.5
Max Month Flow	Mgal/d	4.25
BOD	lb/d	*N/A*
TSS	lb/d	*N/A*
TKN	lb/d	*N/A*
TP	lb/d	*N/A*

Table 5. Average 12 Month Performance, June2011 to May2012 – Grandview.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1.19	711	390	N/A	2.6	5.1	0.2

Table 6. Temperature – Grandview.

Avg. Month, high (°C)	26.0
Avg. Month, low (°C)	14.0

Table 7. Treatment Scheme – Grandview.

Oxidation Ditch				
Number of Ditches	**Aerator Type**	**Volume (Mgal) per Ditch**	**Detention Time (hrs)**	**Aerators per Ditch**
2	Carrousel	1.4	22.0	2
Note: Anaerobic / Anoxic tanks before ditch equal about 20% of ditch volume.				
Secondary Clarifier				
Number	2			
Diameter (ft)	56			
Hydraulic Application Rate (gpd/ft^2)	609			
Note: Sludge stabilization - Anaerobic digestion with biosolids to drying beds, 2 years holding.				

Table 8. Additional Comments – Grandview.

1. High industrial wastewater input.
2. The influent wastewater is split between an aerated lagoon and the oxidation ditch system.
3. The carousel is preceded by in anaerobic and anoxic tank so EBPR may be occurring.
4. The SRT is about 14 to 15 days.
5. Two train system.
6. The lagoon effluent goes to a habitat wetland.
7. The biosolids are held in drying beds for about one year prior to land application.
8. The SVI is claimed to be in range of 40 to 50 mL/g.
9. This suggests that EBPR is occurring.
10. Effluent quality at clarifiers looked excellent. Low suspended solids.
11. Phosphorus removal performance data would have to be obtained at the plant to determine how to best optimize it.

A-1.2. City of Granger - WWTP

Type of Treatment Facility: Oxidation Ditch

FIGURE 11. GRANGER WWTP – AERIAL VIEW.

TABLE 9. PERMIT REQUIREMENT - GRANGER.

Parameter	Unit	Max Month	Max Week
BOD	mg/L	30	45
TSS	mg/L	30	45
NH_4-N	mg/L	4.5	7.9

TABLE 10. DESIGN CRITERIA – GRANGER.

Parameter	Unit	Annual Av.	Max. Month	Unit	Annual Av.	Max. Month
Avg. Flow	Mgal/d	0.28	0.32	Mgal/d	0.28	0.32
BOD	lb/d	684	749	mg/L	293	281
TSS	lb/d	500	754	mg/L	214	283
TKN	lb/d	151	174	mg/L	65	65
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*	*N/A*

TABLE 11. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 – GRANGER.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.199	283	209	55	6.6	4.6	0.80

TABLE 12. TEMPERATURE – GRANGER.

Avg. Month, high (°C)	26.0
Avg. Month, low (°C)	10.8

TABLE 13. TREATMENT SCHEME – GRANGER.

Oxidation Ditch					
Number of Ditches	**Aerator Type**	**Volume (Mgal) per Ditch**	**Detention Time (hrs) per Ditch**	**Aerators per Ditch**	**Aerator Hp**
1	Brush Aerator	0.21	31.0	2	20
Note: Currently only one ditch, but new ditch will be built.					
Secondary Clarifier					
Number				1	1
Diameter (ft)				40	70
Hydraulic Application Rate (gpd/ft^2)				223	73
Note: Sludge stabilization - Anaerobic digestion (but presently not aerated or mixed well). Sludge thickened and hauled to composting.					

TABLE 14. ADDITIONAL COMMENTS – GRANGER.

1. Mainly domestic wastewater.
2. Proposed design does not have selector anaerobic zone.
3. Simple operation is desired.
4. Under loaded ditches, at long SRT.
5. Modifications to new design would be timely for instituting EBPR.

A-1.3. City of Mabton - WWTP

Type of Treatment Facility: Oxidation Ditch

FIGURE 12. MABTON WWTP – AERIAL VIEW.

TABLE 15. PERMIT REQUIREMENT - MABTON.

Parameter	Unit	Max		
		Month	Week	Day
BOD	mg/L	10	15	*N/A*
TSS	mg/L	30	45	*N/A*
NH_4-N	mg/L	2.9	*N/A*	4.5

TABLE 16. DESIGN CRITERIA – MABTON.

Parameter	Unit	Annual Avg.	Max. Month	Unit	Annual Avg.	Max. Month
Avg Flow	Mgal/d	0.25	0.31	Mgal/d	0.25	0.31
BOD	lb/d	544	726	mg/L	261	281
TSS	lb/d	507	779	mg/L	243	301
TKN	lb/d	*N/A*	164	mg/L	*N/A*	63
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*	*N/A*

TABLE 17. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 - MABTON.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.199	301	192	*N/A*	5.1	6.5	0.80

Table 18. Temperature – Mabton.

Avg. Month, high (°C)	24.0
Avg. Month, low (°C)	9.4

Table 19. Treatment Scheme - Mabton.

Oxidation Ditch, with Anaerobic and Anoxic Selector Zones					
Number of Ditches	**Aerator Type**	**Volume (Mgal) per Ditch**	**Detention Time (hrs) per Ditch**	**Aerators per Ditch**	**Aerator Hp**
1	Brush Aerator	0.198	15.3	2	20

Proposed Upgrade (will be designed to have EBPR possibility):

Process Tank	**Volume**	**HRT, hrs**
Anaerobic 1 (gallons)	4,085	0.32
Anaerobic 2 (gallons)	4,085	0.32
Anaerobic 3 (gallons)	8,170	0.63
Anoxic 1 (gallons)	40,000	3.10
Anoxic 2 (gallons	55,000	4.26
Aerobic(gallons)	177,000	13.70
Oxidation Ditch(gallons)	198,000	15.33
Total volume (gallons)	486,340	37.65
Internal Recycle	4.7	*N/A*

Secondary Clarifier	
Number	2
Diameter (ft)	30
Hydraulic Application Rate (gpd/ft^2)	439

Note: Sludge stabilization - Anaerobic digestion (but presently not aerated or mixed well). Sludge thickened and hauled to composting.

Table 20. Additional Comments – Mabton.

1. Plant is to be upgraded with anaerobic/anoxic tanks.
2. Will have a very low loading and long SRT.
3. Possible to manipulate mixers in new plant for EBPR.

A-1.4. City of Naches - WWTP

Type of Treatment Facility: Oxidation Ditch

FIGURE 13. NACHES WWTP – AERIAL VIEW.

TABLE 21. PERMIT REQUIREMENT - NACHES.

Parameter	Unit	Max	
		Month	Week
BOD	mg/L	30	45
TSS	mg/L	30	45
NH_4-N	mg/L	*N/A*	*N/A*

TABLE 22. DESIGN CRITERIA – NACHES.

