INLAND EMPIRE PAPER COMPANY

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DEPARTMENT OF ECOLOGY
OFFICE OF DIRECTOR

February 26, 2010

Via U.S. Mail and e-mail: tstu461@ecy.wa.gov

Mr. Ted Sturdevant
Director
Washington State Department of Ecology
P.O. Box 47600
Olympia, WA 98504-7600

Re: Request for Dispute Resolution
Spokane River and Lake Spokane Dissolved Oxygen TMDL Water Quality Improvement Plan

Dear Mr. Sturdevant:

Inland Empire Paper Company ("IEP") requests dispute resolution on the Spokane River and Lake Spokane Dissolved Oxygen Total Maximum Daily Load Water Quality Improvement Report, Revised February 2010 (Pub. No. 07-10-073) ("TMDL") pursuant to Department of Ecology WQP 1-25.

IEP is a party to the March 7, 2007, Memorandum of Agreement ("MOA") regarding Foundational Concepts, Managed Implementation Plan, and Dissolved Oxygen TMDL for the Spokane River. (Appendix D). IEP was a participant in the Spokane River Collaborative Process Technology Work Group that led to the adoption of the MOA and has committed to implementing cutting edge technology and source reduction to achieve the highest possible water quality standards in the Spokane River and Lake Spokane. Under the MOA, the Department of Ecology ("Ecology") is obligated to adopt a TMDL and implementation plan for the TMDL consistent with the Foundational Concepts document dated June 30, 2007.

IEP regrets that Ecology has fallen so far short of its commitments in the MOA. There is no justification for Ecology's determination that IEP can achieve a monthly maximum average of 50 µg/L and a seasonal average phosphorus limit of 36 µg/L. IEP is not aware of any water quality treatment technology that would allow it to achieve this limit. Nor is IEP aware of any source reductions or available non-point source reductions that would afford a reasonable opportunity to comply with the proposed waste load allocation in the TMDL. IEP has asked Ecology in several public and private meetings to identify where credits for non-point source reductions are available for IEP to achieve its proposed allocation. Ecology has been unable to identify any legitimate opportunities that would provide IEP with certainty that the delta can be achieved.

1. Request for Dispute Resolution

(a) Ecology has erroneously determined that treatment technology is available to IEP that can achieve a 36 µg/L seasonal average of phosphorus concentration in its discharges.

The central decision in the TMDL is the conclusion that IEP can achieve a seasonal average phosphorus discharge level of 36 µg/L through water quality treatment. This decision drives the TMDL and yet there is no discussion anywhere in the TMDL as to the basis for this decision as applied to IEP.

This decision is arbitrary and capricious and is not supported by substantial evidence. As part of the Collaborative Process Technology Work Group, IEP conducted pilot testing of numerous state-of-the-art tertiary treatment technologies at its facility. The results of that testing demonstrated that IEP, with aggressive application of treatment technology and management, may be able to achieve an average effluent level for total phosphorus between 70 and 100 µg/L.[1] IEP may not be able to achieve an average of 50 µg/L even with substantial reductions in water use and water re-use in its industrial processes. It is unreasonable to conclude that IEP can ever achieve a seasonal average of 36 µg/L. The pilot testing demonstrated that IEP will not be able to achieve the same level of phosphorus removal as municipal Waste Water Treatment Plants ("WWTP") using the same technologies. IEP was orders of magnitude higher in chemical use and was unable to attain equivalent levels of reduction. This was confirmed with the results at other facilities during the collaborative process, two reviews of treatment technology presented to Ecology in a 2005 study of exemplary WWTPs by CH2M Hill and HDR,[2] and in a memorandum dated September 28, 2005, from Ross & Associates (included as Appendix L in the TMDL). IEP argued against a 50 µg/L limit at the time and maintains that it can only achieve 100 µg/L with any confidence.

The conclusion that IEP can achieve a seasonal average phosphorus discharge level of 36 µg/L is apparently derived from Appendix J to the TMDL, a March 2009 memorandum by EPA staff. However, the memorandum is not discussed anywhere in the body of the TMDL.

Ecology cannot rely on the EPA memorandum, TMDL Appendix J, to conclude that treatment technology available to IEP can routinely achieve a seasonal average of 36 µg/L. It is clear from the public record in this matter that the EPA analysis resulted from a two week effort to justify a number, rather than any impartial or professional evaluation of the performance data.[3]

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[1] Douglas P. Krapas, *IEP Pilot Study Report: Tertiary WWT Pilot Trials for Ultra-Low Phosphorus Removal*, June thru July, 2005 and November thru December, 2005.

[2] CH2M Hill, *Technical Memorandum Evaluation of Exemplary WWTPs Practicing High Removal of Phosphorus* (Nov. 21, 2005).

[3] E-mail from Brian Nickel (Mar. 24, 2009).

The analysis relies, for example, on a marketing statement by a vice president of business development for a contractor: Veolia Water North America.[4] More important, the EPA memorandum does not analyze the treatment technology at a single comparable pulp and paper mill anywhere in the Country.

IEP also objects to both the reliance on and use of the Region 10 report on treatment technology principally authored by David Ragsdale: *Advanced Wastewater Treatment to Achieve Low Concentrations of Phosphorus* (Region 10, April 2007). Mr. Ragsdale, referring to the Spokane River Collaborative Process, was quoted as saying that "[t]hey came up with a new process and I'm not supposed to talk about it. I have a difference of opinion than the official agency perspective."[5]

Mr. Ragsdale, apparently acting based on his "difference of opinion," prepared the April 2007 report without public notice or any involvement by the dischargers or their consultants. Furthermore, the analysis included active participation by an attorney representing the Sierra Club and a vendor of treatment technology.[6]

IEP also objects to the biased use of discharge monitoring data in the 2009 EPA memorandum. The 2009 memorandum uses data from a 2008 EPA report on nutrient removal technologies, but relies on a subset of that data: just 3 facilities out of 29 full-scale treatment plants. The three plants selected are among the three smallest plants evaluated in the 2008 report and are not representative of the flows or configurations of the plants operating in the Spokane River basin. Furthermore, none of the selected facilities included any industrial application or, more pertinently, any pulp and paper mill applications.

Ecology is well aware that IEP will have significant difficulties attempting to achieve a phosphorus maximum monthly average of 50 μg/L even with internal water conservation, reclamation and re-use. This was confirmed through extensive pilot testing of a wide cross section of state-of-the-art phosphorus treatment technologies. Testing and optimization of IEP's full-scale Trident HS system has further substantiated the difficulties in attaining phosphorus reduction of IEP's effluent.

There was recognition and agreement amongst the stakeholders, EPA, and Ecology that IEP's effluent differs significantly from municipal wastewater treatment facilities and that there were limitations to IEP's phosphorus treatment capabilities. This understanding was considered in the previous version of the scenarios that included IEP's Total Phosphorus Waste Load

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[4] In contrast to the marketing statements of Veolia's Vice President of Business Development, see Appendix J at 2, IEP's concerns regarding EPA's analysis are based on actual use of Veolia treatment technology. IEP included Veolia technology in its pilot testing and the technology averaged two to three times the proposed WLA.

[5] J. Hagengruber, "*Scientist Departure Taints River Cleanup Plan*," SPOKESMAN REVIEW (Sept. 10, 2007), available at http://www.spokesmanreview.com/local/story.asp?ID=208812&page=all.

[6] "Advance Wastewater Treatment to Achieve Low Concentration of a Phosphorus," EPA 910-R-07-002, at 2. The document also claims that Ken Merrill, an Ecology employee, was consulted on the report.

Allocation ("WLA") at 50 μg/L. To our knowledge, there was no concern expressed by any party to this consideration in the scenarios.

It was also understood that IEP should not be treated the same as the POTWs in the TMDL modeling assumption. The modeling assumptions under Scenario #1 originally retained a 50 μg/L seasonal average for IEP, while the municipalities were assumed to be able to treat to a monthly maximum of 50 μg/L.[7] IEP confirmed with both Ecology and EPA that this would be the modeling assumption for Scenario #1.[8] Ecology has instead conferred higher proportional wasteload allocations to the City of Spokane and Spokane County simply because they may monitor more frequently under their permits. There is absolutely no equity in assuming, erroneously, that IEP can achieve the same phosphorus removal as the municipal WWTPs and then grant the municipal dischargers higher mass loadings than all other dischargers.

Finally, the TMDL will not be legally defensible if the essential regulatory decision in this matter rests on Appendix J. One measure of this document is whether it would ever be accepted as part of an engineering report under WAC 173-240-130. IEP cannot imagine a circumstance where Ecology would accept from a permit applicant the use of marketing statements and selective use of data to establish performance capabilities for a proposed treatment system. Ecology has not addressed this concern anywhere in its response to comments. It is simply insufficient for Ecology to dismiss the errors and omissions in this record under the rubric that it made an equitable assessment of responsibility under the TMDL.

The dispute resolution panel should address specifically what "equitable" decision was made and the basis for the "equitable" assessment by Ecology.

(b) Ecology has unlawfully applied dissolved oxygen criteria for natural water bodies to Lake Spokane, which is a reservoir.

Lake Spokane is a man-made reservoir that is formed by a hydroelectric dam, Long Lake Dam. Constructed in 1915, the dam is the largest hydroelectric development on the Spokane River and is located approximately 25-30 miles northwest of the city of Spokane. It operates with a regulated reservoir, Lake Spokane, which is approximately 23.5 miles long with a maximum depth of 180 feet and a 5,060-acre impounded surface area at normal full pool elevation of 1,536 feet.[9]

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[7] "Setting Phosphorus Targets in the Spokane TMDL to meet Dissolved Oxygen Criteria," April 1, 2009. On page 2, under item (3), it states:

> Set the Discharger phosphorus wasteload allocations based on two TMDL scenarios:
> - Scenario #1: 50 μg/L for all sources except Kaiser (35 μg/L)
> - Scenario #2: 35 μg/L for all Washington sources except Inland Empire and Idaho sources (all remain at 50 μg/L)

[8] E-mail exchange between Doug Krapas and DOE (May 2009).

[9] B. Cusimano, *Spokane River and Lake Spokane (Long Lake) Pollutant Loading Assessment for Protecting Dissolved Oxygen*, at 61 (February 2004) ("Cusimano 2004"); Steve Blewett, *A History of The Washington Water*

Physical, chemical, and biological processes in the reservoir, even without additional human impacts due to pollution, are different than what they would be if the river were free flowing.[10] The reservoir is usually completely mixed or un-stratified until the beginning of June because of the large amount of inflow water due to spring snowmelt conditions that significantly increase flows in the Spokane River.[11] The reservoir thermally stratifies from June through September and stagnation of deep water results in low dissolved oxygen ("DO") concentrations near the lower portion of the reservoir in the summer and early fall.[12]

In a free flowing river, without the presence of the Long Lake Dam, the impacts from dischargers including IEP would not cause a violation of the dissolved oxygen criteria.[13]

The dissolved oxygen criteria are set forth in WAC 173-201A-200(1)(d) (Table (1)(d)). In accordance with WAC 173-201A-200(1)(d)(ii), for lakes, "human actions considered cumulatively may not decrease the dissolved oxygen levels more than 0.2 mg/L below *natural conditions.*" (Emphasis added).

Because Lake Spokane results from the operation and maintenance of Long Lake Dam it is not a "natural condition" as defined under the state water quality standards. Ecology has specifically recognized this fact and this interpretation of its water quality standards:

> Reservoirs with a mean detention time of greater than 15 days are treated as lakes under the water quality standards. The water quality standards for lakes are often based on maintaining natural conditions, but the fact is the dam and the "lake" behind it are not natural. This means that Ecology cannot treat dam effects to water quality as natural.[14]

Ecology also made this interpretation clear in its response to comments on a draft guidance document for water quality certifications for hydroelectric projects:

> Dams are held accountable for the water quality of the downstream waters and the requirement is to meet the assigned water quality standards for the river downstream of the impoundment. It is only within the impoundment itself that a different approach is being

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Power Company 1889 to 1989 (1989); Spokane River Draft Environmental Assessment, Volume 1 (July 2005) and Spokane River Draft Environmental Assessment, Volume II (Feb. 2005).

[10] Cusimano 2004, at 61.

[11] Cusimano 2004, at 32.

[12] HDR, Preliminary Draft Environmental Assessment, p. 5-125 (2005).

[13] WDOE, *Water Quality Certifications for Existing Hydropower Dams-Guidance Manual* at 28, Publication No. 04-10-022 (March 2005).

[14] WDOE, *Water Quality Certifications for Existing Hydropower Dams-Guidance Manual* at 28, Publication No. 04-10-022 (March 2005).

> taken. Within the reservoir the water quality and physical habitat conditions will take on the characteristics of a lake. The requirement to achieve the highest attainable water quality with these reservoirs reflects the requirement in the water quality standards for lakes and reservoirs – where human effects are generally not allowed to cause any substantial changes from natural conditions. **And this requirement is written the way it is because of the recognition that the reservoir itself is not a natural condition.**[15]

The use designation also provides that dissolved oxygen measurements should be taken to "represent the dominant aquatic habitat." WAC 173-201A-200(1)(d)(iv). This requirement for measuring dissolved oxygen is important when considering a reservoir since the deep hypoxic layer created by an impoundment is not likely to have ever been suitable habitat, let alone the dominant aquatic habitat. Ecology staff has acknowledged internally that achieving the highest attainable water quality standards in a reservoir requires some assessment of net biological benefits. "[I]f the largest net improvement in water quality was obtained by focusing on creating improvements in a deep hypoxic layer of a reservoir, but most of the species of concern rely on the epilimnion and metalimnion (upper layers), then maximizing the water quality improvement in the hypolimnion may not really represent the highest attainable condition."[16]

On October 24, 2008, Ecology issued a letter styled as an "interpretative guidance" on the application of the state water quality standards to reservoirs (Appendix 1). The letter opens with the proposition that "natural conditions" are defined as "the water quality conditions absent any human-caused pollution." The letter then makes an enormous illogical leap by suggesting that because reservoirs can meet the definition of "lakes," that such reservoirs are "treated the same as lakes."

The letter then claims that this syllogism is "consistent with the way we determine natural conditions in temperature TMDLs." This statement is not accurate. IEP has not been able, in fact, to find a single temperature TMDL related to a reservoir that treated the impoundment as a natural condition for water quality modeling.[17]

If there is any doubt as to how Ecology actually interprets its standards, it is made clear on the second page of the letter: "**the dam and the lake behind it are not natural, since they**

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[15] C. Maynard, *WDOE Water Quality Certifications for Existing Hydropower Dams Guidance Manual Comments and Responses,* at 12 (Feb. 2005) (emphasis added).

[16] Conceptual Staff Draft, undated.

[17] Department of Ecology staff has made similar conclusions. *See* 11/28/07 e-mail from Susan Braley to Paul Picket ("The precedence has been NOT to model the reservoir for temperature natural background above the dam when it is treated as a lake. We did not model reservoir temperatures for Baker Lake, the Lewis River dams, Rife Lake (on Cowlitz) and Cushman. According to Chris' Reservoir Table, Packwood Lake is the only reservoir that we are requiring modeling for natural pre-dam temperature.").

were created by human actions." Ecology then admits in the letter that "**Ecology cannot treat the effects of dams on water quality as natural.**"

It is accordingly unlawful for Ecology to define the effects of the Long Lake Dam impoundment as "natural" for the purposes of the state water quality criteria for dissolved oxygen. The thermal stratification of Lake Spokane in critical summer months results from human actions. The depressed dissolved oxygen levels in the deeper areas of the reservoir are not therefore natural conditions and cannot be used for the application of the dissolved oxygen criteria.

The TMDL, for example, confirms that there is no obligation for strict compliance with the DO criteria in the lake. There is no specific assignment of a load allocation to the dam operator. Therefore, there is no obligation on the part of the dam operator to achieve DO criteria that only apply to natural lakes. The TMDL makes clear, at page 46, that the dam operator is only subject to a requirement to "**improve** dissolved oxygen impairments that occur in the reservoir downstream" of the compliance point for dischargers. Likewise, the implementation plan for the TMDL states, at page 70, that it is the dam operator's responsibility "to **counteract** the impacts of the impoundment on dissolved oxygen levels."

IEP and other dischargers to the Spokane River are subject to the same standard with respect to dissolved oxygen levels in the reservoir as the dam operator. Ecology may require dischargers to "improve" dissolved oxygen conditions or "counteract" dissolved oxygen sags, but it is not the obligation of dischargers, any more than it is an obligation of the dam operator, to strictly comply with DO criteria that only apply to natural water bodies.

(c) Ecology has violated state and federal law by adopting new phosphorus criteria for the Spokane River without rule making or federal approval of changes to the state water quality standards.

Washington State Water Quality Standards establish a phosphorus criterion in the Spokane River. Under those standards, the average euphotic zone concentration of total phosphorus (as P) shall not exceed 25 μg/L during the period June 1 to October 1. WAC 173-201A-602 (Table 602 WRIA 54). Ecology cannot disregard this criterion without rule making under the state Administrative Procedures Act, and approval by EPA under the Clean Water Act—which it has not done.

Ecology is also legally barred from imposing EPA eco-region criteria as water quality criteria in Washington without rule making and formal EPA approval of a revision to the state water quality standards under the provisions of the Clean Water Act. Again, Ecology has not taken these required steps.

The TMDL imposes an entirely new criteria based on EPA eco-region criteria that have never been adopted as state water quality criteria. Ecology has not followed its own regulations regarding the development of nutrient standards under WAC 173-201A-230, or complied with the requirements of the state Administrative Procedure Act and Clean Water Act for adopting new water quality standards.

Even if Ecology is authorized to use the EPA eco-region criteria in developing the TMDL, it is apparent that the criteria have not been properly applied. The Spokane River at Nine Mile Dam is on the border of two EPA eco-regions: the Columbia Plateau and Northern Rockies. It is inappropriate, however, to derive a standard from the EPA eco-region criteria based on mapping alone. More important is the contrast between actual ecological conditions.