Parameter	Unit	Annual Avg.	Unit	Annual Avg.
Avg. Flow	Mgal/d	0.144	Mgal/d	0.144
BOD	lb/d	216	mg/L	180
TSS	*N/A*	*N/A*	*N/A*	*N/A*
TKN	*N/A*	*N/A*	*N/A*	*N/A*
TP	*N/A*	*N/A*	*N/A*	*N/A*

TABLE 23. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 – NACHES.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.075	250	212	*N/A*	2.0	3.7	0.13

TABLE 24. TEMPERATURE – NACHES.

Avg. Month, high (°C)	20.5
Avg. Month, low (°C)	6.0

TABLE 25. TREATMENT SCHEME – NACHES.

Oxidation Ditch					
Number of Ditches	**Aerator Type**	**Volume (Mgal) per Ditch**	**Detention Time (hrs) per Ditch**	**Aerators per Ditch**	**Aerator Hp**
1	Brush Aerator	0.104	17.3	2	5
Secondary Clarifier					
Number				1	
Diameter (ft)				34	
Hydraulic Application Rate (gpd/ft^2)				158.68	
Note: Simple classic trapezoidal channel oxidation ditch and sludge drying beds.					

TABLE 26. ADDITIONAL COMMENTS – NACHES.

1. Mainly domestic wastewater.
2. Old chlorine tank may be available for fermentation of some mixed liquor.

A-1.5. City of Zillah - WWTP

Type of Treatment Facility: Oxidation Ditch

FIGURE 14. ZILLAH WWTP – AERIAL VIEW.

FIGURE 15. ZILLAH WWTP – NEWER AERATION TANK.

TABLE 27. PERMIT REQUIREMENT - ZILLAH.

Parameter	Unit	Max	
		Month	Week
BOD	mg/L	*N/A*	
TSS	mg/L		
NH_4-N	mg/L		

TABLE 28. DESIGN CRITERIA – ZILLAH.

Parameter	Unit	Annual Avg.	Max. Month	Unit	Max. Month
Avg. Flow	Mgal/d	0.42	0.49	Mgal/d	0.49
BOD	lb/d	*N/A*	1064	mg/L	260
TSS	lb/d	*N/A*	1107	mg/L	271
TKN	lb/d	*N/A*	213	mg/L	52
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*

TABLE 29. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 – ZILLAH.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.211	211	190	*N/A*	2.9	10.2	0.32

TABLE 30. TEMPERATURE – ZILLAH.

Avg. Month, high (°C)	21.3
Avg. Month, low (°C)	10.0

TABLE 31. TREATMENT SCHEME – ZILLAH.

Oxidation Ditch					
Number of Ditches	**Aerator Type**	**Volume (Mgal) per Ditch**	**Detention Time (hrs) per Ditch**	**Aerators per Ditch**	**Aerator (Hp)**
1	Brush Aerator	0.235	11.5	2	15
Plant upgraded about 10 years ago, added a long narrow tank with aerated anoxic zones and aerobic zones. Possible EBPR modification will convert a portion of anoxic zones to anaerobic as shown below.					
Process Tank	**Volume**	**HRT, hrs**			
Anaerobic 1 (gallons)	5,385	0.26			
Anaerobic 2 (gallons)	5,385	0.26			
Anaerobic 3 (gallons)	10,800	0.53			
Aerobic (gallons)	130,000	6.37			
Oxidation Ditch (gallons)	235,000	11.51			
Total volume (gallons)	386,570	18.93			
Internal Recycle	0	0			
Secondary Clarifier					
Number	2				
Diameter (ft)	30				
Hydraulic Application Rate (gpd/ft^2)	694				
Note: Sludge stabilization - Anaerobic digestion 2@ 55,000 gallons). A Rotary drum is used for dewatering and then trucked to drying beds.					

TABLE 32. ADDITIONAL COMMENTS – ZILLAH.

1.	SVI value is 70-80 mL/g.
2.	Effluent P is generally >2.0 mg/L.
3.	Front of aeration channel is mixed with coarse bubble aeration.

Appendix A-2. Sludge Facilities

A-1.1. City of Toppenish - WWTP

Type of Treatment Facility: Activated sludge Bardenpho like

FIGURE 16. TOPPENISH WWTP – AERIAL VIEW.

TABLE 33. PERMIT REQUIREMENT - TOPPENISH.

Parameter	Unit	Max	
		Month	Week
BOD	mg/L	*N/A*	
TSS	mg/L		
NH_4-N	mg/L		

TABLE 34. DESIGN CRITERIA – TOPPENISH.

Parameter	Unit	Annual Avg.	Max. Month	Unit	Max. Month
Avg Flow	Mgal/d	1.23	1.67	Mgal/d	1.67
BOD	lb/d	*N/A*	2581	mg/L	185
TSS	lb/d	*N/A*	2634	mg/L	189
TKN	lb/d	*N/A*	516	mg/L	37
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*

TABLE 35. AVERAGE 12 MONTH PERFORMANCE, JUNE2011 TO MAY2012 – TOPPENISH.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
N/A						

TABLE 36. TEMPERATURE – TOPPENISH.

Avg. Month, high (°C)	*N/A*
Avg. Month, low (°C)	*N/A*

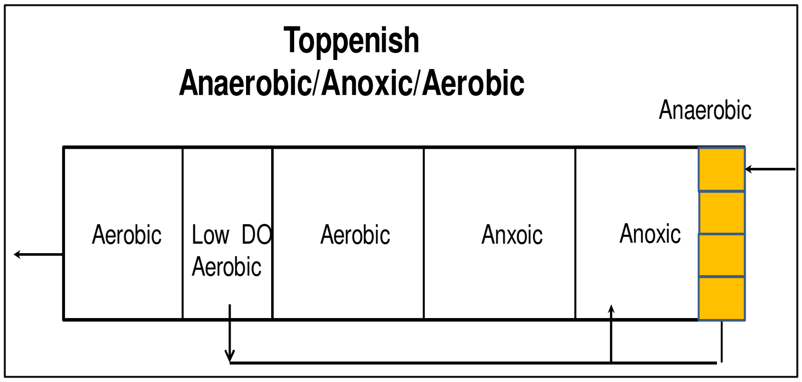

FIGURE 17. TOPPENISH WWTP FLOW SCHEME, TYPICAL OF EACH OF TWO TRAINS.

TABLE 37. FLOW SCHEME – TOPPENISH.

Description		
• Primary Treatment • Bardenpho-type Secondary ○ 4-stage anaerobic, two stage anoxic, aerobic, low DO aerobic (some denitrification will occur) and aerobic • Secondary Clarifiers		
Primary Clarifier		
Number	1	1
Diameter (ft)	45	80
Hydraulic Application Rate (gpd/ft²)	1051	332
Aeration Tanks		
Number	2	
Shape	Rectangular	
Length (ft)	125	
Width (ft)	27	
Depth (ft)	15	
Volume (Mgal)	0.76	
Detention Time (Hours)	14.78	
Secondary Clarifier		
Number	1	1
Diameter (ft)	70	65
Hydraulic Application Rate (gpd/ft²)	434	504
Note: Sludge stabilization – Anaerobic digestion.		

TABLE 38. ADDITIONAL COMMENTS – TOPPENISH.

1. The plan achieves EBPR, but sometimes, P is greater than 2 to 3 mg/L.
2. The EBPR is less efficient when receiving weaker wastewater.
3. A small primary clarifier may be used for fermentation of primary sludge or mixed liquor.
4. The influent BOD: P ratio is about 40 which is favorable for EBPR.

A-2.2. City of Yakima - WWTP

Type of Treatment Facility: Activated Sludge

FIGURE 18. YAKIMA WWTP – AERIAL VIEW.

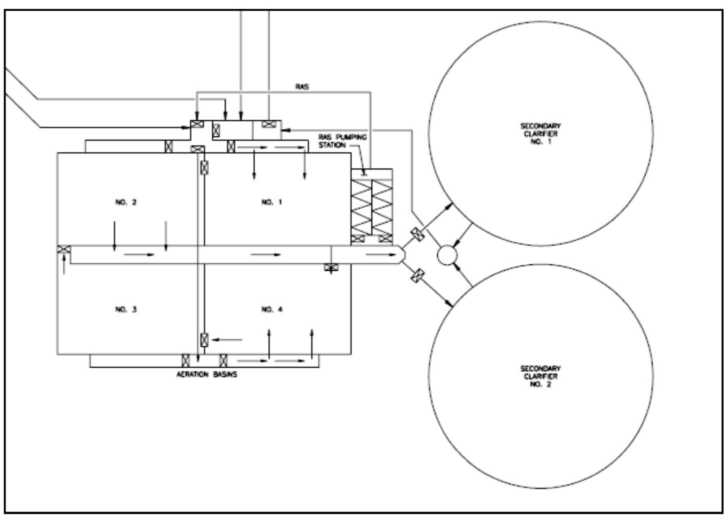

FIGURE 19. YAKIMA WWTP - EXISTING AERATION TANK AND CLARIFIERS.

TABLE 39. PERMIT REQUIREMENT - YAKIMA.

Parameter	Unit	Month	Week
BOD	mg/L	30	45
TSS	mg/L	30	45
NH_4-N	mg/L	4.16	12.3

TABLE 40. DESIGN CRITERIA (WITHOUT DEL MONTE LOAD) – YAKIMA.

Parameter	Unit	Annual Av.	Max. Month	Unit	Max. Month
Avg Flow	Mgal/d	11.25	16.8	Mgal/d	16.8
BOD	lb/d	25,919	31,171	mg/L	222
TSS	lb/d	19,321	27,850	mg/L	199
TKN	lb/d	1,810	2,812	mg/L	20
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*

TABLE 41. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 – YAKIMA.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
9.57	348	288	36	7.6	12.7	0.64

TABLE 42. TEMPERATURE – YAKIMA.

Avg. Month, high (°C)	22.4
Avg. Month, low (°C)	14.4

TABLE 43. FLOW SCHEME – YAKIMA.

Description	
• Primary treatment, 2 train – 2 stage activated sludge, secondary clarifiers, chlorine. • Rock (8ft) trickling filters after primary treatment- roughing with high industrial wastes. • Fine bubble aeration system, Deeper tanks ~ 25ft. • Anaerobic Digestion. • Centrate to lagoon after struvite recovery process. • Biosolids to land.	
Primary Clarifier	
Number	4
Diameter (ft)	90
Hydraulic Application Rate (gpd/ft^2)	1,774 (annual average)
Aeration Tanks	
Number	4
Shape	rectangular
Length, ft	90
width, ft	60
depth, ft	26
Volume, Mgal	4.20
HRT, hours	8.94 (annual avg.)
Secondary Clarifier	
Number	2
Diameter (ft)	140
Hydraulic Application Rate (gpd/ft^2)	733 (annual average)
Note: Simple classic trapezoidal channel oxidation ditch and sludge drying beds.	

TABLE 44. ADDITIONAL COMMENTS – YAKIMA.

1.	The facility is being converted to a JHB EBPR removal process.
2.	Simulation modeling predicts good P removal, < 1.0 mg/L effluent P.
3.	Industrial waste line will feed UASB reactors with effluent feeding to activated sludge.
4.	A struvite recovery process is in place for N and P removal from centrate.
5.	The facility also has flood plain restoration work which will help fish habitat.
6.	The plant is a major example of sustainability in wastewater treatment.

A-2.3. Benton City- WWTP

Type of Treatment Facility: Activated Sludge

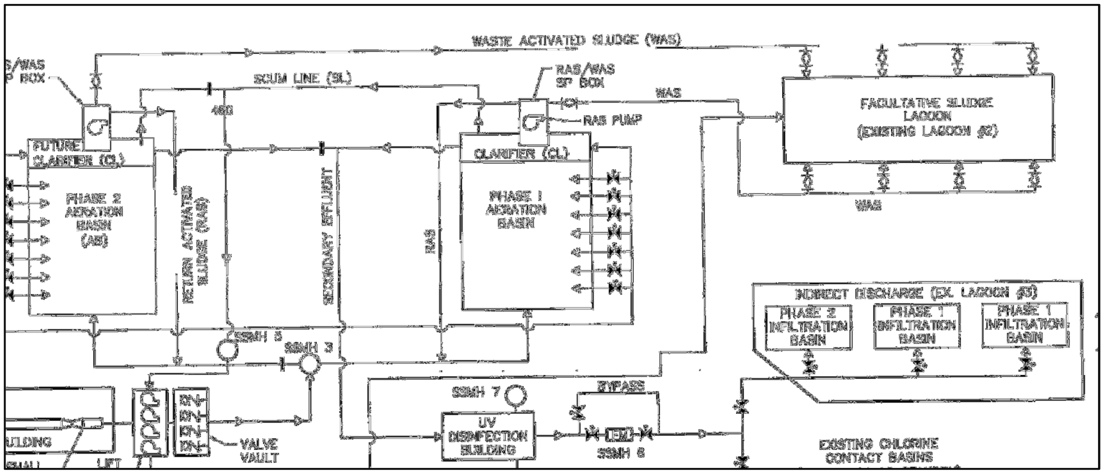

FIGURE 20. BENTON CITY WWTP – DESIGN PLAN.

TABLE 45. PERMIT REQUIREMENT – BENTON CITY.

Parameter	Unit	Max Month	Max Week
BOD	mg/L	10	30
TSS	mg/L	15	30
NH_4-N	mg/L	2	5
NO_3-N	mg/L	7	10

TABLE 46. DESIGN CRITERIA – BENTON CITY (2020).

Parameter	Unit	Annual Av.	Max. Month	Unit	Annual Av.
Avg Flow	Mgal/d	1.0	1.0	Mgal/d	1.0
BOD	lb/d	*N/A*	1,793	mg/L	215
TSS	lb/d	*N/A*	1,793	mg/L	215
TKN	lb/d	*N/A*	333	mg/L	40
NH_4-N	lb/d	*N/A*	210	mg/L	25
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*

TABLE 47. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 – BENTON CITY.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.228	160	240	N/A	1.7	1.2	0.26

TABLE 48. TEMPERATURE – BENTON CITY.