Furthermore, the data used for the EPA guidance and the accuracy of the results have not been verified. Ecology's TMDL is therefore not supported by verified data.

More important, EPA cautions that states need to evaluate the guidance criteria in light of specific designated uses that need to be protected. As such, it is improper for Ecology to simply apply the guidance criteria without a more specific analysis of how it applies to the Spokane River.

These concerns are set forth in two e-mail messages from Idaho DEQ staff and incorporated herein by reference. The dispute resolution panel should address the specific concerns raised in these e-mail messages.[18]

The dispute resolution panel should also address the justification for how the eco-region criteria are actually applied in the TMDL analysis. Scenario #1 is justified because it meets the 10 μg/L eco-region criteria 65% of the time under the water quality model. The results from Scenario #2 indicate that the eco-region criterion is met 62% of the time, a difference of less than one-week. Why is this slight difference in achieving the ad-hoc phosphorus criteria a deciding factor in the selection of Scenario #1 for establishing WLAs?

2. Prior Consideration of the Request for Dispute Resolution

Each of the foregoing requests for dispute resolution has been raised formally and informally with the Department. The final TMDL and response to comments largely ignored IEP's comments and failed to address the specific questions re-stated above.

3. Applicable Law and Regulations

The Department of Ecology is required to respond to all comments submitted on the TMDL. Pursuant to 40 CFR section 130.7(c)(ii) and the 1997 Memorandum of Agreement between the Department of Ecology and EPA, Ecology must ensure that the TMDL submittals to EPA include Responsiveness Summaries to public comments as described in 40 CFR section 25.8. Under 40 CFR section 25.8 the response to comments must include "the agency's specific

[18] E-mail exchange between Robert Steed and John Tindall (April 13, 2009).

responses in terms of modifications of the proposed action or an explanation for rejection of proposals made by the public."

Ecology's obligation to respond to public comments is heightened by the lack of transparency in the TMDL as to the source and basis for WLAs. What information does Ecology have that IEP can achieve a monthly average of 50 μg/L? How is it "equitable" to assign IEP a WLA that it cannot achieve with technology and where there are no readily available delta elimination opportunities to achieve compliance with the WLA?

The TMDL simply fails to provide an explanation as to the core decision by Ecology that IEP can meet a seasonal average of 36 μg/L in phosphorus loading. The TMDL includes the EPA analysis of treatment technology from March 2009 as Appendix J but does not discuss that document anywhere in the body. Ecology does not disclose whether it agrees or disagrees with the weak and baseless conclusions of the EPA memorandum. Nor does the TMDL disclose whether Ecology has adopted the EPA conclusions simply as a means to force dischargers to fund non-point source reductions. More important for the dispute resolution process, the only information in the record regarding the treatment technology available to IEP is contained in IEP pilot testing. The EPA memorandum does not address treatment technology at a pulp and paper mill.

Ecology cannot legally adopt a TMDL, and EPA cannot approve a TMDL, under the Clean Water Act, 33 U.S.C. section 1313(d)(1(C), that is arbitrary and capricious. The TMDL here will be arbitrary and capricious if it does not consider an important aspect of the problem or runs counter to the evidence before the agencies.

A TMDL with load allocations for non-point sources of pollution must also include reasonable assurance that the load allocations can be achieved.[19] Because the TMDL does not, it violates EPA guidelines.

4. Prior Correspondence

The issues raised in this request for dispute resolution were included in the comment letter submitted by IEP on the draft TMDL.

5. Relief Requested

IEP has never wavered in its commitment to advanced water quality treatment and aggressive phosphorus removal from its effluent. As a private business IEP requires regulatory certainty that its investment will allow it to remain in business. The TMDL does not provide this certainty. It inequitably assumes that IEP can achieve a monthly maximum average that is not substantiated by extensive research and knowledge about treatment technology available to a pulp and paper mill. It is inequitable to treat IEP as if it was operating a municipal WWTP. IEP cannot achieve the same levels of phosphorus removal and does not have the ability to rely on

[19] EPA Guidelines for Reviewing TMDLs Under Existing Regulations issued in 1992 (May 20, 2002)

higher future flows and effluent offsets to achieve its waste load allocation. IEP requests that Ecology provide IEP with a technologically achievable waste load allocation.

6. Oral Presentation

IEP requests an opportunity to present its case for dispute resolution in person before the dispute resolution panel as provided in WQP 1-25 at Ecology headquarters. IEP reserves the right to be represented at the oral presentation by its employees, its consultants, and attorneys.

IEP assumes that the dispute resolution panel will be neutral and will not be briefed or otherwise confer with Ecology staff or any other party regarding the matters subject to this request for dispute resolution other than through written submissions that are copied to IEP and oral presentations to the panel in an open proceeding. Please advise me immediately if the panel intends to confer with Ecology staff or others independently on matters that are subject to the foregoing dispute resolution request.

Sincerely,

Kevin D. Rasler

Kevin D. Rasler
President and General Manager

Enclosures
cc: Kelly Susewind, WDOE (ksus461@ecy.wa.gov)
Jim Bellatty, WDOE (jbel461@ecy.wa.gov)

Footnote 1

Inland Empire Paper Company

PILOT STUDY REPORT

TERTIARY WWT PILOT TRIALS

for

ULTRA-LOW PHOSPHORUS REMOVAL

Conducted at

INLAND EMPIRE PAPER COMPANY

June thru July, 2005
and
November thru December, 2005

by
Douglas P. Krapas
Environmental Manager
Inland Empire Paper Company

1.0 EXECUTIVE SUMMARY

Inland Empire Paper Company (IEP) conducted concurrent pilot-scale testing of the following three low-level phosphorus reduction technologies from June to July, 2005: Parkson Corporations Dyna Sand® Filtration, USFilter's Trident®, and Zenon Environmental Inc.'s ZeeWeed® Immersed Membrane. Additional concurrent pilot testing was conducted with USFilter's Trident HS® and Kruger Incorporated's ACTIFLO® technologies from November through December, 2005.

All of the pilot systems received final effluent withdrawn from the launder ring of IEP's secondary clarifier that is currently being discharged to the Spokane River. The pilot test protocol required that each system use the same coagulants during the various phases of testing. During the first three studies, tests were conducted with aluminum sulfate solution (Alum), ferric chloride, and poly-aluminum chloride coagulants. The suppliers were permitted to vary the dosage of coagulant feed in an attempt to achieve the lowest total phosphorus effluent possible. The pilot system suppliers were also permitted to use other chemical feeds such as polymers and pH control to optimize their processes if necessary. Both grab and composite samples were collected and submitted to IEP's lab and to two third party outside laboratories (Anatek and Ecology) for analysis.

The first three pilot systems operated in June, 2005 encountered similar setbacks upon initial operation with IEP's effluent. None of the systems were able to achieve significant phosphorus reductions with chemical feeds typical of previous pilot trials at other facilities. All of the suppliers concluded that IEP's effluent contained a significant fraction of non-reactive phosphorus and other components that competed for reaction with the coagulant chemical, such as color from the tannins associated with the wood products and calcium by-products from the recycling of old newsprint. Significant dosages of chemical coagulants were subsequently required to attain the lowest possible levels of total phosphorus.

During the first phase of testing IEP's influent phosphorus levels averaged approximately 0.45 mg/L. Approximately 80% of the influent phosphorus was abated relatively rapidly at coagulant dosages up to 150 ppm (active) with the best performing technology. Coagulant dosages were increased from 150 ppm up to 400 ppm (active) with diminishing returns, resulting in approximately an additional 8% reduction (88% overall reduction) at the higher dosage rates.

Each technology's performance varied widely. The Parkson dual-sand filter system suffered many setbacks due to flow balancing, chemical feed problems, solids overload, and equipment faults. The average effluent phosphorus level from the Parkson system throughout the duration of the tests was approximately 0.21 mg/L.

The Trident multi-media filtering system experienced significant downtime due to frequent flushing and backwashing of the adsorption clarifier and filter sections. The adsorption clarifier and multi-media filter sections of the Trident system both cycle based on differential pressure, so the abundance of solid precipitants resulted in frequent cleaning cycles of these stages of the filter. However, the Trident system was able to achieve consistently low levels of Total P, averaging 0.077 mg/L over the course of the study.

Of the first three tertiary pilot systems tested, the Zenon membrane system was the overall best performer for achieving consistent low-levels of total P averaging 0.054 mg/L. The Zenon membrane however is prone to fouling with IEP's effluent. Specific constituents that exist in pulp and paper mill effluent, such as calcium-based compounds, are known to cause membrane fouling. Significant fouling eventually requires a lengthy cleaning cycle with an extended duration soak in both citric acid and sodium hypochlorite to remove inorganic and organic materials that blind the membrane. Numerous membrane suppliers have also warned that membrane life with IEP's effluent may also be limited.

Subsequent tests conducted with USFilter's Trident HS® technology, and Kruger Incorporated's ACTIFLO® technologies performed significantly better due to the knowledge gained from the prior pilot studies. USFilter recommended the Trident HS (High Solids) due to the significant amount of chemical solids precipitated from IEP's effluent. The Trident HS incorporates a Tube Settler section prior to the adsorption clarifier and filter sections for continuous removal of rejects. This significant reduction of solids greatly reduces the downtime associated with flushing of the adsorption clarifier and backwashing of the filter. Total P values from the Trident HS were all below 0.10 mg/L, averaging 0.057 mg/L over the total range of data collected. In addition, the net production time was increased from 76-81% with the Trident to 88-94% with the Trident HS due to enhanced solids removal with the tube settler.

Kruger's ACTIFLO technology consisting of enhanced flocculation and settling around micro-sand particles performed relatively well with an overall Total P effluent average of 0.088 mg/L. The Actiflo system lacks a physical filtering barrier, so upset conditions can result in effluent passing through the system completely unabated. It is also possible to "float" the microsand out of the system and into the final effluent during particular upset conditions. The Actiflo system may be best suited as a pre-clarifier for continuous removal of the solids, but would likely require additional filtration for achieving ultra low-levels of total P.

For the best performing technologies, optimum reduction of Total P was achieved with adjustments of the influent pH to approximately 6.0 using acid addition. A significant amount of acid addition will be necessary for full-scale application to decrease IEP's average effluent pH of 7.0 for optimum tertiary treatment. Consequently, additional chemical may then be required to increase the pH to suitable levels after tertiary treatment for discharge to the river or for re-use within the mill's processes.

During the course of the studies, IEP could find no significant advantage of one type of coagulant versus another in the reduction of phosphorus. Ferric chloride is at a disadvantage due to its acidic properties, corrosion potential, difficulty in handling, and potential for discoloration when returned to the mill's processes for water re-use.

Polyaluminum Chloride was also tested with no apparent advantage over the other coagulants for phosphorus reduction. Aluminum sulfate solution (Alum) is currently widely used throughout various mill processes, is the least costly of all the coagulants, and is readily available, making it the coagulant of choice at IEP.

A significant amount of rejects or chemical sludge are generated by the tertiary treatment process due to the large quantities of coagulant chemicals required to achieve ultra-low levels of Total P. Additional research is necessary to address the questions of how best to deal with the chemical sludge generated for full-scale implementation:

- Can the reject stream be returned to the Primary Clarifier for removal of the solids generated by the tertiary treatment equipment?
- Will the precipitant chemical sludge settle for removal as primary sludge or be re-entrained in the waste water stream requiring further treatment?
- If the chemical sludge cannot be returned to the Primary Clarifier, how is such a fine and fragile sludge formation de-watered, and to what extent can the rejects be de-watered?
- How will the chemical sludge be disposed of to assure that the phosphorus will not be returned to the environment through ground-water leachate or some other means?

The pilot studies have shown that a significant amount of total phosphorus in IEP's wastewater can effectively be removed with specific tertiary treatment technologies. Effluent Total P values less than the first phase TMDL target of 0.05 mg/L were achieved intermittently with significant dosages of chemical coagulant during steady-state conditions. Average values of Total P over the length of the studies were between 0.05 and 1.0 mg/L for the best performers. Effluent Total P values less than the second phase TMDL target of 0.01 mg/L were not attainable during IEP's study. Furthermore, the reliability of the testing methods and subsequent data at the levels approaching the detection limit are questionable.

Each technology has its specific methods of operation for obtaining these optimum reduction efficiencies and each has its own associated inherent consequences. Caution must be exercised in consideration of the data presented in this report, as pilot scale results are not necessarily indicative of full-scale system operation. Further evaluation of the economic feasibility of each technology combined with the technical evaluation provided herein is necessary to determine the most suitable full-scale technology.

2.0 INTRODUCTION

Lake Spokane (or Long Lake) is included on the Washington State Department of Ecology's (Ecology) list of impaired water bodies for dissolved oxygen. Section 303(d) of the Federal Clean Water Act requires the Ecology to establish Total Maximum Daily Loads (TMDL's) for pollutants to ensure that the impaired water bodies attain water quality standards. In accordance with this procedure, Ecology issued a "Draft TMDL" in October 2004 that proposed ultra-low limits on point source dischargers for Phosphorus (<0.05 mg/L by 2008 and <0.01 mg/L by 2016), BOD (<3 ppm) and Ammonia (<3 ppm).

Upon issuance of the "Draft TMDL," IEP began investigating low-level phosphorus reduction technologies and their capabilities for attaining the limits specified within the draft TMDL. IEP soon discovered that the data supporting low-level phosphorus performance were based mainly on "Municipal" Waste Water Treatment Systems (WWTS) and that there was little data supporting "Industrial" WWTS, and specifically no data for pulp and paper applications. The lack of data for industrial applications was of serious concern to IEP due to the significant differences in effluent characteristics between "Municipal" and IEP's pulp and paper process.

IEP elected to take a proactive approach in resolving this lack of data by pursuing pilot-scale system trials of low-level phosphorus reduction technologies. IEP was initially introduced to a local start-up company, Blue Water Technologies (Coeur d'Alene, ID), that was in the development stages of a Sand Filtration technology for low-level phosphorus reduction. IEP performed pilot scale testing of Blue Water's sand filter from June through July, 2005 with disappointing results. Blue Water's pilot system was only able to achieve consistent operation at phosphorus levels between 0.14 to 0.28 mg/L, well above the limits specified within the draft TMDL. The system also used significant quantities of chemical coagulant and suffered problems such as solids overload that limited operating time and performance. The disappointing results reaffirmed IEP's concern regarding the performance of these reduction technologies with IEP's effluent.

IEP opted at this point to begin pursuing pilot testing using well established technologies with long-standing and proven full-scale performance. After thorough evaluation of numerous suppliers, IEP elected to perform concurrent testing with the following three technologies: Parkson Corporation's Dyna Sand® Filtration Technology, USFilter's Trident® technology, and Zenon Environmental Incorporated's ZeeWeed® Immersed Membrane technology. These three suppliers provided an excellent cross-section of the best performing phosphorus reduction technologies currently available. Testing of all three technologies was performed during the months of June and July, 2005.

Subsequent concurrent testing was performed during the months of November and December, 2005 with USFilter's Trident HS® and Kruger Incorporated's ACTIFLO® technologies. Based on previous results from the Trident pilot trials, USFilter suggested that improved performance could be achieved with IEP's effluent using their Trident HS technology. Kruger performed bench-scale testing during the prior pilot testing of the three competing technologies, but was unable to mobilize their pilot equipment at that time. Due to the promising bench-scale results, IEP opted to test the pilot-scale ACTIFLO technology in conjunction with the Trident HS pilot testing.

This report summarizes the results of all five of these phosphorus reduction pilot studies. Although a wealth of data was collected regarding the performance of these various technologies, this report focuses primarily on their capabilities regarding total phosphorus reduction. A compilation of the raw data collected during the studies is included in the appendices of this report.

3.0 OBSERVATIONS & DISCUSSIONS

The Washington State Department of Ecology (Ecology) issued a "draft" Dissolved Oxygen Total Maximum Daily Load (TMDL) for the Lake Spokane in October, 2004. The draft TMDL proposes ultra-low limits for phosphorus for all waste water dischargers to the river. In response to this draft TMDL, IEP began investigating state-of-the-art proven and available technologies for phosphorus reduction of waste water treatment applications. IEP discovered that supporting data for these technologies was based upon performance at Municipal waste water treatment plant applications and that there was no supporting data for pulp and paper applications. IEP decided after extensive research to perform pilot plant testing at its newsprint mill located in Spokane, WA.

IEP produces an average of 500 tons/day of newsprint from approximately 55% virgin wood fiber and 45% recycled old newsprint. This production results in approximately 2.6 to 3.7 million gallons per day (MGD) of wastewater that is treated in IEP's wastewater treatment system (WWTS). Approximately 1.5 MGD of non-contact cooling water (NCCW) is also produced that does not require treatment as it does not come in contact with the mill's processes. All fresh water used within the mill's processes is provided by wells located on the mill property. IEP recently completed several in-house water conservation and reuse projects that reduced the flow to the WWTS and discharge to the Spokane River by approximately 1.0 million gallons/day.

The current activated sludge WWTS consists of a primary clarifier, Orbal® aerated stabilization basin and a secondary clarifier. Flow and quality of the influent to the WWTS varies based on the grade of newsprint being produced. IEP produces a "High-Bright" grade of newsprint that requires an increased flow of fresh water, resulting in higher flows to the WWTS. The High-Bright type newsprint requires additional bleaching, fillers and brighteners that also affect the wastewater quality. IEP produces a colored newsprint paper that also affects wastewater quality.

The paper making process results in a natural deficiency of phosphorus within the WWTS. Phosphorus is an essential nutrient necessary for the health of the biological system that consumes the organic matter that is present in the WWTS. The virgin wood fiber and the recycled old newsprint products used in the pulp making process are both deficient in phosphorus. Therefore, the addition of a supplemental source of phosphorus to the WWTS is needed to maintain a healthy level of this essential nutrient. IEP adds ammonium ortho-polyphosphate as a readily available source of both phosphorus and nitrogen.

After extensive research, IEP concluded that tertiary treatment provided the best opportunity for low-level phosphorus reduction with IEP's existing WWTS configuration. IEP also identified three proven tertiary treatment technologies that had been applied for low-level phosphorus reduction: membrane filtration, sand filtration and adsorption/clarification. After the disappointing results with the Blue Water's sand filtration pilot study, IEP selected three of the top performing and well established tertiary treatment technologies to provide a representative cross-section for pilot testing:

Parkson Corporation's Dyna Sand® Filtration Technology, USFilter's Trident® technology, and Zenon Environmental Inc.'s ZeeWeed® Immersed Membrane technology. These systems were concurrently tested from June through July, 2005.

Subsequent testing was performed with USFilter's Trident HS® technology, and Kruger Incorporated's ACTIFLO® technologies from November through December, 2005. USFilter's Trident HS® technology is a newly developed concept that incorporates a tube settling stage prior to the adsorption clarifier for enhanced removal of solids. Kruger Incorporated's ACTIFLO® technology utilizes enhanced flocculation around micro-sand particles promoting settling through tube clarification.

A discussion of IEP's test protocol and the performance of each pilot system are provided in the following sections of the report.

4.0 PILOT TEST PROTOCOL

The primary objective of the waste water treatment pilot study was to investigate the phosphorus treatment capabilities of the following state-of-the-art technologies: Parkson Corporation's Dyna Sand® Filtration, USFilter's Trident®, Zenon Environmental Inc.'s ZeeWeed® Immersed Membrane, Kruger Incorporated's ACTIFLO®, and USFilter's Trident HS®. The systems were operated as tertiary treatment using secondary clarifier effluent as the source water with the following characteristics:

Property	Units	Typical	Minimum	Maximum
pH		8.02	7.60	8.40
Conductivity		1,887	1,523	2,330
Temperature	°C	28.2	26.8	30.2
TSS	mg/L	10.55	2.20	37.00
TDS	mg/L	1.53	1.17	1.92
Total Alkalinity	mg/L	463	378	626
Total Hardness	mg/L as $CaCO_3$	265	60	368
Ortho Phosphate	mg/L	0.15	0.01	0.86
Total Phosphorus	mg/L	0.33	0.05	1.05
Ammonia	mg/L	2.04	0.00	10.88
BOD	mg/L as BOD_5	10.2	3.5	29.6
COD	mg/L	245.2	154.0	380.0
Aluminum	mg/L	0.25	0.17	0.36
Iron	mg/L	0.076		
Manganese	mg/L	0.635		
Turbidity	NTU	4	2.4	35
Color (True)	c.u.	142	94	142

The following objectives were used to evaluate the performance of each technology:

- Perform a minimum four (4) week trial using various coagulants, polymers and pH control (if required) to evaluate the performance of each system under the above varying conditions. Coagulants to be used include aluminum sulfate (Alum), polyaluminum chloride (PAX) and ferric chloride. Polymer selection, pH control and chemical dosages shall be at the pilot system supplier's discretion.

- Determine the overall effectiveness of each pilot system to treat IEP's waste water to the lowest Total Phosphorus level consistently achievable.

- Perform Coagulant response curves at varying dosages to evaluate the effectiveness of each coagulant for phosphorus reduction.

- Perform extended operation at optimized dosages of each coagulant to evaluate long-term and consistent operating conditions.
- Evaluate equipment performance throughout the test periods to determine the benefits and downfalls of each technology.
- Determine reject flow rates, volume, characteristics and effects on technology run lengths (if applicable).
- Evaluate treated effluent quality through laboratory analysis.
- Determine operating parameters for full-scale system design.

In order to evaluate the above objectives, IEP collected both composite and grab samples of the source water, treated water and residuals for laboratory testing. IEP determined total phosphorous levels using EPA Standard Method 365.2 (phosphorus by colorimetry using Ascorbic Acid Standard Method 4500-P-E for waste water) using a HACH Model 2500 Spectrophotometer, with a reported detection limit of 0.02 mg/L for phosphate.

Composite samples were also split for collaborative low level total phosphorus (0.005 mg/L detection limit) testing by the following two outside laboratories: Anatek Labs, Inc. using EPA Standard Method 365.3, and WA State Department of Ecology's Freshwater Monitoring Unit using EPA Standard Method 200.8 ICP-MS (Inductively Coupled Plasma – Mass Spectrometry).

Each laboratory was responsible for providing all appropriate sample containers, properly prepared and preserved in accordance with the methods outlined by the specific method of analysis.

In addition, each pilot system supplier was required to submit specific test protocols and procedures for operation and evaluation of their specific pilot system technology.

5.0 Parkson Corporation Dynasand D2™ Advanced Filtration System

Parkson Corporation's DynaSand Filter® is a continuous backwash, upflow, deep bed, granular media filter. The DynaSand D2™ filtration process contains two continuously self-cleaning DynaSand Filters connected in series. The Parkson Corporation pilot system consisted of the following major equipment:

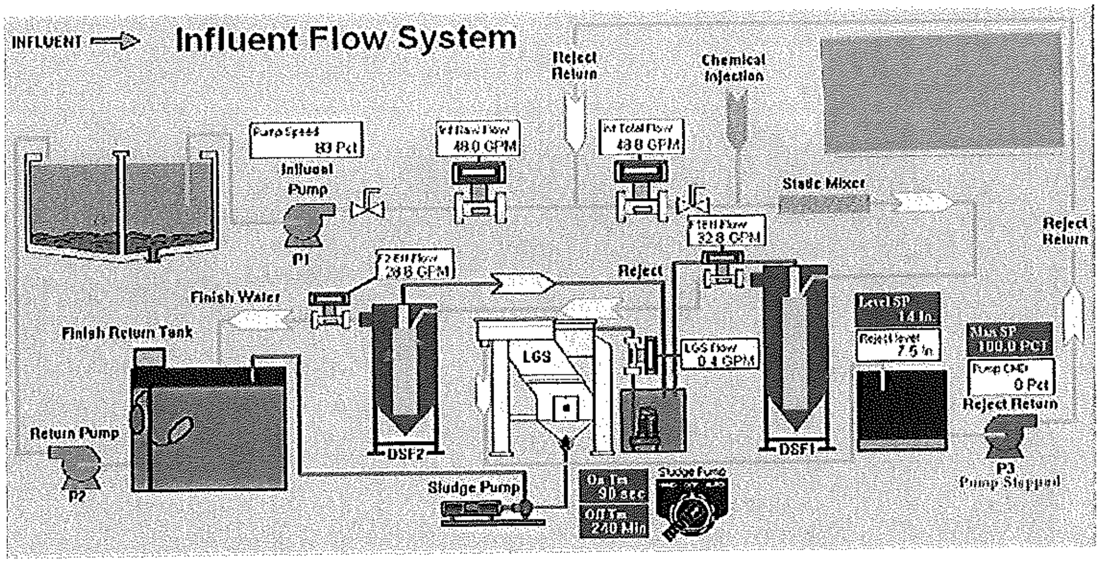
- One 10.7 sq. ft. deep-bed Dyna-Sand Filter (larger sand size)
- One 10.7 sq. ft. standard depth bed Dyna-Sand Filter (finer sand size)
- One Lamella Gravity Separator/Clarifier with flash mix-flocculation tank
- One 40 ft. instrumentation container with an office, chemical pumps, feed pump, and equipment for testing influent and filtrate parameters.
- 4.5 tons of larger filter media in 3000# bags for the deep bed sand filter.
- 3 tons of finer filter media in 3000# bags for the standard bed sand filter.
- SCADA system for: long distance and local process monitoring, equipment control, chemical dosing, flow control, system alarm, data logging, reporting, and generating trend graphs.

The Parkson system was the largest capacity system and the most complex arrangement of the first three pilot systems tested, requiring a significant amount of real estate and manpower for mechanical and electrical installation. The Parkson pilot system was initially configured with an influent rate of approximately 50 gpm from IEP's secondary clarifier launder ring.

Influent from IEP's secondary clarifier launder ring was pumped into Parkson's control trailer where coagulant and polymer chemicals were added ahead of a static mixer. The chemically treated influent was then fed to the first sand filter. After passing through the first sand filter approximately 35 gpm of flow was returned to the control trailer and 15 gpm of reject flow was sent to the Lamella Gravity Separator (LGS). Effluent from the first sand filter was further treated with additional coagulant and sent to the second sand filter. Of the approximate 35 gpm sent to the second sand filter, approximately 5 gpm was rejected to the LGS and 30 gpm of final effluent was analyzed then discharged back into IEP's Primary Clarifier.

The LGS was initially intended to remove the solids from the reject streams from both sand filters with return of the clarified water back to the influent feed line. However, Parkson was unable to return the clarified water back to the influent feed line due to equipment problems, so the entire reject flow was discharged to IEP's Primary Clarifier. The LGS was eventually configured as an up-front solids separator/clarifier prior to the sand filters due to solids overload of the sand filters experienced during the course of the study. In this configuration, clarified water from the LGS was sent to the sand filters and the rejects from the LGS were discharged to IEP's Primary Clarifier.

The following control panel print-out provides a general flow diagram for the Parkson Pilot system as it was initially configured.



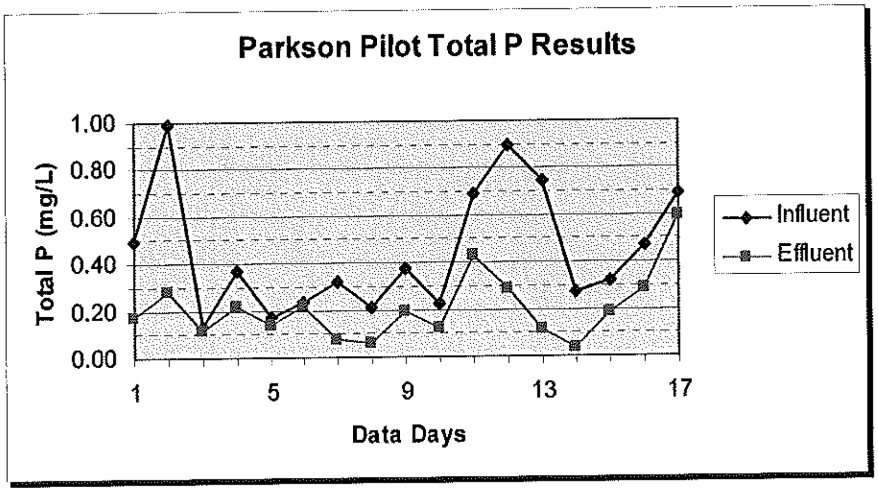
The Parkson pilot system commenced operation on June 6 and completed operation on July 28, 2005. The Parkson system suffered logistical and operational problems from the onset of operation and was never able to achieve long-term, consistent low-level P reduction. The Parkson arrangement relied upon head pressure after the first sand filter to promote flow throughout the balance of the system. Marginal system head pressure resulted in flow imbalances throughout the study due to improper configuration of the first sand filter. Minor flow disruptions in downstream equipment resulted in flooding of the first sand filter and in other cases inadequate flow to downstream equipment.

The system also utilized a ChemScan® Analyzer for on-line analysis of phosphate and turbidity to control the dosing of chemical feed. However, due to reliability issues surrounding the ChemScan® system, the chemical feed systems were put into a "manual" mode of operation in lieu of the "automatic" dosing mode using the analyzer.

Extensive algae growth was observed throughout the Parkson pilot system, including both sand filters, the lamella gravity separator, and intermediate sump tanks due to the outdoor installation of the equipment. The algae growth initially caused intermittent disruptions in flow throughout the system. The sand filters were eventually covered with an opaque plastic covering to reduce the algae growth.

The most significant issue concerning the operation of the Parkson pilot system was the significant amount of solids overload resulting from precipitation with high chemical dosages. Parkson eventually decided to utilize the lamella separator as an influent pre-filter before the sand filters, in lieu of a rejects separator. This modification resulted in a significant amount of piping reconfiguration and downtime. In this configuration the second sand filter had little to no effect on P reduction.

The system also suffered continual chemical feed rate control problems due to broken lines, air infiltration into the lines due to piping and fitting problems, and pump failures. Inconsistent feed of coagulant and polymers resulted in inconsistent results. The following chart provides a summary of the influent and effluent Total P results obtained for the Parkson pilot system throughout the length of the study.



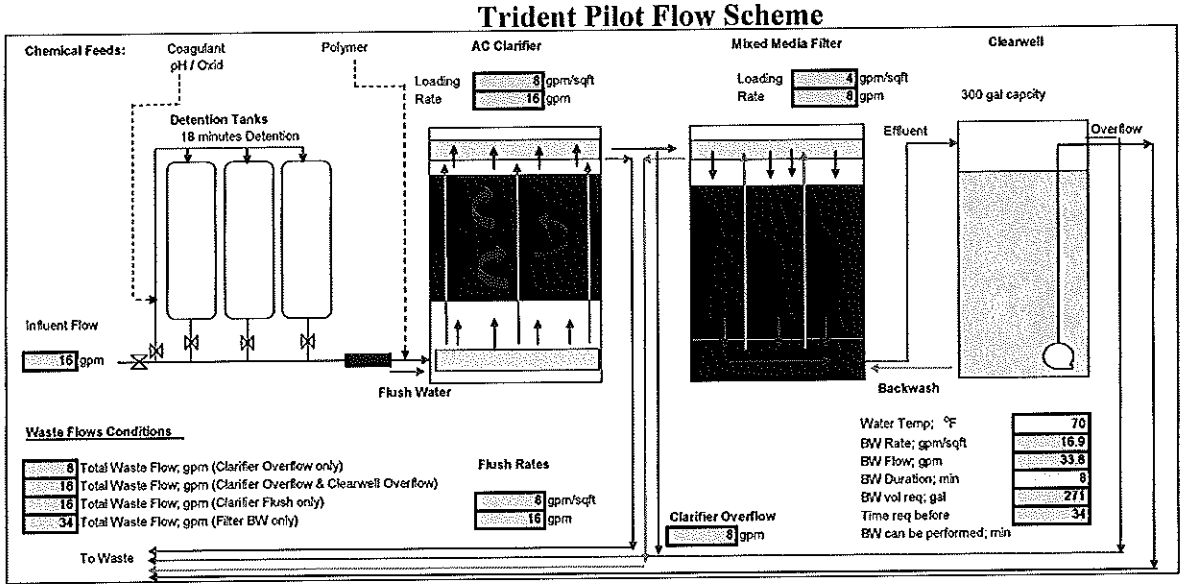
IEP's influent Total P can vary significantly due to the many process variables within the mill. During the Parkson study, the influent Total P averaged 0.45 mg/L while ranging from 0.05 to 1.05 mg/L. The effluent phosphorus from the Parkson pilot system also varied significantly, and more or less followed the trend of the influent phosphorus. Effluent Total P from the Parkson pilot system averaged 0.21 mg/L over the duration of the study for an average Total P reduction of 53%. Only three Total P data points were below 0.10 mg/L. The lowest data point observed was 0.04 mg/L per IEP's analytical method and 0.039 for both Anatek's and Ecology's analytical methods. Statistically, the Parkson pilot operation resulted in a 95th percentile effluent phosphorus of 0.325 mg/L and a 99th percentile effluent phosphorus of 0.409 over the range of data collected.

Although the Parkson pilot system performed relatively poorly in comparison to the other pilot studies, it is believed that the majority of this poor performance was due to problems inherent to the pilot system configuration and equipment operational problems, and not necessarily to the Parkson process. The Parkson process does have operational advantages over competing technologies such as the continuous cleaning of rejects which minimizes the need for redundant equipment. The process is relatively simple from an operational standpoint and also requires the least amount of energy in comparison to competing systems. However, it would be very difficult to recommend this technology for full-scale tertiary treatment of IEP's effluent due to the sub-par and inconsistent performance for P reduction during the pilot studies.

6.0 USFilter's Trident® Technology

USFilter's Trident® technology pilot system includes raw water chemical feed systems, detention tanks, an Adsorption Clarifier (AC), Mixed Media Filter and a Clearwell for backwashing. The following schematic provides a general flow diagram for the Trident pilot system:

Trident Pilot Flow Scheme



Notes:
1. Flow rates & Loading rates shown above are typical operating conditions for the treatment process; site operating conditions may differ
2. Coagulant/pH adj./oxidant typically ahead of detention tanks or static mixer
3. Polymer typically fed after static mixer & prior to clarifier
4. Waste flows can be combined or separated.

The Trident pilot system arrived as a pre-packaged trailer mounted unit and required very little installation, set-up and preparation time. The pilot was sized for an influent flow rate to the AC of approximately 20 gpm and a mixed-media filter flow rate of approximately 10 gpm. Coagulant and pH control (hydrochloric acid) chemicals are introduced into the influent stream prior to entering the detention tanks. The feed rate of coagulant is controlled by the operator to maintain a target turbidity going into the AC. The feed rate of acid for pH control is controlled by the operator to maintain a target pH of approximately 6.0 (continuous pH monitor). After approximately 18 minutes of residence time in the detention tanks, the effluent and flocculated sludge are discharged to the AC. Polymer is introduced to the stream prior to the AC to enhance flocculation.

The AC is an up flow unit filled with small plastic beads. The larger solid formations are captured within the media matrix and the effluent flows into the down-flow multi-media filter. Finer solid formations are removed by the progressively smaller mixed-media filter consisting of 18" of anthracite, 9" of silica and 3" of garnet. Both the AC filter and mixed-media filter operate primarily off of differential pressure as solids build up across the filters over time. Upon reaching the set-point differential pressures, the system operation is interrupted to flush the AC or to backwash the mixed-media filter. Final effluent from the Trident system fills a Clearwell for backwashing the mixed-media filter or is sent to IEP's sewer system if the Clearwell is full.