Avg. Month, high (°C)	23.0
Avg. Month, low (°C)	*N/A*

TABLE 49. TREATMENT SCHEME – BENTON CITY.

<table>
<tr><th colspan="4">Activated Sludge - Description</th></tr>
<tr><td colspan="4">Completely mixed activated sludge.
Secondary clarifiers attached to aeration basins.
Waste sludge to lagoon (source of P release).
UV disinfection, effluent to infiltration beds.</td></tr>
<tr><th colspan="4">Aeration Tanks</th></tr>
<tr><th>Aeration Type</th><th>Number of Basins</th><th>Volume (Mgal) per Basin</th><th>Detention Time (hrs) per Basin</th></tr>
<tr><td>Fine Bubble Air</td><td>2</td><td>0.71</td><td>34.1</td></tr>
<tr><th colspan="4">Secondary Clarifier</th></tr>
<tr><th colspan="2">Number</th><td colspan="2">2</td></tr>
<tr><th colspan="2">Rectangular, area each (ft^2)</th><td colspan="2">1,330</td></tr>
<tr><th colspan="2">Hydraulic Application Rate (gpd/ft^2)</th><td colspan="2">376</td></tr>
<tr><td colspan="4">Note: No site visit was made due to time and budget constraints.</td></tr>
</table>

A-2.4. City of Ellensburg - WWTP

Type of Treatment Facility: Activated Sludge

FIGURE 21. ELLENSBURG WWTP – AERIAL VIEW.

TABLE 50. PERMIT REQUIREMENT – ELLENSBURG.

Parameter	Unit	Max	
		Month	Week
BOD	mg/L	30	45
TSS	mg/L	30	45
NH_4-N	mg/L	*N/A*	*N/A*
TP	mg/L	*N/A*	*N/A*

TABLE 51. DESIGN CRITERIA – ELLENSBURG (2020).

Parameter	Unit	Annual Avg.	Max. Month	Unit	Avg.
Avg Flow	Mgal/d	5.0	8.0	Mgal/d	8.0
BOD	lb/d	*N/A*	10,000	mg/L	150
TSS	lb/d	*N/A*	8,000	mg/L	120
TKN	lb/d	*N/A*	*N/A*	mg/L	*N/A*
NH_4-N	lb/d	*N/A*	*N/A*	mg/L	*N/A*
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*

TABLE 52. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 – ELLENSBURG.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
2.65	173	153	*N/A*	4.7	5.2	1.1

Table 53. Temperature – Ellensburg.

Avg. Month, high (°C)	16.7
Avg. Month, low (°C)	9.2

Table 54. Treatment Scheme – Ellensburg.

Activated Sludge				
Aeration Type	**Number of Tanks**	**Volume (Mgal) per Tanks**	**Detention Time (hrs) per Tanks**	**Depth (ft)**
Surface Aerators	2	1.25	7.5	12.0 (at max month)
Note: **Activated sludge-2, Sloped wall -** square aeration basins. Two secondary clarifiers, anaerobic sludge digestion, UV disinfection.				
Secondary Clarifier				
Number				2
Diameter (ft)				80
Hydraulic Application Rate (gpd/ft^2)				796

[It may be possible to time the aerators for nitrogen removal and an external basin may be needed for mixed liquor fermentation]

A-2.5. City of Richland - WWTP

Type of Treatment Facility: Activated Sludge

TABLE 55. PERMIT REQUIREMENT – RICHLAND.

Parameter	Unit	Annual Avg.	Max Month
BOD	mg/L	30	30
TSS	mg/L	3	2
TKN	mg/L	2.7	2
TP	mg/L	0.43	0.33

TABLE 56. DESIGN CRITERIA – RICHLAND (2020).

Parameter	Unit	Annual Avg.	Max. Month	Unit	Avg.
Avg Flow	Mgal/d	8.9	11.0	Mgal/d	11.0
BOD	lb/d	17,000	17,800	mg/L	194
TSS	lb/d	14,800	18,800	mg/L	205
TKN	lb/d	*N/A*	*N/A*	mg/L	*N/A*
NH_4-N	lb/d	*N/A*	*N/A*	mg/L	*N/A*
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*

TABLE 57. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 – RICHLAND.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.28	223	272	*N/A*	13.4	7.8	1.7

TABLE 58. TEMPERATURE – RICHLAND.

Avg. Month, high (°C)	23.4
Avg. Month, low (°C)	15.6

TABLE 59. TREATMENT SCHEME, ACTIVATED SLUDGE – RICHLAND.

Activated Sludge				
Aeration Type	**Number of Tanks**	**Volume (Mgal) per Tanks**	**Detention Time (hrs) per Tanks**	**Depth (ft)**
Surface Aerators	2	1.83	9.9	20.0 (annual avg.)
Note: Primary clarification, completely mixed activated sludge aeration basins, secondary clarifiers, Flotation sludge thickening, Anaerobic digestion, Effluent chlorination. Present scheme does not lend itself ideally for manipulation for phosphorus removal but some partitioning may be possible or the construction of a small outside fermenter.				
Primary Clarifier				
Number	2			
Diameter (ft)	85			
Hydraulic Application Rate (gpd/ft^2)	785 (annual avg.)			
Secondary Clarifier				
Number	2			
Diameter (ft)	135			
Hydraulic Application Rate (gpd/ft^2)	311 (annual avg.)			

A-2.6. City of Kennewick - WWTP

Type of Treatment Facility: Activated Sludge

TABLE 60. PERMIT REQUIREMENT – KENNEWICK.

Parameter	Unit	Annual Avg.	Max Month
BOD	mg/L	*N/A*	*N/A*
TSS	mg/L	*N/A*	*N/A*
TKN	mg/L	*N/A*	*N/A*
TP	mg/L	*N/A*	*N/A*

TABLE 61. DESIGN CRITERIA – KENNEWICK.

Parameter	Unit	Annual Avg.	Max. Month	Unit	Avg.
Avg Flow	Mgal/d	6.6	10.2	Mgal/d	10.2
BOD	lb/d	24,500	26,700	mg/L	304
TSS	lb/d	*N/A*	*N/A*	mg/L	*N/A*
TKN	lb/d	*N/A*	*N/A*	mg/L	*N/A*
NH_4-N	lb/d	*N/A*	*N/A*	mg/L	*N/A*
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*

TABLE 62. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 – KENNEWICK.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
5.22	257	300	37	4.7	6.4	3.1

TABLE 63. TEMPERATURE – KENNEWICK.

Avg. Month, high (°C)	22.5
Avg. Month, low (°C)	11.4

TABLE 64. TREATMENT SCHEME – KENNEWICK.

Activated Sludge				
Aeration Type	**Number of Tanks**	**Volume (Mgal) per Tank**	**Detention Time (hrs) per Tank**	**Depth (ft)**
N/A	*N/A*	*N/A*	*N/A*	*N/A*
Note: Primary treatment, Activated sludge and secondary clarification, design information was not available. Future ‘selector” cells are envisaged for SVI control. These could also serve the purpose of assisting in EBPR.				
Primary Clarifier				
Number	1	1		
Diameter (ft)	90	120		
Hydraulic Application Rate (gpd/ft^2)	802	451 (max month)		
Secondary Clarifier				
Number	7			
Rect. Area (ft^2)	2,900			
Hydraulic Application Rate (gpd/ft^2)	502 (max month)			

A-2.7. City of Selah - WWTP

Type of Treatment Facility: Activated Sludge

FIGURE 22. SELAH WWTP – AERIAL VIEW.