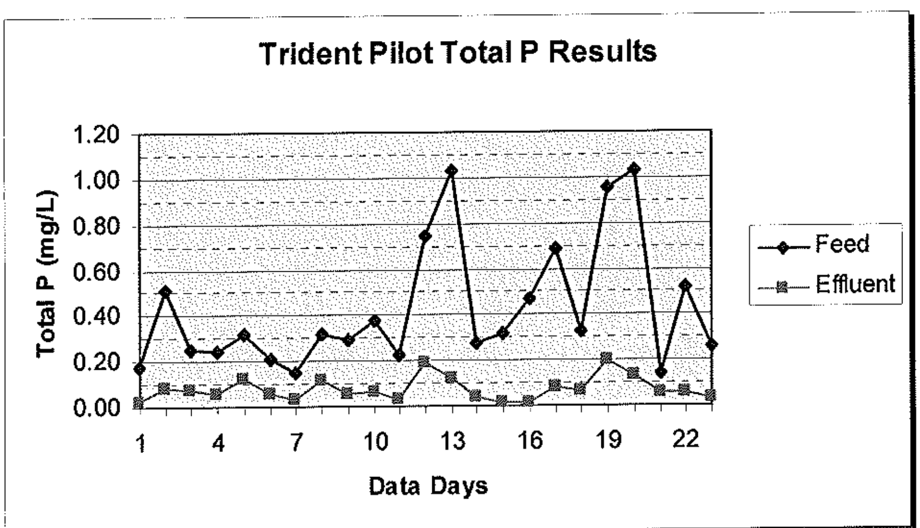
The Trident pilot system operated relatively well, but also suffered similar operational issues as experienced with the other pilot systems. The most prevalent operational problem was due to solids overload of both the AC and the mixed-media filter. Frequency of AC flush and mixed-media filter backwash cycles were highly dependant upon IEP's effluent quality, the type and dosage of coagulant, polymer and pH. AC operation ranged anywhere from 45 minutes to 5 hours between flushes, and the mixed-media filter operation ranged anywhere from 50 minutes to 56 hours between backwash cycles. This frequent flushing and backwashing of the solids from the Trident system would require significant equipment redundancy to accommodate the time out of service.

The Trident pilot system began operation on June 13 and completed operation on August 8, 2005. The pilot system was operated with the following three coagulant variations:

- Aluminum Sulfate (Alum) Coagulant
- Ferric Chloride Coagulant
- Polyaluminum Chloride (PAX) Coagulant

USFilter varied the coagulant dosages during each of the above scenarios and experimented with different polymers, dosages and pH control to optimize the system operation. Alum combined with small dosages of polymer (1 to 2 ppm) and acid to control the pH to approximately 6.0 appeared to be the most effective combination in optimizing the Trident P reduction. However, significant dosages of coagulant in the range of 300 to 450 ppm (active) were required to obtain consistently low levels of effluent Total P. USFilter described IEP's effluent as the most difficult that they have encountered due to a significant fraction of non-reactive P combined with competing reactions, such as color resulting from the tannins and lignin in the processed wood products.

The following chart provides a summary of the influent and effluent Total P results obtained for the Trident pilot system throughout the length of the study.



IEP's influent Total P can vary significantly due to the many process variables within the mill. During the Trident study, the influent Total P averaged 0.43 mg/L while ranging from 0.05 to 1.05 mg/L. The effluent phosphorus from the Trident pilot system was relatively consistent, but appeared to follow the trend of the influent phosphorus. Effluent Total P from the Trident pilot system averaged 0.077 mg/L over the duration of the study for an average Total P reduction of approximately 82%. Seventeen of the twenty-three Total P data points (74%) were below 0.10 mg/L, and seven of the twenty-three data points (30%) were below 0.05 mg/L. The lowest data point observed was 0.02 mg/L per IEP's analytical method, 0.025 per Anatek's, and 0.035 per Ecology's. Statistically, the Trident pilot operation resulted with a 95th percentile effluent Total P of 0.184 mg/L and a 99th percentile effluent Total P of 0.197 over the range of IEP data collected.

Overall, the Trident pilot system performed relatively well with IEP's secondary effluent. The main concern was the high solids loading after precipitation with large quantities of coagulant. This significant solids loading resulted in frequent flushing of the AC and backwashing of the mixed-media filter. The frequent flushing and backwashing would require a significant amount of redundancy in full-scale application to accommodate the interruptions in equipment operation. USFilter has recommended the use of a Trident HS (High-Solids) system that includes an integral Tube Settler for removal of a significant fraction of the solids ahead of the AC. Full-scale application of the Trident system will also require significant amounts of coagulant, polymer and acid for optimum P reduction. Additional chemical (caustic) may also be required to elevate the final effluent pH prior to discharge. The Trident process, as with all other P reduction processes, will generate significant amounts of chemical sludge to achieve the lowest possible levels of Total P.

7.0 Zenon's ZeeWeed® Membrane Technology

The Zenon ZeeWeed® based water treatment process draws wastewater through an "outside-in" hollow fiber membrane. The system operates under a low-pressure vacuum that is induced within the hollow membrane fibers by a centrifugal permeate pump. The chemically treated water is drawn through the membrane into the hollow fibers and is pumped out by the permeate pump. Air flow is introduced at the bottom of the membrane module to create turbulence which scrubs and cleans the outside of the membrane fibers. This reduces the solids accumulation on the membrane surface, thereby reducing the membrane cleaning frequency.

During normal operation, regular membrane cleaning is automatically incorporated into the ZeeWeed® system to help reduce fouling and maintain the membrane flux. This is achieved by periodically reversing the flow through the membrane (back pulsing) using stored permeate. During the trials at IEP, the back pulse duration was approximately 15 seconds and occurred once every 15 minutes.

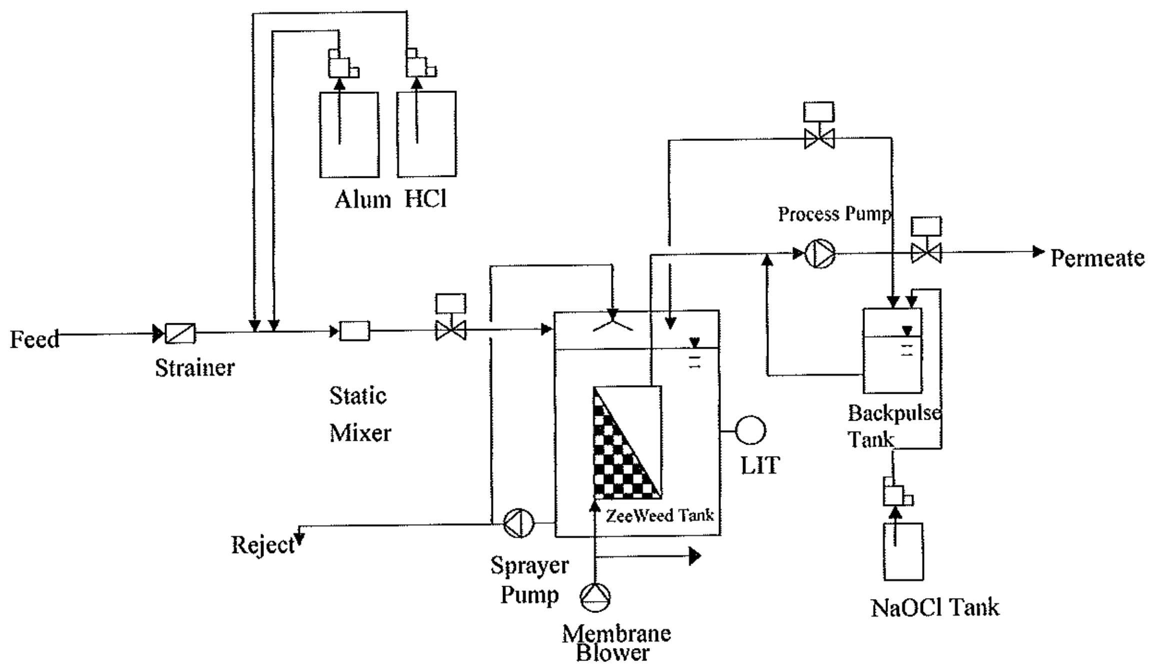
Permeate is discharged from the system while the concentrated solids remain within the ZeeWeed® process tank. The process tank level is maintained by the addition of fresh feed. The overall system balance is maintained by discharging a controlled volume of reject sludge from the system.

The pilot unit comes fully equipped with the following major equipment:

- Self contained ZeeWeed® skid with integral PLC control
- Membrane – Three (3) ZW-500C modules
- Permeate Pump - Self priming centrifugal pump - 15 USGPM @ 15 psig
- Sprayer Pump - Single Stage Centrifugal – up to 20 USGPM at 15 psig
- Aeration Blower - 20 SCFM @ 5 psig
- Feed Strainer – Duplex Basket with fine and coarse screens
- Reject Pump - Self priming centrifugal pump - 15 USGPM @ 15 psig
- Chemical addition systems for membrane cleaning, pH control and coagulant addition
- Transformer (460/3/60 to 230/1/60)

The following schematic provides a general flow diagram for the Zenon pilot system:

ZEEWEED® TERTIARY PILOT – IEPC



The Zenon pilot system was configured for operation at the following target set points:

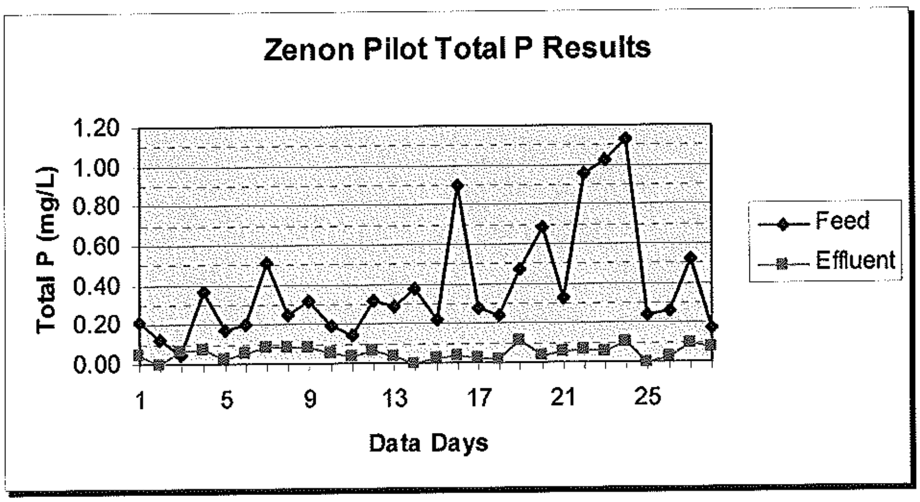
• Feed Rate to ZeeWeed Tank	7.81 gpm (assumes 90% recovery)
• Permeate Flow	8.68 gpm (for ZW500c)
• Reject Flow	0.87 gpm (assumes 90% recovery)
• Airflow	16 - 17 cfm
• Back Pulse Duration	15 sec
• Permeate Duration	15 min

The Zenon pilot system began operation on June 13 and completed operation on August 12, 2005. The pilot system was operated with the following three coagulant variations:

- Aluminum Sulfate (Alum) Coagulant
- Ferric Chloride Coagulant
- Polyaluminum Chloride (PAX) Coagulant

Zenon varied the coagulant dosages during each of the above scenarios and utilized acid for pH control to optimize the system operation. The feed rate of coagulant is controlled by the Operator to maintain a target turbidity going into the AC. The feed rate of acid was controlled automatically to maintain a setpoint of 6.0 with a pH probe feedback signal. Unlike the other pilot systems, Zenon did not use a polymer due to concerns of membrane fouling. Both the Alum and Ferric Chloride combined with acid addition were equally effective in optimizing the P reduction. Results with the PAX were erratic and did not provide consistent low level P results. The Zenon membrane pilot system also operated with slightly lower dosages of coagulant than the other pilot systems. Coagulant dosages in the range of 270 to 300 ppm (active) were required to obtain consistently low levels of effluent P.

The following chart provides a summary of the influent and effluent Total P results obtained for the Zenon pilot system throughout the length of the study.



IEP's influent Total P can vary significantly due to the many process variables within the mill. During the Zenon study the influent Total P averaged 0.45 mg/L, ranging from 0.05 to 1.05 mg/L. The effluent Total P from the Zenon pilot system was very consistent averaging 0.054 mg/L over the duration of the study for an average Total P reduction of approximately 88%. Twenty-six of the thirty-two Total P data points (81%) were below 0.10 mg/L, and thirteen of the thirty-two data points (41%) were below 0.05 mg/L. The lowest data points observed were 0.02 mg/L (MDL) per IEP's analytical method, 0.026 per Anatek's analytical methods, and 0.027 per Ecology's analytical methods. Statistically, the Zenon pilot operation resulted in a 95th percentile effluent Total P of 0.102 mg/L and a 99th percentile effluent Total P of 0.116 over the range of data collected.

The Zenon pilot system provided the most efficient and consistent phosphorus reduction of the three pilot systems tested. The most significant operational problem and a primary concern to IEP is the propensity for fouling of the membranes. Specific constituents that exist primarily in pulp and paper mill effluent, such as calcium based compounds, are known to cause membrane fouling. Membrane type systems function on Trans-Membrane Pressure (TMP) which is a measure of the pressure drop across the membrane. System backwash cycles can operate on either a TMP or timed cycle basis. However, the TMP increases over time to a limit that requires the system to be shut-down for out-of-service cleaning of the membrane due to fouling. This process requires the membranes to be soaked for extended durations in citric acid and then sodium hypochlorite solutions to remove the inorganic and organic contaminants plugging the membranes.

During the thirty one days of operation, the Zenon pilot system was shut down on three occasions, totaling 3 days, to perform soaking and cleaning of the membranes. For full-scale application, a significant amount of down time, labor and chemicals would be necessary for this cleaning process. In addition, a significant amount of equipment redundancy would be required to accommodate this frequent down time.

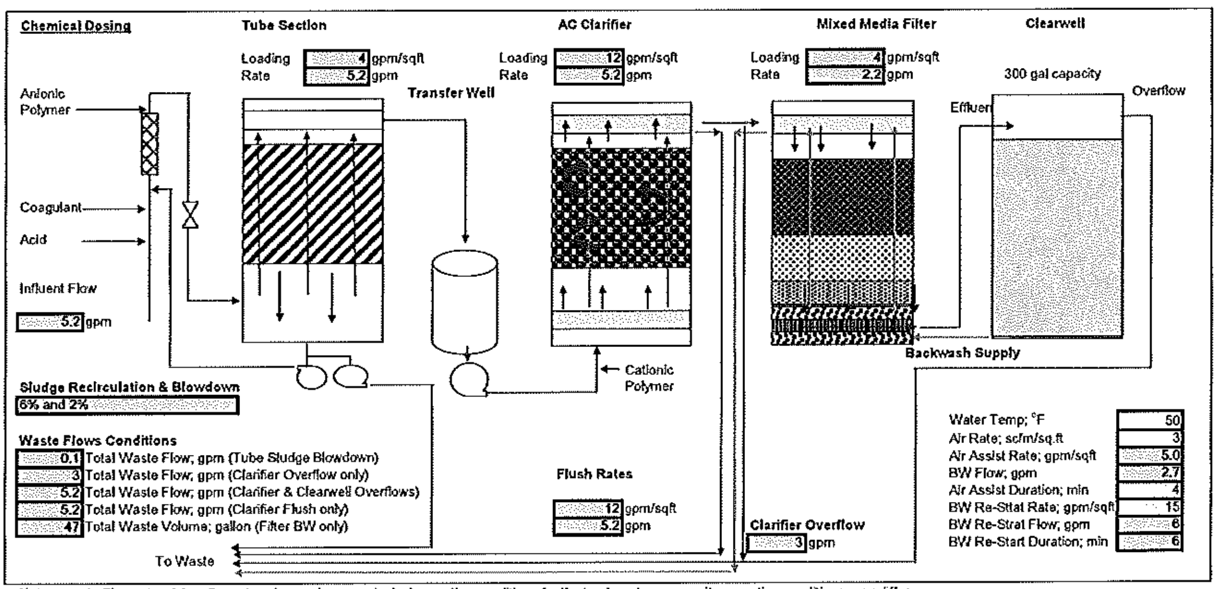
IEP also conducted extended studies using the Zenon pilot system as a Membrane Bio-Reactor (MBR). During these tests, frequent fouling of the membrane was encountered and numerous membrane soaks were necessary to return the TMP to a normal operating condition. The operational duration between fouling of the membranes varied from several days to several weeks depending upon the operating conditions.

Another concern regarding the use of membrane type technologies with IEP's effluent is membrane life. Membrane suppliers consider IEP's pulp and paper effluent as a severe duty industrial application that can have an adverse affect on membrane life. The membrane suppliers expressed reluctance in providing any extended guarantees on membrane life. Ongoing operational costs for membrane replacement have been projected to be a significant fraction of the total capital equipment cost.

Capital equipment costs for the membrane systems are also 3 to 5 times greater than competing technologies, based on proposals received for IEP full-scale application. Considering the significant capital, operation and maintenance costs combined with the operational concerns experienced above, membrane tertiary treatment would likely not be the technology of choice for IEP's application.

8.0 USFilter's Trident HS® Technology

After the initial pilot experiences with the Trident system, USFilter suggested that the newly developed Trident HS system would be better suited for treating IEP's effluent. The Trident HS or "High Solids" is specifically designed for treating effluent streams with a significant amount of solids through the addition of a tube settling section prior to the Adsorption Clarifier (AC). The tube settler section continuously removes a significant fraction of the precipitated solids, thus reducing the loading to the AC and filter sections. The pilot-scale Trident HS system is similar in configuration to that of the Trident system, except for the addition of the tube section and elimination of the detention tanks. The following schematic provides a general flow diagram for the Trident HS pilot system:



Notes:
1. Flow rates & Loading rates shown above are typical operating conditions for the treatment process; site operating conditions may differ
2. Coagulant/pH adj./oxidant typically ahead of static mixer
3. Polymer typically fed after static mixer & prior to AC clarifier
4. Waste flows can be combined or separated.
5. Valving not shown for clarity.
6. Sludge recirculation and blowdown variable based on raw water conditions.

The Trident HS pilot system arrived as a pre-packaged trailer mounted unit and required very little installation, set-up and preparation time. Flow rates through the Trident HS pilot system were approximately ¼ of the previous Trident pilot system with an influent flow rate through the tube section and AC of approximately 5.2 gpm and a filter flow rate of approximately 2.2 gpm. Coagulant, an anionic polymer and acid for pH control were introduced into the influent stream prior to entering the tube section. The tube section uses 60° inclined tubes for enhanced sludge removal through sludge blanket flocculation and gravity settling of the upward effluent flow. Sludge is continuously wasted from the bottom of the tube section and is also re-circulated back to the point of chemical addition to aid in seeding solids flocculation. Effluent is discharged from the top of the tube settler section into a transfer well where it is pumped into the AC.

The balance of the Trident HS system consisting of the upward flow AC and downward flow mixed-media filter is similar to that of the Trident system previously described. Progressively finer solids are removed in the subsequent stages of this system. Both the AC and mixed-media filter operate primarily off of differential pressure as solids build up over time. Upon reaching the set-point differential pressures, the system operation is interrupted to flush the AC or to backwash the mixed-media filter. Both stages may also be operated on a time cycle basis, dependant upon optimum operating conditions. Final effluent from the Trident HS system is used to fill a Clearwell for backwashing the mixed-media filter or is sent to IEP's mill sewer system.

The Trident HS pilot system operated relatively well, significantly minimizing the problems that plagued the Trident system (unit without the tube settler) while providing the lowest total P performance of all the pilot systems tested. The addition of the tube settling section in continuously removing a significant fraction of the solids increased the net operating time of the AC and multi-media filter sections. Net production time for the Trident HS averaged between 88 to 94% versus that of the Trident system at 76 to 81%.

The tube settler was susceptible to solids overload and also to proper solids flocculation. The abundance of solids produced by the process required a high waste rate from the tube clarifier that prevented seeding of the influent. The inability to seed the influent with recirculation of the sludge resulted in higher chemical demand and a higher reject rate of sludge. Special care into the proper design of the tube settler stage will be necessary for full-scale application to resolve the problem of sludge overload.

The proper dosage of chemicals and the instrumentation and controls for assuring optimum flocculation are also crucial to the proper operating performance of the Trident HS system. Significant variations in IEP's effluent quality due to process changes in the pulp and paper mill will require automated control of chemical feeds. The proper dosage of chemicals will rely upon instrument feedback to maintain target set points for optimum operation.

Flushing of the AC was performed on a time cycle basis varying from 4 to 8 hours based on the selected operating conditions. The time cycle for flushing of the AC was selected in lieu of differential pressure due to the extension of operating time resulting from the addition of the tube settler. The efficient removal of solids by the tube settler stage greatly decreased the solids build-up in the AC, thus increasing the cycle time based on differential pressure. These extended periods of operation resulted in the AC media becoming sticky, causing difficulties in fluidizing and cleaning. Operations on a timed cycle helped to minimize this problem, but did not eliminate it. Severe agitation and vibration was necessary at times to free the AC media. This may be due to the slenderness ratio of the Trident HS pilot AC, excessive polymer dosage or may be an inherent problem associated with IEP's application that needs to be considered for full-scale system design.

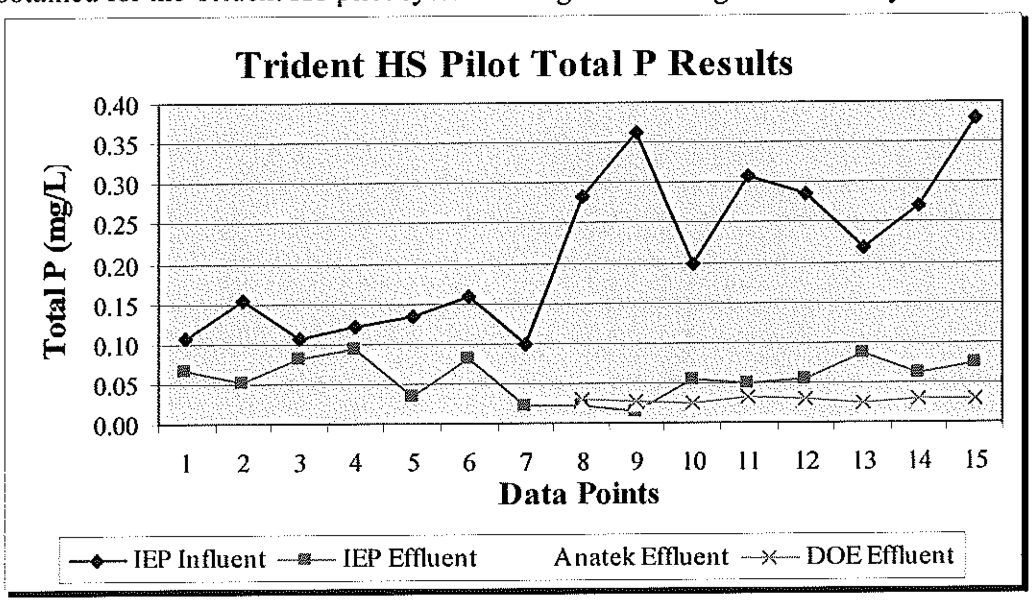
The Trident HS pilot system began operation on November 17 and completed operation on December 6, 2005. The pilot system operated with the following chemical treatments:

- Coagulant - Aluminum Sulfate (Alum)
- Hydrochloric Acid (Muriatic) for pH control
- Anionic Polymer – Cytec A110
- Cationic Polymers – Ciba Magnafloc LT22
  Ciba Zetag 7563
  Cytec C492
  Cytec C496

After evaluating the results from the first three pilot studies, IEP elected to pursue subsequent testing with only Alum as the coagulant since no significant advantages were discovered with other coagulants. Having also learned from the prior pilot study results, USFilter began operations with the Trident HS pilot system where they had left off with the Trident pilot study. The pH was closely controlled to approximately 6.0 with hydrochloric acid to optimize the phosphorus precipitation. The acid was injected ahead of the static mixer and monitored with a continuous pH probe/monitor. The feed rate of acid varied significantly based on the effluent quality and coagulant dosage rates.

Significant dosages of Alum combined with pre-determined dosages of polymer resulted in immediate and significant reductions of phosphorus. USFilter varied Alum dosages and experimented with different polymers to optimize system operations. Significant dosages of coagulant ranging from 200 to 400 ppm (active) were required to obtain consistently low levels of effluent total P, as experienced during the previous pilot studies.

The following chart provides a summary of the influent and effluent Total P results obtained for the Trident HS pilot system throughout the length of the study:



The influent total phosphorus based on IEP lab data averaged 0.213 mg/L over the course of the study. There was a significant discrepancy between the influent total P conducted by the outside laboratories for the last eight days of testing (not shown for clarity). The average influent total P reported by Anatek of 0.213 mg/L is significantly higher than the 0.129 mg/L reported by Ecology. The average total phosphorus reported by IEP's lab during this same eight day period was higher yet at 0.288 mg/L. The discrepancy of results from split samples analyzed by three different labs raises serious concerns. A standard methodology for analysis of total P approaching the current lower detection limit will need to be established that assures reliability for compliance monitoring.

Building upon the knowledge gained from the prior pilot studies, the USFilter Trident HS system performed relatively well from the start. All effluent values from the Trident HS were below 0.10 mg/L. The effluent total phosphorus based on IEP's lab data averaged 0.057 mg/L over the course of the study. Average effluent total phosphorus values reported by the outside labs for the last eight days of testing were more consistent than the influent total P results. Anatek reported an average effluent total phosphorus of 0.024 mg/L and Ecology reported an average of 0.029 mg/L. Once again, IEP's lab reported effluent total phosphorus levels significantly higher than the outside laboratories, averaging 0.053 mg/L over the last eight days of testing. Statistically, the Trident HS operation resulted in a 95^{th} percentile effluent Total P of 0.090 mg/L and a 99^{th} percentile effluent Total P of 0.093 mg/L over the range of IEP data analyzed.

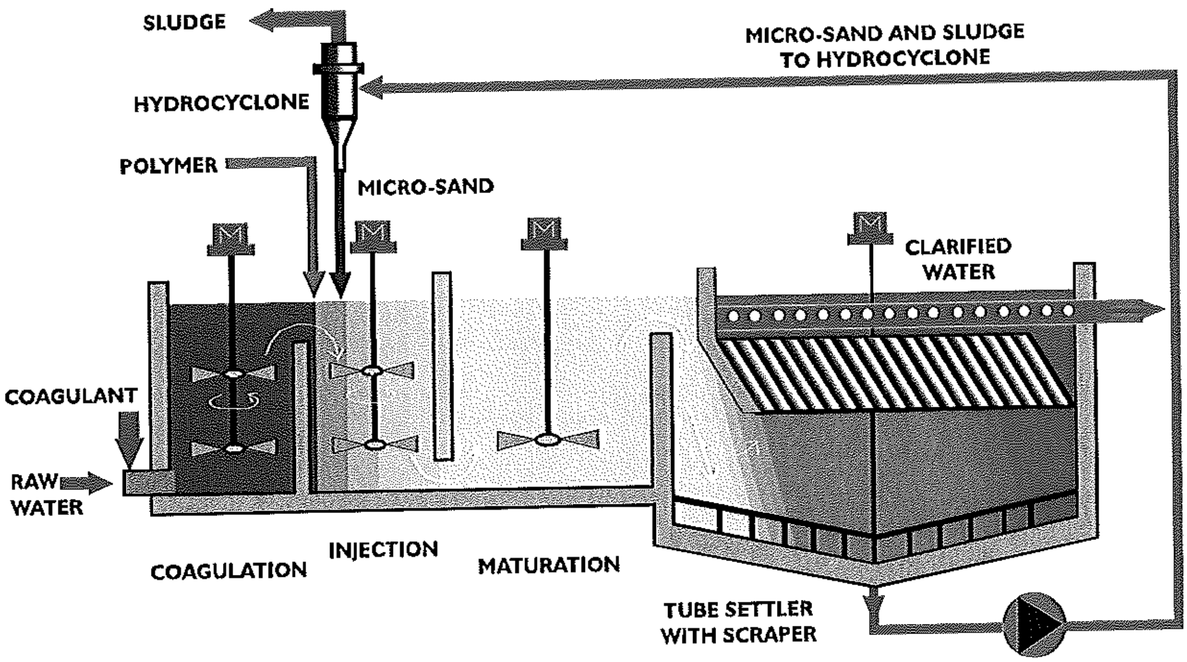
Total Suspended Solids (TSS) analysis was completed on grab samples to profile solids removal throughout the process. TSS results indicate that the bulk (95 %) of the solids removal occurs across the tube section, with tube reject solids averaging 0.57% by weight. During the study the Trident HS pilot unit was operated with a loading rate of 4 gpm/sq.ft on the tubes, 12 gpm/sq.ft. on the clarifier and 4 gpm/sq.ft. on the filter, without up-front detention time. A comparison of the reject percentages between the Trident and Trident HS pilot studies is provided below:

	Trident HS	**Trident**
• % Total Reject Water:	6.7 % - 14 %	18 % - 21 %
• % Filter Backwash Waste:	2.1 % - 2.5 %	1.0 % - 4.0 %
• % Clarifier Flush Water:	2.6 % - 9.4 %	14 % - 20 %
• % Tube Reject Waste:	1.0% - 3.0%	
• % Time Out of Service:	1.8 % - 7.5 %	15 % - 22 %
• % Net Production:	88 % - 94 %	76 % - 81 %

In spite of the discrepancies in the data reported by the three labs, the USFilter Trident HS was one of the overall best performers for phosphorus removal of all the pilot technologies tested with IEP's effluent. Although several operating problems were experienced with the pilot system that need to be considered in a full-scale system design. The following areas of concern need to be addressed as a result of these studies: proper sizing of the tube settler stage to prevent overload, proper sizing of the sludge wasting systems to prevent overload, chemical dosage and sludge recirculation instrumentation and controls to assure optimum flocculation over a wide range of influent operating conditions, and methods to prevent agglomeration of the AC media.

9.0 Kruger's Actiflo® Technology

Kruger Incorporated's ACTIFLO® technology consists of enhanced flocculation and settling around micro-sand particles. The basic mechanism for removal of the formed solids is settling clarification of the ballasted sand/flocculated sludge particles through a tube settler. Solids are removed from the micro-sand particle with a hydro-cyclone, and the sand is re-injected into the process. The following diagram illustrates the general arrangement of Kruger Incorporated's ACTIFLO® technology:



Kruger's ACTIFLO® pilot system arrived as a pre-packaged trailer mounted unit and required very little installation, set-up and preparation time. The arrangement consisted of three coagulation/flocculation tanks (Coagulation Tank, Injection Tank and a Maturation Tank), a 764 gallon settling tank, and a Hydrocyclone for sludge separation and sand re-injection.

Influent flow of raw water into the ACTIFLO® pilot system averaged 200gpm, the highest flow rate of any of the pilot systems tested at IEP. The waste flow rate to the Hydrocyclone was set at approximately 25 gpm with 20 gpm removed as sludge and 5 gpm returned to the ACTIFLO® pilot system as recovered microsand. The final clarified effluent from the ACTIFLO® system was discharged from the tube settler and sent back to IEP's mill sewer system.

Coagulant was added to the raw water prior to the coagulation tank. Anionic polymer and the microsand are introduced at the Injection Tank where high-density flocculation of solids binds with the microsand particles. The ballasted microsand and solids particles are then continuously removed from the bottom of the tube settler and sent to the hydrocyclone for separation.

The ACTIFLO® pilot system operated relatively well in reducing phosphorus with minimal operational difficulties. Many of the minor problems encountered during the course of the study were due to freezing weather conditions, including frozen chemical feed lines. The pilot system was also equipped with post-Actiflo sand type filters for further phosphorus reduction experimentation that were inoperable due to freezing. An incident also occurred where the microsand was "floated" out of the tube settler requiring that the system be re-charged with a new sand supply. Proper chemical addition and dosages are critical to the ACTIFLO® process to assure proper flocculation of the solids with the micro-sand particles for both efficient removal of the solids and to minimize the loss of the microsand. The ACTIFLO® system does not include any filter barrier and relies strictly upon proper adhesion of the solids to the microsand for removal via gravity clarification. Upsets in any of the above parameters can result in inefficient operation and the possibility of the effluent passing through the system unabated.

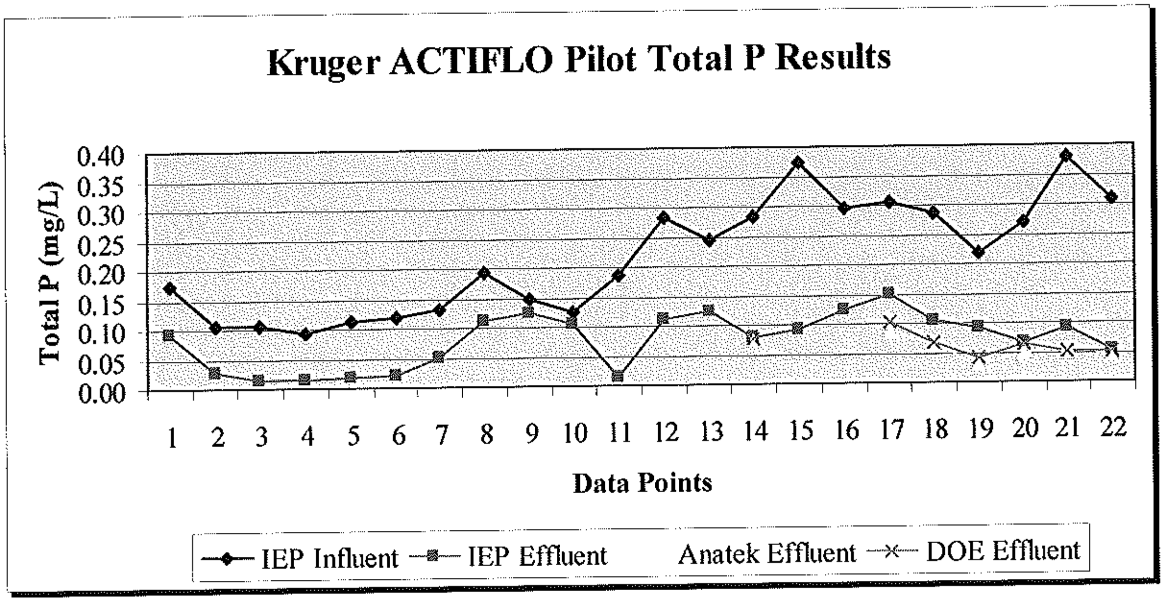
The ACTIFLO® pilot system began operation on November 18 and completed operation on December 8, 2005. The pilot system operated with the following chemical treatment:

- Coagulant - Aluminum Sulfate (Alum)
- Coagulant – Polyaluminum Chloride, PAX-18 (brief trial period)
- Anionic Polymer – Ciba Magnafloc 155
  Ciba Magnafloc 90L
- Hydrochloric Acid (Muriatic)for pH control (brief trial period)

Consistent with the USFilter Trident HS trial, IEP elected to pursue subsequent testing with only Alum as the coagulant since no significant advantages were discovered with other coagulants during prior pilot studies. Kruger however, experimented briefly with Polyaluminum Chloride (PAX-18) to evaluate any benefits in comparison to the Alum coagulant. Kruger concluded that Alum was capable of attaining the same total phosphorus removal at lower dosage rates than the PAX-18. Kruger varied the Alum dosages and experimented with different polymers to optimize the system operation with varying influent conditions. Significant dosages of coagulant ranging from 250 to 350 ppm (active) were required to obtain consistently low levels of effluent P, similar to that experienced by all other pilot studies.

Throughout the ACTIFLO® pilot study pH control was accomplished with the addition of the acidic Aluminum Sulfate coagulant, resulting in an average pH ranging from 7.05 to 7.25. Optimization of pH was conducted at the end of the study using Hydrochloric acid to observe the effects on phosphorus reduction. Various dosages of acid were introduced into the influent to reduce the effluent pH in steps ranging from 6.64 to a low of 6.24. A significant phosphorus reduction of approximately 31% was observed when decreasing the pH to approximately 6.5 with acid addition. However, no appreciable phosphorus reductions were observed with further decreases in pH from 6.5 to 6.2.