TABLE 65. PERMIT REQUIREMENT –SELAH.

Parameter	Unit	Annual Avg.	Max Month
BOD	mg/L	30	45
TSS	mg/L	30	45
TKN	mg/L	*N/A*	2.9
TP	mg/L	*N/A*	*N/A*

TABLE 66. DESIGN CRITERIA – SELAH.

Parameter	Unit	Annual Avg.	Max. Month	Unit	Avg.
Avg Flow	Mgal/d	1.5	2.0	Mgal/d	2.0
BOD	lb/d	*N/A*	3,300	mg/L	198
TSS	lb/d	*N/A*	4,400	mg/L	264
TKN	lb/d	*N/A*	*N/A*	mg/L	*N/A*
NH_4-N	lb/d	*N/A*	*N/A*	mg/L	*N/A*
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*

Table 67. Average 12 Month Performance, June 2011 to May 2012 – Selah.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1.26	183	1,995	242	4.1	7.6	0.1

Table 68. Temperature – Selah.

Avg. Month, high (°C)	19.6
Avg. Month, low (°C)	9.2

Table 69. Treatment Scheme – Selah.

Activated Sludge							
Aeration Type	**Number of Tanks**	**Volume (Mgal) per Basin**	**Detention Time (hrs) per Basin**	**Depth (ft)**	**Number Per Tank**	**Aerator Hp**	**Motor**
Surface Aerators	2	0.3928	9.4	12.0 (max month)	2	20/30	2 speed
Notes: An industrial aerated lagoon receives food processing waste and the effluent goes to Selah WWTP (lagoon is 6.93 Mgal). The domestic waste enters through a separate pipeline. 2 rectangular sloped aeration basins provide activated sludge treatment. Aerobic digester. Industrial flow can bypass lagoon and feed higher strength to WWTP. Possible side fermenter for EBPR.							

Secondary Clarifier	
Number	2
Diameter (ft)	85
Hydraulic Application Rate (gpd/ft²)	176 (max month)

Appendix A-3. Sequencing Batch Reactors (SBRs)

A-3.1. City of Kittitas - WWTP

Type of Treatment Facility: SBR

FIGURE 23. KITTITAS WWTP – AERIAL VIEW.

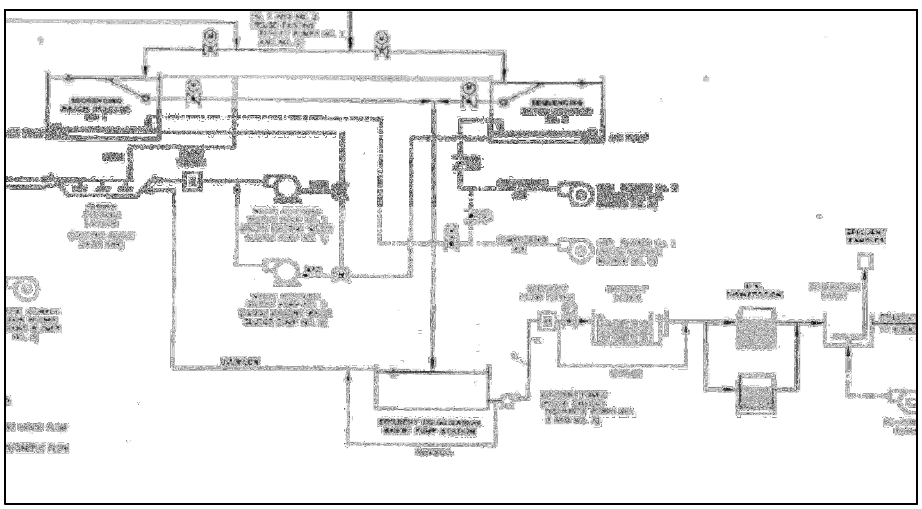

FIGURE 24. KITTITAS FACILITY DESIGN – AERIAL VIEW.

TABLE 70. PERMIT REQUIREMENT - KITTITAS.

Parameter	Unit	Max	
		Month	Week
BOD	mg/L	*N/A*	*N/A*
TSS	mg/L	*N/A*	*N/A*
TKN	mg/L	*N/A*	*N/A*
TP	mg/L	*N/A*	*N/A*

Table 71. Design Criteria – Kittitas.

Parameter	Unit	Max. Month	Avg. Month	Unit	Avg.
Avg Flow	Mgal/d	0.5	.025	Mgal/d	0.25
BOD	lb/d	*N/A*	430	mg/L	206
TSS	lb/d	*N/A*	433	mg/L	212
TKN	lb/d	*N/A*	96	mg/L	46
NH_4-N	lb/d	*N/A*	54	mg/L	26
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*

Table 72. Average 12 Month Performance, June 2011 to May 2012 – Kittitas.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.21	197	159	*N/A*	1.7	2.2	0.1

Table 73. Temperature – Kittitas.

Avg. Month, high (°C)	18.0
Avg. Month, low (°C)	11.0

Table 74. Treatment Scheme – Kittitas.

<table>
<tr><th colspan="6">SBR</th></tr>
<tr><th rowspan="2">Aeration Type</th><th rowspan="2">Number of Tanks</th><th rowspan="2">Full Volume (Mgal) per Tank</th><th rowspan="2">Nominal Detention Time (hrs) per Tank</th><th colspan="2">Depth</th></tr>
<tr><th>High (ft)</th><th>Low (ft)</th></tr>
<tr><td rowspan="3">Fine Bubble</td><td>2</td><td>0.71</td><td>34.1</td><td>16</td><td>11</td></tr>
<tr><th>Blowers</th><th>Type</th><th>Hp</th><th colspan="2">SCFM</th></tr>
<tr><td>2</td><td>Positive Displacement</td><td>2370</td><td colspan="2">237.0</td></tr>
<tr><td colspan="6">Note - Two SBR tanks Followed by an effluent equalization tank, effluent filtration, UV disinfection, SBR sludge is wasted to a storage lagoon, Effluent filtration in fabric disc filters.</td></tr>
<tr><th colspan="6">Reaeration Tank</th></tr>
<tr><th colspan="3">Number</th><td colspan="3">1</td></tr>
<tr><th colspan="3">Volume (gal)</th><td colspan="3">5,700</td></tr>
<tr><td colspan="6">Notes: Set program aerate in last 75% of fill set cycle times. Operations can control DO.</td></tr>
</table>