The following chart provides a summary of the influent and effluent Total P results obtained for the ACTIFLO® pilot system throughout the length of the study:



The influent total phosphorus based on IEP lab data averaged 0.222 mg/L over the course of the study. As discussed in the Trident HS results, there was a significant discrepancy between the influent total phosphorus conducted by the outside laboratories for eight days of testing (not shown for clarity). The average influent phosphorus reported by Ecology's lab of 0.136 is significantly lower than that reported by IEP's lab (0.213 mg/L) and Anatek's lab (0.219 mg/L).

In observing the results presented by the above graph, it is apparent that the effluent total phosphorus concentration follows a similar trend to that of the influent phosphorus concentration. This same performance phenomenon is similar to that experienced by the earlier trials with the Parkson Corporation Dyna Sand® Filtration and USFilter's Trident® pilot systems. In spite of this trend following, Kruger's ACTIFLO® system performed relatively well in reducing phosphorus. One of the composite samples collected during testing was significantly high due to the loss of Alum supply from a frozen chemical feed line and is not included in the analysis. The effluent total phosphorus based on IEP's lab data averaged 0.078 mg/L over the course of the study. Average effluent total phosphorus values reported by the outside labs for seven days of optimum testing were more consistent than the influent results. Anatek reported an average effluent total phosphorus of 0.058 mg/L and the WA Ecology reported and average of 0.066 mg/L. IEP's lab results over these same seven days of optimum testing was 0.093 mg/L, consistently higher than the outside laboratories as seems to be the trend from the other pilot studies.

Statistically, the ACTIFLO® pilot system operated with a 95th percentile effluent Total P of 0.127 mg/L and a 99th percentile effluent Total P of 0.148 mg/L over the range of IEP data analyzed.

10.0 Conclusions

All pilot system suppliers studied under this project concurred that IEP's effluent chemistry was the most difficult that they have encountered for phosphorus removal. The consensus of the supplier's professional opinions is that this is due primarily to a significant fraction of non-reactive phosphorus contained within IEP's effluent. IEP investigated this matter in greater detail and discovered numerous research studies regarding the bioavailability of phosphorus in pulp and paper mill effluents (see references). These studies conclude that only 60 to 80% of effluent phosphorus was biologically available in the pulp and paper mills studied, consistent with the results of the pilot studies conducted at IEP.

Upon discovering this information, IEP contracted with the National Council for Air and Stream Improvement (NCASI) to perform a Bioavailability assay of IEP's effluent. A representative composite sample was collected at the discharge of the secondary clarifier and submitted to NCASI in January, 2006. NCASI concluded that after a 133 day study period, "essentially no organic nitrogen or phosphorus was converted to bioavailable (inorganic) forms. These results indicate that the organic nitrogen and phosphorus fractions of Inland Empire final effluent are highly refractory in nature."

During the initial Trident pilot study a brief test was performed with varying coagulant doses to observe the effects on P reduction. Approximately 80% reduction of Total P was readily realized with approximately 150 ppm (active) of coagulant feed. Increased dosages of coagulant beyond 150 ppm resulted in diminishing reductions in Total P. An additional Total P reduction of only 7% was realized with coagulant dosages as high as 350 ppm (active). These higher dosages of coagulant would equate to significant chemical usage for full-scale application with diminishing returns in phosphorus reduction.

Optimum reduction of Total P was experienced by Zenon, USFilter and Kruger with adjustments of the influent pH to approximately 6.2 using acid addition. A significant amount of acid addition will be necessary at full-scale flows to achieve the lower target pH for optimum tertiary treatment. Consequently, additional caustic chemical feed may then be required after tertiary treatment to increase the pH to suitable levels for discharge to the river or for re-use in IEP's processes. With the potential use of coagulant, polymer(s), acid and caustic chemicals, the tertiary treatment process will be very chemical intensive resulting in significant operating costs. Furthermore, the excessive use of metal based ion coagulant chemicals (aluminum sulfate, poly-aluminum chloride, ferric chloride, etc.) to achieve ultra-low levels of Total P can result in residual slip of these metal ions in the final effluent.

A significant amount of rejects or chemical sludge was generated by all the pilot systems due to the excessive amount of coagulant chemicals used. The reject rates ranged from 10 to 30% depending highly upon the selected technology and operating conditions. This reject flow is equivalent to approximately 300,000 to 1,050,00 gallons per day when scaled up to IEP's total treated effluent flow. How to deal with the significant amount of rejects raises numerous technical questions that have yet to be determined. Can this reject stream be returned to the primary clarifier, assuming that the precipitant chemical sludge will settle to be removed as primary sludge, in lieu of being re-entrained in the waste water stream? If not, is it possible to de-water such a fine and fragile chemical sludge formation, and to what extent can the rejects be de-watered?

Another concern raised from the pilot study results is the reliability of the testing methods at these ultra-low levels that are approaching the quantitative detection limits of the analysis methods currently available. The following chart illustrates the differences between the effluent total phosphorus data obtained from all three laboratories, using different methods of analysis:

Pilot Test Description	Sample Date	IEP (mg/L)	Anatek (mg/L)	Ecology (mg/L)
Detection Limit		**0.020**	**0.005**	**0.005**
Parkson	07/07/05	0.110	1.070	0.039
	07/15/05	0.130	0.129	0.154
	07/28/05	0.600	0.833	0.568
Trident	07/15/05	0.070	0.032	0.049
	07/28/05	0.100	0.081	0.044
	08/09/05	0.055	0.031	0.035
Zenon	07/07/05	0.080	0.055	0.027
	07/15/05	0.030	0.026	0.040
	07/28/05	0.040	0.105	0.087
	08/09/05	0.055	0.027	0.027
Trident HS	11/29/05	1.419	0.024	0.029
	11/30/05	1.406	0.022	0.027
	12/01/05	0.000	0.019	0.026
	12/02/05	1.417	0.029	0.032
	12/03/05	0.000	0.026	0.030
	12/04/05	0.000	0.021	0.026
	12/05/05	0.000	0.024	0.031
	12/06/05	0.000	0.029	0.029
Kruger ACTIFLO	11/29/05	0.081	0.073	0.079
	11/30/05	0.290	0.208	0.104
	12/02/05	0.153	0.085	0.104
	12/03/05	0.107	0.066	0.068
	12/04/05	0.094	0.029	0.043
	12/05/05	0.068	0.049	0.063
	12/06/05	0.094	0.058	0.051
	12/07/05	0.055	0.045	0.053
AVERAGES		**0.248**	**0.123**	**0.072**

Effluent samples were collected from each pilot system and split for analysis by each laboratory. Anatek and the Ecology provided sample containers that were properly prepared and preserved in accordance with the methods outlined by their specific methods of analysis. The results from each laboratory of an equivalent sample could vary by as much as 100%. This discrepancy raises serious concerns when attempting to comply with ultra-low limits of total phosphorus.

Furthermore, an operating facility will need to obtain reliable real-time results of the treatment performance in order to make any necessary changes to the process to assure optimum reduction of phosphorus and for compliance. Submittal of samples for outside laboratory analysis requiring several days of turn around time for results does not provide a realistic approach for an operating facility attempting to comply with such stringent standards. A standard method of analysis will need to be developed and approved by the regulatory agency that can be performed at the operator's facility and assure accurate results.

Another concern regarding the performance of any of these technologies for full-scale application is the supplier's design and performance guarantees. Based on feedback from all of the supplier's, it is unlikely that any are willing to provide performance guarantees below 0.05 mg/L based on the results of the pilot studies performed at IEP. Therefore, the liability for achieving ultra-low levels of phosphorus with tertiary treatment is likely to fall upon facility operators with no recourse in holding the supplier responsible for performance of their equipment. This is a significant leap of faith required by facility operators with potentially serious financial consequences. Furthermore, suppliers may provide an overly conservative design to meet these ultra-low limits, thus greatly inflating the overall capital cost of equipment.

Of the six state-of-the-art phosphorus reduction technologies pilot tested with IEP's effluent, Zenon's ZeeWeed® Membrane and USFilter's Trident HS® technologies offered the most promising performance for obtaining consistently low-levels of effluent phosphorus. However, operation of the pilot Zenon membrane system resulted in serious concerns relative to IEP's effluent, including: rapid fouling of the membrane due to constituents that exist in IEP's pulp and paper mill effluent, excessive down-time required to properly clean the membranes, redundancy of equipment required to accommodate this down-time, significant capital cost, higher operation and maintenance cost, and uncertainties associated with membrane life. Based on the conclusion of the pilot studies, USFilter's Trident HS® technology appears to offer the best opportunity for successfully treating IEP's effluent for ultra-low phosphorus reduction.

It is apparent from the studies that a significant amount of phosphorus contained in IEP's waste water can effectively be removed with specific tertiary treatment technologies. Effluent Total P levels below 0.05 mg/L are achievable on an intermittent basis and average levels at or below 0.10 mg/L may consistently be attainable for permitting purposes. However, each technology has its specific methods of operation for achieving these optimum reduction efficiencies and each has its own associated inherent consequences. Caution must be exercised in consideration of the data presented herein, as pilot scale results are not necessarily indicative of full-scale system operation.

References:

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- Priha, M. (1994). Bioavailability of pulp and paper mill effluent phosphorus.
- Priha, M. and Angi, A. (June, 2000). The impact of nutrient loading of pulp and paper mill effluent in eutrophication of receiving waters.
- Bradford, M.E. and Peters, R.H. (1987). The relationship between chemically analyzed phosphorus fractions and bioavailable phosphorus.

Parkson Sand Filter
Pre-Trial Resultsw/Alum

		pH			Phosphorus - P						
					Ortho			Total			
Date	Time	Feed	Filter 1	Filter 2	Feed	Filter 1	Filter 2	Feed	Filter 1	Filter 2	Comments
6-06-05					1.98	1.27					
6-06-05	9:20 pm	7.9	7.1		1.62	0.23					
6-07-05	8:30 am	7.9	7.1		1.39	0.17		1.51	0.26		
6-07-05	1:55 pm	7.9	6.9		1.24	0.09		1.38	0.13		
6-08-05	8:32 am	7.9	7.1	7.1	0.87	0.21	0.13			0.25	
6-08-05	3:00 pm				0.68	0.16	0.10			0.23	
6-09-05	7:40 am				0.29	0.11	0.03			0.09	
6-09-05	7:40 am						0.04			0.13	Duplicate
6-09-05	7:40 am									0.11	Duplicate
Average		**7.9**	**7.1**	**7.1**	**1.15**	**0.32**	**0.08**	**1.45**	**0.20**	**0.16**	

Parkson Sand Filter
Feed w/Alum

Date	Temp. °C	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Comments
6-13-05		8.0	2180	6.2	1.61			0.65	0.86			5.93		
6-14-05	26.8	7.8	1914	8.0	1.44	392	292	0.86	1.05	0		9.83	215	
6-15-06	27.4	7.8	1523					0.48	0.59			5.33		
6-16-05	26.8	7.8	1553	2.8	1.17			0.44	0.50	0	0.01	3.45	165	
6-17-05	28.3	7.9	1990	4				0.65	0.99			12.9	256	
6-20-05								0.12	0.21					
6-20-05								0.19						
6-21-05am	29.9	7.99	1990					0.12	0.13					
6-22-05	30.2	7.95	1835					0.12	0.05					
6-23-05am	30.0	7.90	2070					0.19	0.37					
6-23-05pm								0.13						
6-24-05am	29.2	7.91	1817					0.12	0.55					
6-24-05pm								0.07						
6-27-05		7.9	1880					0.08	0.20	0		7.7		
6-28-05		7.9	1920	6.0		472	256	0.10	0.51	0	5.76	8.02	230	
6-29-05		8.2	1980	12.0	1.75	548	312	0.07	0.21	0	1.28	13.05		Composite
6-30-05		7.9	1860	3.6	1.49	490	292	0.08	0.24	0	4.80	5.7		Composite
7-06-05		7.9	1530			378	280	0.11	0.32	0	0.03	9.15		Grab
7-07-05		8.3	2040	9.6		460	60	0.11	0.21	0	0.01	12.3	285	Composite
7-08-05		8.1	1950	8.0		464	272	0.06	0.15	0	0.01			Grab
7-12-05		7.9	1910	2.4	1.57	412	224	0.12	0.32	0	1.28			Grab
7-13-05		8.1	1930	6.8		468	248	0.11	0.29	0	0.00			Grab
7-14-05		8.0	2260	4.4	1.87			0.17	0.38					Grab
7-15-05		8.0	2330	2.2	1.92				0.30				370	Composite
Average	**27.33**	**8.0**	**1934**	**5.85**	**1.60**	**453.8**	**248.4**	**0.22**	**0.40**	**0.00**	**1.46**	**8.5**	**254**	
Median	**27.33**	**7.90**	**1931.94**	**5.85**	**1.58**	**462.00**	**264.00**	**0.12**	**0.32**	**0.00**	**0.66**	**8.49**	**253.50**	
Minimum	**26.80**	**7.80**	**1523.00**	**2.20**	**1.17**	**378.00**	**60.00**	**0.06**	**0.05**	**0.00**	**0.00**	**3.45**	**165.00**	
Maximum	**28.30**	**8.30**	**2330.00**	**12.00**	**1.92**	**548.00**	**312.00**	**0.86**	**1.05**	**0.00**	**5.76**	**13.05**	**370.00**	

Parkson Sand Filter
Filter One w/Alum

Date	Temp. °C	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Comments
6-13-05		7.7		2.4	1.67			0.58						
6-14-05		7.6	2080	1.2	1.60	394	312	0.77				10.05	198	
6-16-05 am		7.5	1630	10.4	1.20			0.17	0.52			1.5	152	
6-16-05 pm		7.2						0.09						
6-17-05		7.7	1710	2.0				0.18	0.38			4.5	162	
-21-05pm u/f								0.08	0.21					
5-21-05pm F								0.31	0.11					
6-23-05 pm								0.17	0.30					
6-30-05		7.5	1860	2.4	1.63	434	260	0.06	0.17	0	5.12	9.3		Composite
7-06-05								0.05	0.08					
7-07-05								0.04	0.06					8:00 am
7-07-05								0.06	0.06					9:20 am
7-07-05		7.0	1960					0.02	0.11					Composite
7-07-05								0.01						8:50 pm
7-08-05								0.06						6:45 am
7-08-05								0.03						9:00 am
7-13-05		7.3	2020	1.6		304	224	0.01	0.11	0	0	4.8		7:30 am
7-13-05								0.02	0.15					10:25 am
7-14-05		7.4	2250	8.0	1.70			0.10	0.25			10.8		11:55 am
7-15-05		7.3	2360	7.6	1.91			0.05	0.13				324	Composite
Average	#DIV/0!	7.4	1984	4.45	1.62	377.3	265.3	0.14	0.19	0.00	2.56	6.8	209	

Parkson Sand Filter
Lamella Gravity Setteler w/Alum

Date	Temp. °C	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Comments
7-13-05		7.1	2030	43.0		308	236	0.07	0.25	0	0.01	9.75		7:30 am
7-13-05								0.14						10:25 am
7-14-05		6.8	2270					0.06				6.9		11:55 am
Average		7.0	2150	43.00		308.0	236.0	0.09	0.25	0.0	0.01	8.3	#DIV/0!	