A-3.1. City of Cowiche - WWTP

Type of Treatment Facility: SBR

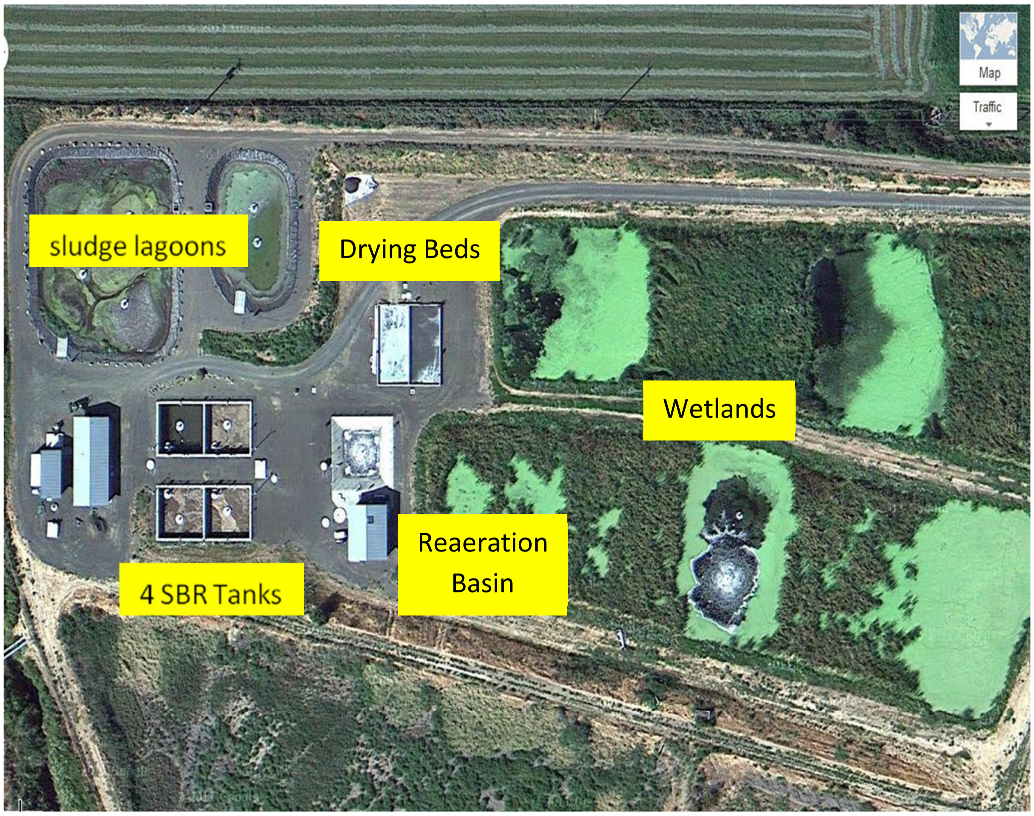

FIGURE 25. COWICHE WWTP – AERIAL VIEW.

TABLE 75. PERMIT REQUIREMENT - COWICHE.

Parameter	Unit	Annual Avg.	Max Month
BOD	mg/L	*N/A*	*N/A*
TSS	mg/L	*N/A*	*N/A*
TKN	mg/L	*N/A*	*N/A*
TP	mg/L	*N/A*	*N/A*

TABLE 76. DESIGN CRITERIA – COWICHE.

Parameter	Unit	Max. Month	Avg. Month	Unit	Avg
Avg Flow	Mgal/d	*N/A*	0.25	Mgal/d	0.25
BOD	lb/d	*N/A*	*N/A*	mg/L	*N/A*
TSS	lb/d	*N/A*	*N/A*	mg/L	*N/A*
TKN	lb/d	*N/A*	*N/A*	mg/L	*N/A*
NH_4-N	lb/d	*N/A*	*N/A*	mg/L	*N/A*
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*

TABLE 77. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 – COWICHE.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.09	279	135	*N/A*	4.1	1.8	0.2

TABLE 78. TEMPERATURE – COWICHE.

Avg. Month, high (°C)	13.7
Avg. Month, low (°C)	5.1

TABLE 79. TREATMENT SCHEME – COWICHE.

<table>
<tr><th colspan="6">SBR</th></tr>
<tr><th rowspan="2">Aeration Tanks</th><th rowspan="2">Number of Basins</th><th rowspan="2">Full Volume (Mgal) per Basin</th><th rowspan="2">Nominal Detention Time (hrs) per Basin</th><th colspan="2">Depth</th></tr>
<tr><th>High (ft)</th><th>Low (ft)</th></tr>
<tr><td rowspan="3">Surface</td><td>4</td><td>0.2</td><td>76.8</td><td>16</td><td>11</td></tr>
<tr><td>Number</td><td>Type</td><td colspan="3">Hp</td></tr>
<tr><td>2</td><td>Surface</td><td colspan="3">15</td></tr>
<tr><td colspan="6">*Note - Four SBR tanks followed by a preaeration tank, SBR sludge is wasted to a storage lagoon, 2 Aqua Disk cloth filters for effluent treatment.</td></tr>
<tr><th colspan="6">Reaeration Tank</th></tr>
<tr><td colspan="3">Number</td><td colspan="3">1</td></tr>
<tr><td colspan="3">Volume (gal)</td><td colspan="3">18,000</td></tr>
<tr><td colspan="6">Notes: Set program aerate in last 75% of fill set cycle times. Operations can control DO.</td></tr>
</table>

A-3.3. City of Cle Elum - WWTP

Type of Treatment Facility: SBR

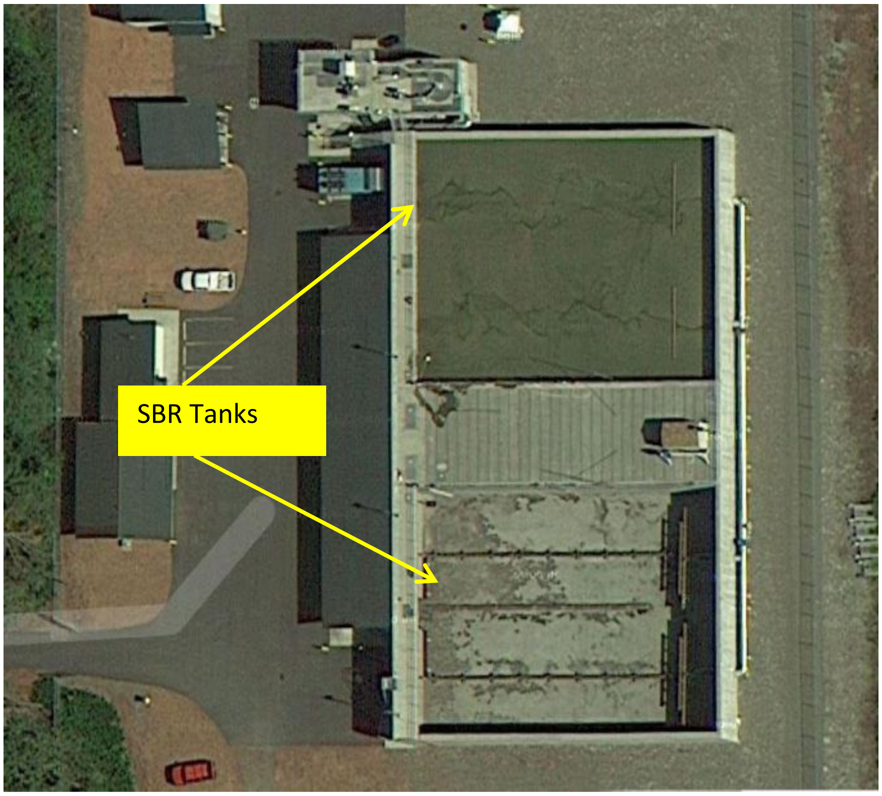

Figure 26. Cle Elum WWTP – Aerial View.