Parkson Sand Filter

Filter Two w/Alum

Date	Temp. °C	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Comments
6-13-05		7.7		1.4	1.64			0.46						
6-14-05		7.6	2050	0	1.58	400	292	0.62				8.25	190	
6-16-05 am		7.6	1640	1.4	1.16			0.11	0.17			0.75	134	
6-16-05 pm		7.2						0.11						
6-17-05		7.6	1740	1.0				0.08	0.28			3.9	154	
6-21-05 pm u/f								0.06	0.11					
6-21-05 F								0.03	0.12					
6-23-05 pm								0.17	0.22					
6-30-05		7.6	1870	2.2		414	252	0.04	0.22	0.05	4.16	14.1		Composite
7-06-05								0.07	0.08					
7-07-05								0.04	0.06					8:00 am
7-07-05								0.04	0.08					9:20 am
7-07-05		7.6	1910	0.0	1.46	260	44	0.05	0.07	0.01	0.07		164	Composite
7-08-05								0.01						6:45 am
7-08-05								0.03						9:00 am
7-14-05		7.7	2270	2.8	1.87			0.09	0.20			7.8		11:55 am
Average		7.6	1913	1.26	1.54	358.0	196.0	0.13	0.15	0.03	2.12	7.0	161	

Parkson Sand Filter

Alum Curve

			Ortho P mg/l			
Date	Time	Alum	Feed	LGS	Filter One	Filter Two
7-15-05	7:40 am	340	0.04	0.04	0.013	0
	10:00 am	300	0.05	0.04	0.013	0.04
	11:55 am	250	0.04	0.05	0.003	0.03
	2:00 pm	150	0.03	0.04	0.05	0.013
	5:00 pm	75	0.006	0.02	0.02	0.003
7-16-05	9:30 am	350	0.09	0.02	0.02	0

Feed
Alum with Phosphoric Acid

Date	Alum ppm	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Aluminum mg/l	Comments
7-26-05	225	8.1	2130					0.05	0.32			14.4			10:30
7-27-05	300	8.0	2180					0.14	0.47			13.6			11:00
7-28-05		7.3	2060	12	1.66	500	268	0.39	0.69	0	0.01	14.0	307	0.66	Composite
Average		7.8	2123	12	1.66	500	268	0.193	0.493	0	0.01	14.0	307	0.66	

Filter One
Alum with Phosphoric Acid

Date	Alum ppm	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Aluminum mg/l	Comments
7-26-05	225	8.0	2110					0.06	0.29			11.7			10:30
7-27-05		8.0	2120					0.13	0.29			12.3			11:00
7-28-05		8.0	2050	1.6	1.65	500	272	0.34	0.60	0	0.03	12.2	302	0.28	Composite
Average		8.0	2093	1.6	1.65	500	272	0.177	0.393	0	0.03	12.07	302	0.28	

Lamella Gravity Setteler
Alum with Phosphoric Acid

Date	Alum ppm	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Aluminum mg/l	Comments
7-26-05	225	8.0	2100					0.08	0.46			16.8			10:30
7-27-05		8.0	2040					0.19	0.45			14.7			11:00
Average		8.0	2070					0.135	0.455			15.75			

Filter Two
Alum with Phosphoric Acid

Date	Alum ppm	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Aluminum ppm	Comments
7-26-05	225	8.0	2100					0.05	0.19			10.2			10:30
7-27-05		8.0	2150					0.11	0.29			9.6			
Average		8.0	2125					0.080	0.240			9.90			

Parkson Sand Filter

FeCl Curve

		FeCl	Ortho P mg/l				Total P mg/l				FeCl mg/l		pH	
Date	Time	Feed Rate	Feed	LGS	Filter One	Filter Two	Feed	LGS	Filter One	Filter Two	Feed	Filter Two	Feed	Filter Two
7-17-05	11:30 am	75	0.08	0.06	0.09	0.11					0.11	12.07	7.8	7.6
7-18-05	10:45 am	200	0.37	0.06	0.15	0.18	0.65		0.35	0.4	0	15.51	8	7.1
7-18-05	2:45 pm	150	0.41	0.21	0.23	0.22	0.69		0.49	0.43	0	35.67	7.8	6.8
7-18-05	4:15 pm	100	0.58			0.32								
7-19-05	11:00 am	260	0.8	0.08	0.02	0.19				0.29	0	4.16	7.9	6.8
7-19-05	12:30 pm	315	0.78			0.19					0	3.57	7.9	6.5
7-20-05	11:00 am	300	0.54	0.02	0.17	0.25					0	2.13	7.7	6.8
7-20-05	3:30 pm		0.46	0.01	0.007	0.03					0	1.54	7.8	6.7
7-20-05	5:00 pm	300				0.11								
7-20-05	8:00 pm	300					0.75			0.12				

Feed
Ferric Chloride

Date	FeCl ppm	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Fe mg/l	Comments
7-21-05		8.2	2070	13.6	1.67	476	316	0.13	0.39			21.4	287	0.53	Grab
Average		8.2	2070	13.6	1.67	476	316	0.13	0.39			21.4	287	0.53	

Filter One
Ferric Chloride

Date	FeCl ppm	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Fe mg/l	Comments
7-21-05		6.8	2520	1.4	1.69	120	348	0.02	0.03			7.65	114	1.72	Grab
Average		6.8	2520	1.4	1.69	120	348	0.02	0.03			7.65	114	1.72	

Lamella Gravity Setteler
Ferric Chloride

Date	FeCl ppm	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Fe mg/l	Comments
7-21-05		6.6	2480	5.2	1.69	10	296	0.00	0.06			2.25	122	5.99	Grab
Average		6.6	2480	5.2	1.69	10	296	0	0.06			2.25	122	5.99	

Filter Two
Ferric Chloride

Date	FeCl ppm	pH	Conductivity	Glass Fiber TSS mg/l	TDS g/l	Alkalinity mg/l	Hardness mg/l	Ortho P mg/l	Total P mg/l	Nitrate N mg/l	Ammonia N mg/l	BOD mg/l	COD mg/l	Fe mg/l	Comments
7-21-05		7.1	2430	8.0	1.72	280	372	0.05	0.13			9.45	175	1.45	Grab
Average		7.1	2430	8.0	1.72	280	372	0.05	0.13			9.45	175	1.45	

Footnote 2

Evaluation of Exemplary WWTPs Practicing High Removal of Phosphorus

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This memorandum was prepared to provide information regarding the performance of exemplary wastewater treatment plants (WWTPs) practicing high removal of phosphorus to assist in determining effluent phosphorus concentrations that are achievable with current wastewater treatment technologies. The Technology Work Group for the Spokane River TMDL identified a number of exemplary WWTPs that were practicing high removal of phosphorus and achieving effluent total phosphorus concentrations of 50 µg/L or less. Nine WWTPs were selected from this group and detailed evaluations were performed. The nine WWTPs were selected based on size, technologies utilized and confidence that the effluent data were reasonable. A tenth WWTP, Breckenridge, Colorado was added because the information became available and it represented potentially the lowest effluent phosphorus concentration of the entire group. The 10 plants were (from largest to smallest):

- Las Vegas, Nevada
- Alexandria, Virginia
- Rock Creek (Portland area), Oregon
- Durham (Portland area), Oregon
- Cauley Creek (Atlanta area), Georgia
- Lone Tree (Arapahoe County), Colorado
- Walton, New York
- Iowa Hill (Breckenridge), Colorado
- Pinery, Colorado
- Stamford, New York

Two years of daily effluent total phosphorus data were obtained for each WWTP and the log normal average and coefficient of variation were calculated for each year. The data for each WWTP were used without modification except to correct obvious data entry errors. The log normal average was used because the log normal distribution typically fits the data better than a normal distribution. The log normal coefficient of variation (COV) is a simple numerical representation of the variation of data. A larger COV indicates greater variation of daily data. Graphs of annual daily data and the log normal average for each WWTP illustrate the variation of the daily data.

Preliminary analyses of the short-term, small-scale pilot studies of phosphorus removal at the City of Spokane River Park Water Reclamation Facility (RPWRF) are also presented for information. Small-scale pilot studies have been performed using Parkson DynaSand D2 Filtration, US Filter Microfloc Trident and Zenon Membrane Filtration technologies and they provide information on what effluent concentrations of total phosphorus may be possible for the City of Spokane. Each pilot has operated for approximately 1 month.

The effluent concentrations are presented in terms of µg/L and mg/L. There are 1,000 µg/L in 1 mg/L. To convert from mg/L to µg/L, multiply by 1,000. The following are examples of the conversion:

0.10 mg/L = 100 µg/L

0.05 mg/L = 50 µg/L

Summary of Results

Table 1 summarizes the evaluation of full-scale exemplary WWTPs practicing high removals of total phosphorus. Factors that appear to be associated with effluent phosphorus concentrations at the exemplary plants include effluent permit limits, treatment plant size, treatment technology, method of solids processing, and the availability of a sufficient number of qualified operators and staff. Another factor that may affect the observed performance is the frequency of sampling and laboratory analytical considerations. Larger WWTPs had higher effluent phosphorus permit limits, had higher effluent phosphorus concentration and included anaerobic digestion. It is not possible to determine cause and effect from the information gathered. While associations exist between effluent phosphorus concentration, effluent phosphorus permit limits, plant size and anaerobic digestion it is not possible to determine which are causative, the magnitude of causative effect and which are just coincidental. The effluent phosphorus concentrations based on the actual daily data for the majority of WWTPs was significantly higher than the information produced by the Technology Work Group for the Spokane River TMDL appeared to show. Plants of substantial size (>2.5 mgd) had similar effluent performance with both chemical clarification followed by media filtration, and membrane bioreactor (MBR) with chemical addition. The larger plants reviewed in this investigation had daily 24-hour composite effluent monitoring and were measuring phosphorus concentrations greater than 25 µg/L. The amount of effluent data is greater and daily sampling of 24-hour composite samples ensures that process variability is well documented. The higher concentrations of effluent total phosphorus require less stringent quality control in the laboratory and are less subject to variation in laboratory analysis. This adds confidence to the reported phosphorus concentration in the effluent.

Exemplary plants reporting the lowest effluent phosphorus concentrations in the range of 8 to 46 µg/L were relatively small (<2.5 mgd), had lower effluent phosphorus limits, had newer phosphorus removal technologies, had limited solids processing and limited sampling and effluent testing. These associations also do not prove cause and effect and it is not possible to determine which factors are causative and most significant. The results from the smaller WWTPs suggest that the larger WWTPs using new phosphorus removal technologies may be able to achieve these lower effluent total phosphorus concentrations. However, the effects of plant size and solids processing must be determined from full-scale operation to confirm if this is indeed feasible. Effluent sampling and laboratory analysis may also significantly affect the apparent performance of the smaller WWTPs. Most of the smaller WWTPs sampled once per week or as little as twice per month. One did not use 24-hour composite samples. The result is the number of effluent data are much less and the potential exists that process variability is not captured with the reduced sampling. The effluent phosphorus concentrations are much less and there is evidence (see later section) that laboratory methods for measurement of phosphorus concentrations less than 25 μg/L are subject to substantial variability. The result of the limited sampling and challenges of measuring low concentrations of total effluent phosphorus is reduced confidence in the reported effluent total phosphorus concentrations for the smaller WWTPs.

The substantially sized treatment plants evaluated in this investigation (> 2.5 mgd) are more comparable to most of the facilities discharging to the Spokane River. These larger facilities are achieving effluent total phosphorus in the range of 71 to 179 μg/L total phosphorus. Notable plants of substantial size employing chemical clarification and media filtration that have performance in this range include the Rock Creek (34 mgd) and Durhman (25 mgd) plants in Oregon. The 5 mgd membrane bioreactor plant (MBR) at Cauley Creek, GA also has effluent phosphorus performance in this range.

The Rock Creek and Durham plants have one of the most restrictive phosphorus limits at 100 μg/L. Rock Creek has achieved effluent total phosphorus concentration of 71 and 82 μg/L over the phosphorus removal season of May to October in 2004 and 2005. Similarly, the Durham plant has achieved effluent total phosphorus concentration of 102 and 73 μg/L over the phosphorus removal seasons in 2004 and 2005. Rock Creek total effluent phosphorus has increased from 48 to 57 μg/L for the years 2001, 2002 and 2003. The recent increase in effluent phosphorus at Rock Creek and Durham is attributed to an increase in effluent total phosphorus concentration in the NPDES permit which now allows monthly median total phosphorus in their effluent of 100 and 110 μg/L, respectively. Less alum is required to be added to meet the less stringent NPDES permit and this saves the wastewater utility money.

All of the exemplary plants examined had data points well above and below the mean. This variability may be related to a variety of conditions that have not been fully assessed in this analysis (process changes, upset, chemical feed, temperature, level of operator experience, etc.) which may, or may not be controllable. For these reasons, permit limits based on a long-term averaging period, such as seasonal averaging, appears essential to successful compliance with phosphorus effluent levels less than 100 μg/L.

TABLE 1
Summary of Exemplary WWTPs in U.S. Practicing High Phosphorus Removal

Facility	Average Design Flow (mgd)	Recent Average Flow (mgd)	NPDES Total Phosphorus Limit (μg/L)	Final Effluent Log Normal Average Total Phosphorus (μg/L)		Coefficient of Variation of Final Effluent Total Phosphorus		Liquids Process	Solids Process
				Year 1	Year 2	Year 1	Year 2		
Las Vegas, Nevada	91	63	170	179	152	0.28	0.52	30-mgd biological nutrient removal, trickling filters and activated sludge for remainder, blended followed by filtration	Thickening, anaerobic digestion and dewatering.
Alexandria, Virginia	54	40	Month 180, week 270	134	88	0.76	0.48	Ferric chloride primary clarification, activated sludge, ferric chloride secondary clarification, alum chemical clarification, multimedia filtration	Pasteurization, anaerobic digestion and dewatering
Rock Creek (Portland area), Oregon	34	32	Month median 100 May 1 through October 31	82	71	0.48	0.47	Alum primary clarification, activated sludge secondary, alum-chemical clarification, alum - multimedia filtration	Anaerobic digestion and dewatering
Durham (Portland area), Oregon	25	17	Month median 110 May 1 through October 31	102	73	1.01	0.65	Biological nutrient removal with alum addition to primary, secondary and chemical clarifiers followed by sand filtration	Fermentation of primary sludge, thickening of waste activated and chemical sludges, anaerobic digestion of primary and waste activated sludge and dewatering

TABLE 1
Summary of Exemplary WWTPs in U.S. Practicing High Phosphorus Removal

Facility	Average Design Flow (mgd)	Recent Average Flow (mgd)	NPDES Total Phosphorus Limit (µg/L)	Final Effluent Log Normal Average Total Phosphorus (µg/L)		Coefficient of Variation of Final Effluent Total Phosphorus		Liquids Process	Solids Process
				Year 1	Year 2	Year 1	Year 2		
Cauley Creek (Atlanta area), Georgia	5.0	4.1	130	123	86	0.57	0.31	Biological nutrient removal with added ferric chloride followed by membrane bioreactor	Thickening, aerobic digestion and dewatering
Lone Tree (Arapahoe County) Colorado	2.4	1.6	Daily 50	40	30	0.64	0.53	Ferric chloride membrane bioreactor using Zenon membranes	Aerobic digestion and dewatering
Walton, New York	1.6	1.1	150		46		0.76	Activated sludge with coagulant addition followed by dual stage Dynasand filtration	Aerobic digestion and dewatering
Iowa Hill (Breckenridge), Colorado	1.5	0.8	Daily 50, annual 225 lbs	9	8	1.01	0.93	Activated sludge with bio-P, BAF, Densadeg with alum, Dynasand filtration	None
Pinery, Colorado	1.0	0.6	Month 50, daily 100, annual 150 lbs	29	31	0.40	0.41	5-stage Bardenpho, Trident process with alum (adsorption clarification, multimedia filtration)	Holding basins, dewatering and air drying
Stamford, New York	0.5	0.4	200		20		0.96	Activated sludge with coagulant addition followed by dual stage Dynasand filtration	Aerobic digestion and dewatering

Table 2 summarizes the pilot testing results at the RPWRF and indicates that 20 µg/L is probably the best any filtration or membrane technology can achieve. Small full-scale facilities indicate that 30 to 40 µg/L are more likely the best effluent concentrations achievable with current filtration or membrane technologies for full-scale facilities. The best years for Rock Creek indicate that 50 to 60 µg/L may be achievable with conventional multimedia effluent filters. The effects of plant size and solids processing are significant unknowns that could affect the ability of plants of substantial size to achieve very low levels of total phosphorus. Nonideal conditions, partial failures of large numbers of parallel process units and human challenges of operating larger systems with large numbers of parallel process units could reduce the ability of larger WWTPs to reliably achieve extremely low concentrations of total phosphorus. Anaerobic digestion may release phosphorus changing chemical requirements or create chemical forms of phosphorus that are not removed by chemical reaction and affect phosphorus removal when attempting to achieve extremely low effluent concentrations.

TABLE 2
Summary of Fall 2005 RPWRF Phosphorus Removal Technology Pilot Testing

Technology	Final Effluent Log Normal Average Total Phosphorus (µg/L)	Coefficient of Variation of Final Effluent Total Phosphorus (µg/L)
US Filter MicroflocTrident	18	0.47
Parkson DynaSand D2 Filtration	16	0.35
Zenon Membrane Filtration	16	0.46

At this time, the lowest demonstrated effluent total phosphorus limit for plants of substantial size (>2.5 mgd) is 100 µg/L based on using a seasonal discharge limit. This limit has been achieved by Rock Creek, Durham, one of two years for Alexandria and one of two years at Cauly Creek. Rock Creek and Durham had effluent total phosphorus limits of 70 µg/L for several years prior to 2004 and 2005. Both plants were able to achieve 50 to 60 µg/L to comply with this effluent limit. However, both of these WWTPs had experience with high levels of phosphorus removal prior to the initiation of these limits and the processes were familiar to plant staff and process control analysts. Phosphorus removal and new wastewater treatment unit processes will be added to all the Spokane River WWTPs. There will be a need to train operations and maintenance staff, learn optimum control strategies and debugging new wastewater treatment unit processes to achieve optimum results. Overly restrictive effluent limits will be counter-productive because they will discourage experimentation to determine how well the new processes can perform for fear of violating NPDES permit limits. Seasonal averaging appears essential to successful compliance at low effluent phosphorus levels since actual plant performance shows a high degree of variability at all plants examined. It may seem counterintuitive, but short-term limits must be substantially higher than the seasonal limits because of the inherent variability of the effluent concentration and fewer results included in the averages for the shorter time periods.

It is likely that concentrations of phosphorus less than 100 µg/L can be achieved at larger plants only by use of more chemicals, better process control, highly trained operators, and state-of-the-art phosphorus removal technology.

It is recommended that longer-term, larger-scale pilot plants be operated to assist in the selection of the phosphorus removal technology that achieves the lowest concentrations of final effluent phosphorus in a cost effective manner. Engineering studies should be conducted using the data from the recently completed pilot studies to evaluate phosphorus removal technologies. Factors including initial capital cost, space requirements and ability to fit on available site area, chemical requirements, operation and maintenance issues and final effluent phosphorus concentration should be evaluated to determine one or two technologies for additional pilot testing. It is recommended that the pilot test be approximately 1 mgd and continue for a period of 1 year. A final engineering evaluation should be conducted to determine the phosphorus removal technology to implement.