Table 80. Permit Requirement – Cle Elum.

Parameter	Unit	Annual Avg.	Max Weekly
BOD	mg/L	30	45
TSS	mg/L	30	45
TKN	mg/L	*N/A*	*N/A*
TP	mg/L	*N/A*	*N/A*

Table 81. Design Criteria – Cle Elum.

Parameter	Unit	Max. Month	Avg. Month	Unit	Avg
Avg Flow	Mgal/d	3.6	2.1	Mgal/d	2.1
BOD	lb/d	*N/A*	4,850	mg/L	277
TSS	lb/d	*N/A*	3,750	mg/L	214
TKN	lb/d	*N/A*	700	mg/L	40
NH_4-N	lb/d	*N/A*	440	mg/L	25
TP	lb/d	*N/A*	*N/A*	mg/L	*N/A*

Table 82. Average 12 Month Performance, June 2011 to May 2012 – Cle Elum.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.73	202	199	*N/A*	5.0	6.4	5.5

Table 83. Temperature – Cle Elum.

Avg. Month, high (°C)	18.3
Avg. Month, low (°C)	7.2

Table 84. Treatment Scheme – Cle Elum.

SBR							
Aeration Type	**Number Per Tank**	**Full Volume (Mgal) Per Tank**	**Nominal Detention Time (hrs) per Tank**	**Depth**		**Number of Blowers**	**Hp**
				High (ft)	**Low (ft)**		
Surface	2	1.55	35.4	21	16.7	2	15
Note - Two SBR tanks followed by equalization and aeration tank, UV disinfection, SBR sludge is wasted to a storage lagoon.							
Reaeration Tank							
Number					1		
Volume (gal)					16,000		
Notes: Set program aerate in last 75% of fill set cycle times. Operations can control DO.							

A-3.4. City of Prosser - WWTP

Type of Treatment Facility: SBR

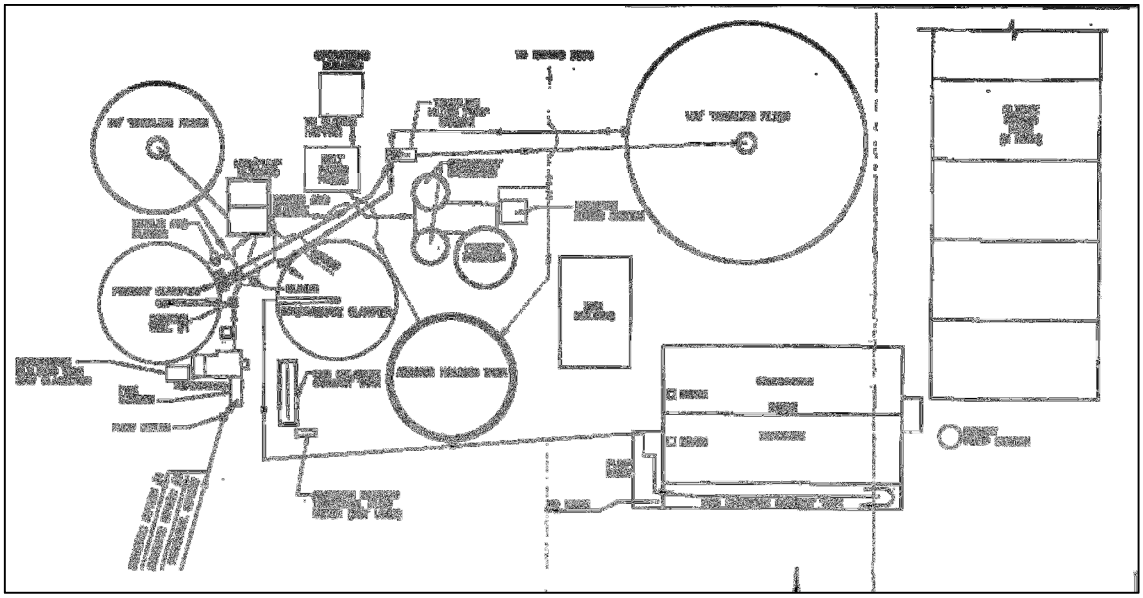

FIGURE 27. PROSSER WWTP LAYOUT.

TABLE 85. PERMIT REQUIREMENT – PROSSER.

Parameter	Unit	Max		
		Month	Week	Day
BOD	mg/L	10	15	*N/A*
TSS	mg/L	15	23	*N/A*
TKN	mg/L	4.4	*N/A*	8.8
TP	mg/L	*N/A*	*N/A*	*N/A*

TABLE 86. DESIGN CRITERIA – PROSSER.

Parameter	Unit	Max. Month	Unit	Avg
Avg Flow	Mgal/d	2	Mgal/d	2
BOD	lb/d	7,424	mg/L	445
TSS	lb/d	4,722	mg/L	283
TKN	lb/d	*N/A*	mg/L	*N/A*
NH_4-N	lb/d	*N/A*	mg/L	*N/A*
TP	lb/d	*N/A*	mg/L	*N/A*

TABLE 87. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 – PROSSER.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.63	505	274	31	3.3	4.8	0.5

TABLE 88. TEMPERATURE – PROSSER.

Avg. Month, high (°C)	25.0
Avg. Month, low (°C)	11.9

TABLE 89. TREATMENT SCHEME – PROSSER.

<table>
<tr><th colspan="6">SBR Description</th></tr>
<tr><td colspan="6">• Primary clarification
• Trickling filters
• Intermediate clarifier
• SBRs
• Effluent chlorination
• Anaerobic digestion
• Drying beds</td></tr>
<tr><th rowspan="2">Aeration Type</th><th rowspan="2">Number Per Tank</th><th rowspan="2">Full Volume (Mgal) per Tank</th><th rowspan="2">Nominal Detention Time (hrs) per Tank</th><th colspan="2">Depth</th></tr>
<tr><th>High (ft)</th><th>Low (ft)</th></tr>
<tr><td rowspan="3">Fine Bubble</td><td>2</td><td>0.61</td><td>14.6</td><td>17</td><td>15</td></tr>
<tr><th colspan="2">Number of Blowers</th><th>Type</th><th colspan="2">Hp</th></tr>
<tr><td colspan="2">N/A</td><td>N/A</td><td colspan="2">N/A</td></tr>
<tr><td colspan="6">Program Characteristics: Set program, aerate in last 75% of fill, aerate in last 75% of fill, set cycle times, operations can control DO.</td></tr>
<tr><th colspan="6">Primary Clarifier</th></tr>
<tr><th colspan="3">Number</th><td colspan="3">1</td></tr>
<tr><th colspan="3">Diameter (ft)</th><td colspan="3">70</td></tr>
<tr><th colspan="3">Hydraulic Application Rate (gpd/ft²)</th><td colspan="3">520 (max month)</td></tr>
<tr><th colspan="6">Trickling Filter</th></tr>
<tr><th colspan="3">Number</th><td colspan="3">1</td></tr>
<tr><th colspan="3">Diameter (ft)</th><td colspan="3">150</td></tr>
<tr><th colspan="3">Media</th><td colspan="3">Rock</td></tr>
<tr><th colspan="3">Media Depth (ft)</th><td colspan="3">5</td></tr>
<tr><th colspan="6">Intermediate Clarifier</th></tr>
<tr><th colspan="3">Number</th><td colspan="3">1</td></tr>
<tr><th colspan="3">Diameter (ft)</th><td colspan="3">70</td></tr>
<tr><th colspan="3">Hydraulic Application Rate (gpd/ft²)</th><td colspan="3">520 (max month)</td></tr>
</table>

A-3.5. Port of Sunnyside - WWTP

Type of Treatment Facility: SBR (dairy and food processing wastewater)

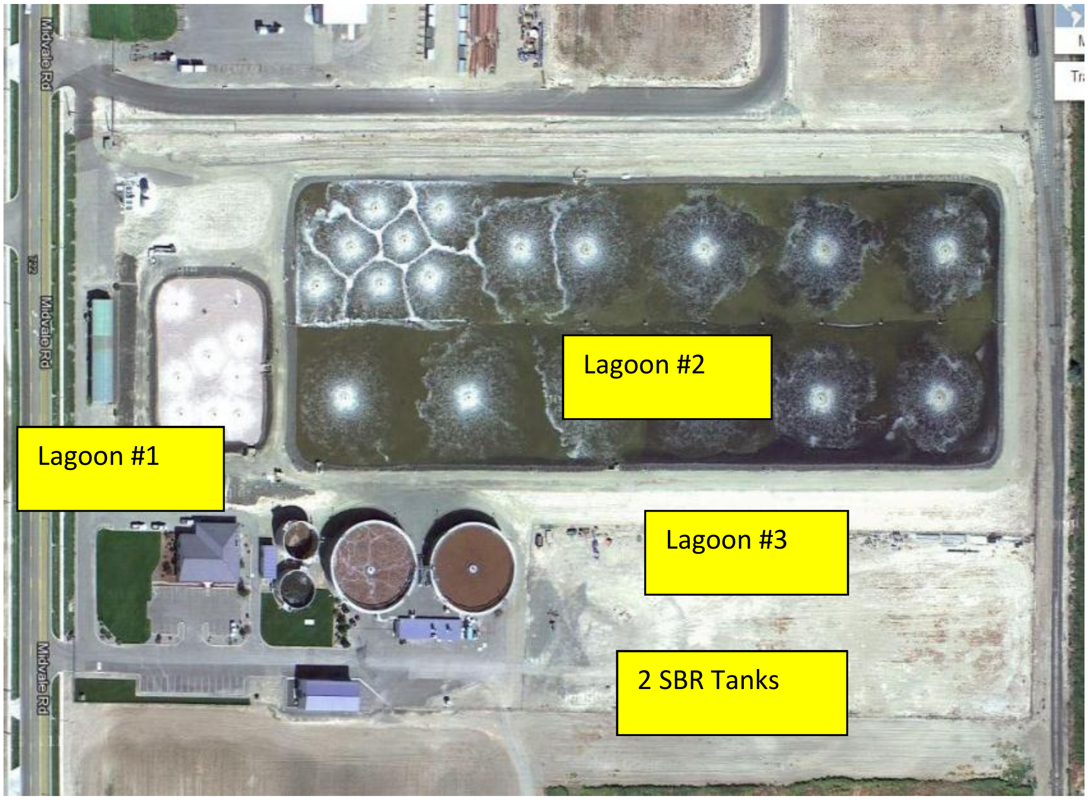

FIGURE 28. PORT OF SUNNYSIDE WWTP – AERIAL VIEW.

TABLE 90. PERMIT REQUIREMENT – PORT OF SUNNYSIDE.

Parameter	Unit	Max		
		Month	Week	Day
BOD	mg/L	*N/A*	60	*N/A*
TSS	mg/L	*N/A*	100	*N/A*
TKN	mg/L	*N/A*	20	*N/A*
TP	mg/L	*N/A*	*N/A*	*N/A*

TABLE 91. DESIGN CRITERIA – PORT OF SUNNYSIDE.

Parameter	Unit	Max. Month	Unit	Avg.
Avg Flow	Mgal/d	0.55	Mgal/d	0.55
BOD	lb/d	14,790	mg/L	3,224
TSS	lb/d	4,310	mg/L	940
TKN	lb/d	757	mg/L	165
NH_4-N	lb/d	*N/A*	mg/L	*N/A*
TP	lb/d	275	mg/L	60

TABLE 92. AVERAGE 12 MONTH PERFORMANCE, JUNE 2011 TO MAY 2012 – PORT OF SUNNYSIDE.

Influent				Effluent		
Flow	BOD	TSS	TKN	BOD	TSS	NH_4-N
MGD	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
0.55	1,367	1,182	108	18.6	33.5	3.8

TABLE 93. TEMPERATURE – PORT OF SUNNYSIDE.

Avg. Month, high (°C)	25.9
Avg. Month, low (°C)	14.5

TABLE 94. TREATMENT SCHEME – PORT OF SUNNYSIDE.

SBR					
Aeration Type	**Number Per Tanks**	**Full Volume (Mgal) per Tank**	**Nominal Detention Time (hrs) per Tank**	**Depth**	
				High (ft)	**Low (ft)**
Fine Bubble	2	1.48	34.1	23.4	-
	Number of Blowers		**SCFM each**	**Hp**	
	5		1,450	100	
Note - All flow to area Lagoon number 1, part of flow goes to lagoon number 2 and number 3. SBR feed is taken from Lagoon number 1, and if low on nitrogen from Lagoon number 3.					
SBR Cycle					
Step			Minutes	Hours	
Mixed fill			60	1	
React fill			300	5	
React			205	3.4	
Settle			80	1.3	
Decant			75	1.3	
Total			720	12	

TABLE 95. ADDITIONAL COMMENTS – PORT OF SUNNYSIDE.

1. All the wastewater goes to lagoon number 1.
2. Lagoon number 1 is 150 Mgal volume and is aerated.
3. Effluent from Lagoon 1 goes to lagoon 2 and 3 or to SBR system.
4. If SBR influent is low on nitrogen, flow is taken out of lagoon number 3.
5. Protein is broken down in these the goons to provide ammonia.
6. The industrial waste load and type varies during the year.
7. The dairy waste is high in protein and is year-round.
8. Food processing waste is in the summer and ends around early December.
9. Food processing provides higher carbohydrate.
10. Low effluent P has been observed during food processing season.