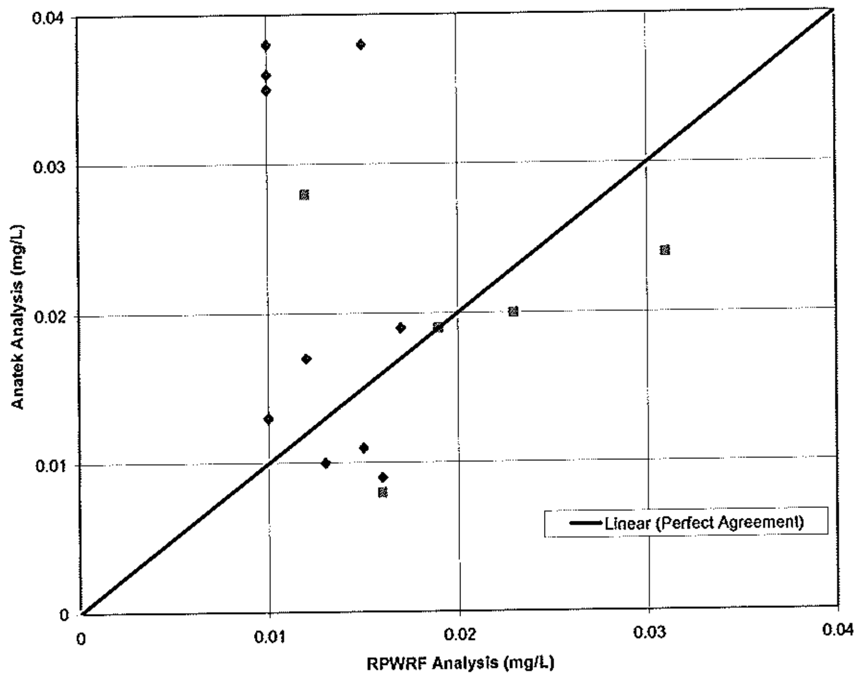
It is recommended that the new facilities be operated for a period of 5 years to establish the final NPDES permit limits for final effluent phosphorus. Issues such as operating large numbers of parallel treatment processes, optimum chemical dosages and operating strategies and the effect of anaerobic digestion can not be determined from pilot testing. This can only be determined from full-scale operation at the WWTPs. It is likely that there will be construction and startup issues that will affect the first year of operation and it is unlikely that optimum phosphorus removal will be achieved. The next 2 years would provide the opportunity to experiment with different strategies to optimize performance. The final 2 years would provide the opportunity to operate using agreed upon strategies to determine the lowest feasible final effluent phosphorous concentrations and this data would be used to establish final NPDES limits.

Analytical Considerations

RPWRF and an accredited private local laboratory in the Spokane area split samples for analysis of total phosphorus during the pilot testing of phosphorus removal technologies at the RPWRF. The results of the laboratory analyses are shown in Figure 1. The individual measurements are shown as points on the graph. The straight line represents perfect correlation between the measurements made by the two laboratories. The results varied widely, so much that there is no meaningful statistical correlation of the results. Typical variation was 2-6 µg/L and several samples varied by more than 25 µg/L. As a result, it is important to recognize the challenges of evaluating WWTPs operating at very low effluent concentrations of total phosphorus and complying with very low total phosphorus effluent permit limits.

Analytical quality control is essential to obtain reliable laboratory results at very low concentrations. The quality of the total phosphorus concentrations in the data used for this analysis is unknown and the uncertainty level in individual measurements is potentially similar in magnitude to the desired effluent total phosphorus concentration. It is more of a challenge for smaller WWTPs to achieve the necessary level of quality control with laboratory staff that may have less training and fewer resources to conduct the laboratory analysis. The RPWRF experience indicates that even two highly skilled laboratories can measure very different concentrations of phosphorus in the same sample.

Figure 1. Analytical Phosphorus Measurement



RPWRF laboratory staff determined that the quantitation limit for total phosphorus was 5 µg/L. This is the lowest concentration that can be measured with the phosphorus analysis technique used by RPWRF and is comparable to the best several universities can measure. This creates some uncertainty about the data for the Iowa Hill (Breckenridge, Colorado) WWTP that has a substantial amount of data between 1 and 10 µg/L.

Las Vegas, Nevada

The City of Las Vegas operates a 91-mgd advanced treatment plant that combines an older plant with a relatively new (May 2003) biological nutrient removal facility (BNR). The process includes multiple parallel trains with trickling filters, activated sludge, effluent filters and the new BNR facilities. The older treatment plant consists of trickling filters, nitrification activated sludge, and effluent filtration. Chemical phosphorus removal was practiced at the older plant with chemical addition (ferric) prior to primary clarification. The new BNR facility started operation in May 2003 and treats 30 mgd of the total plant flow. The BNR effluent is combined with the old treatment system prior to effluent filtration.

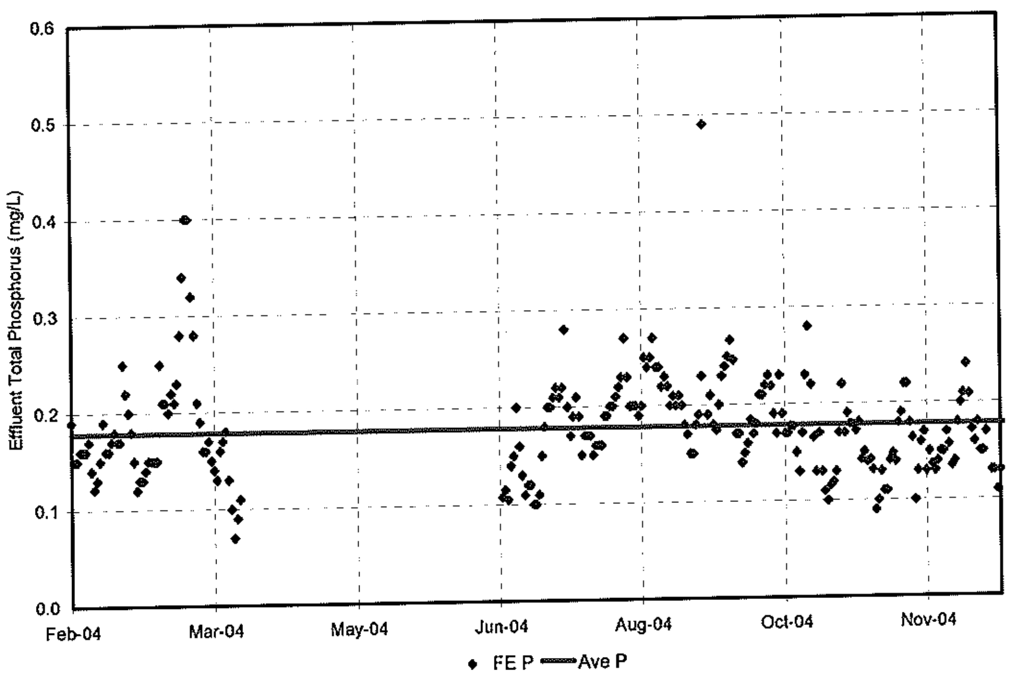
The relatively new (May 2003) biological nutrient removal facility consists of four 7.5-mgd activated sludge process trains with three anaerobic zones, three anoxic zones, and a complete mixed aerobic zone. The aerobic zone is designed as a racetrack with mixers moving the liquid around the basin. Primary clarification is available with ferric feed as an option, mainly used for odor control at low doses.

The solids processing system consists of gravity thickening of primary sludge, centrifuge thickening of waste activated sludge, anaerobic digestion, dewatering and truck hauling of biosolids.

The City of Las Vegas plant discharges into the Las Vegas Wash, which ultimately flows into Lake Mead and the Colorado River. Seasonal phosphorus and ammonia limits apply to the plant. The mass load allocation to the Las Vegas Wash is shared with two other wastewater plants: Clark County and the City of Henderson. As flow increases, the effluent concentration limit decreases. Summer and winter effluent limits for phosphorus at 91 mgd are 0.17 mg/L (126 lbs/day). The summer (March through October) effluent ammonia nitrogen limits are 0.48 mg/L (366 lbs/day) and the winter (November to March) limits are 0.56 mg/L (427 lbs/day).

Daily Las Vegas plant effluent phosphorus data was reviewed from February 1 to December 23, 2004 and from January 1 to July 9, 2005. This data is shown graphically in Figures 2 and 3. The log normal mean of the daily effluent data for 2004 was 0.179 mg/L and for 2005 was 0.152 mg/L.

Figure 2. 2004 Las Vegas WWTP Effluent TP



Alexandria, Virginia

Alexandria, Virginia is a 54-mgd WWTP. Phosphorus removal is accomplished by ferric chloride addition prior to the primary clarifiers, ferric chloride addition following activated sludge ahead of the secondary clarifiers, alum addition prior to chemical clarifiers and multimedia filtration. Solids are processed by pasteurization, anaerobic digestion and dewatering. Daily total phosphorus in the final effluent data for 2003 and 2004 are shown in Figures 4 and 5 along with the log normal average for each year. Final effluent total phosphorus averaged 134 and 88 µg/L well within the permit limit of 180 µg/L for a monthly average. The effluent total phosphorus in 2004 is much lower than in 2003 and there is less daily variation.

Figure 3. 2005 Las Vegas WWTP Effluent TP

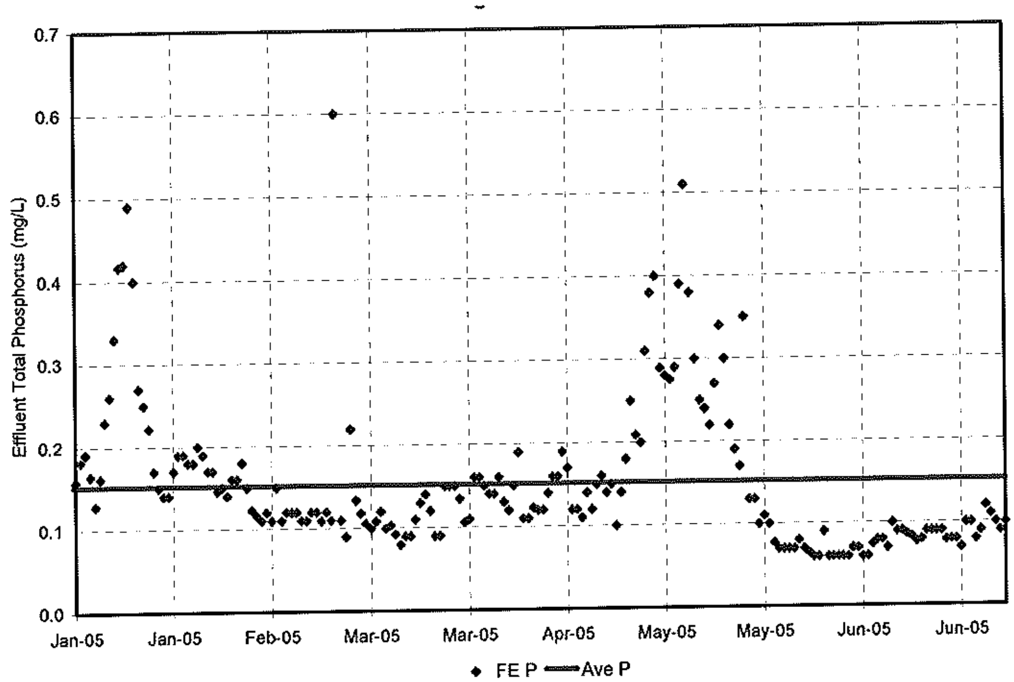


Figure 4. 2003 Alexandria, Virginia Effluent Phosphorus

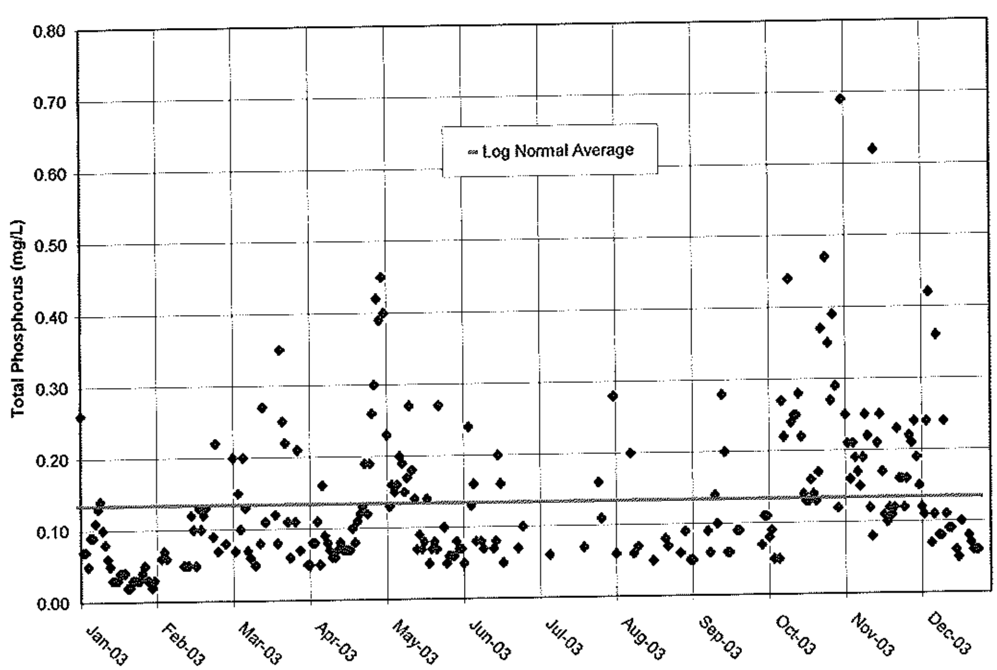
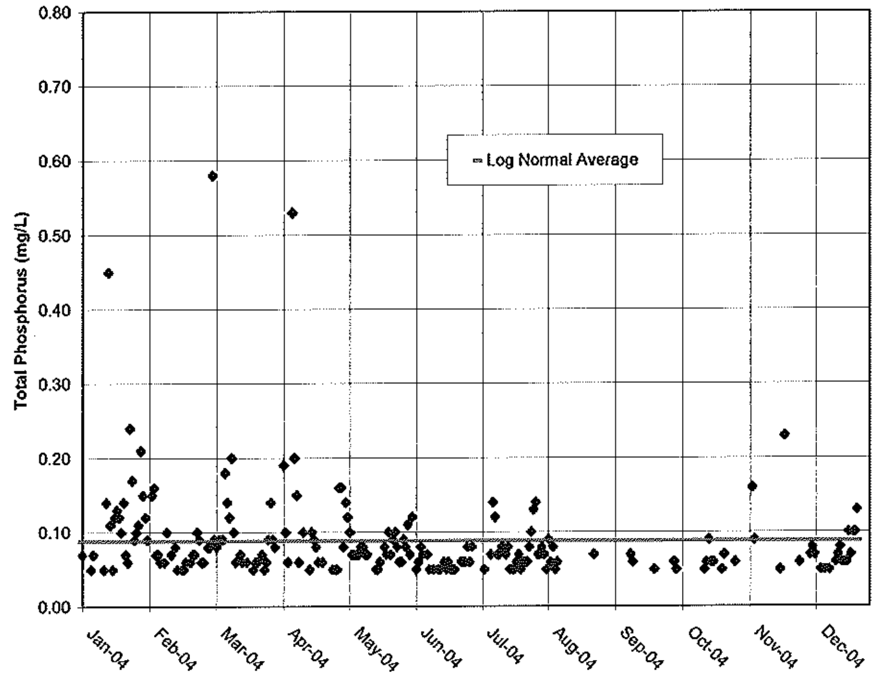


Figure 6. 2004 Alexandria, Virginia Effluent Phosphorus



Rock Creek, Oregon

Rock Creek WWTP has a capacity of 34 mgd. It is operated by Clean Water Services and serves the Hillsboro area west of Portland. Phosphorus is removed by alum addition to the primary clarifiers, alum addition followed by chemical clarification and alum addition followed by multimedia filtration. Solids are processed by anaerobic digestion and dewatering. Daily total phosphorus in the final effluent for years 2004 and 2005 is shown in Figures 6 and 7 with the log normal average for the phosphorus removal season which runs from May to November. Effluent total phosphorus is higher in 2004 than 2005, but was fairly consistent. Effluent total phosphorus was less than the seasonal average of 100 µg/L.

Average effluent total phosphorus is higher in 2004 and 2005 compared to 2001 through 2003 when log average effluent total phosphorus was 48 to 57 µg/L. The NPDES limits for phosphorus were relaxed from 70 µg/L to 100 µg/L and apparently the WWTP is able to reduce chemicals and reduce the phosphorus removal efficiency. The daily data show periods where total effluent phosphorus is 25 to 50 µg/L, but there are other periods when total effluent phosphorus is much higher. With this data, it is not possible to conclude what the minimum effluent concentration of total phosphorus would be if the NPDES permit limits for total phosphorus were lower.

Figure 6. 2004 Rock Creek, Oregon Effluent Phosphorus

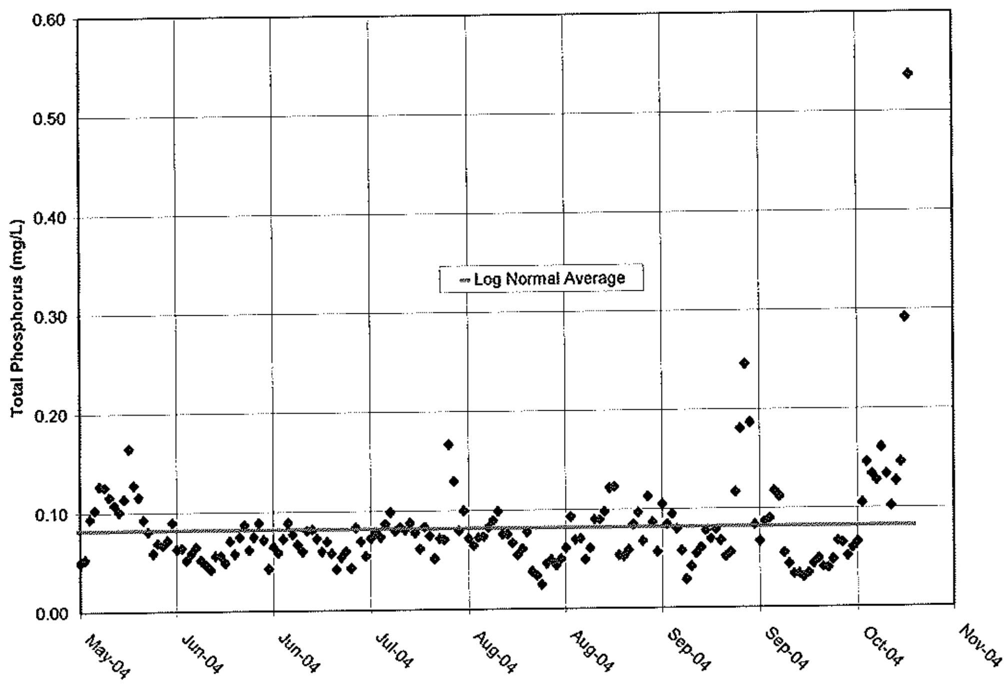
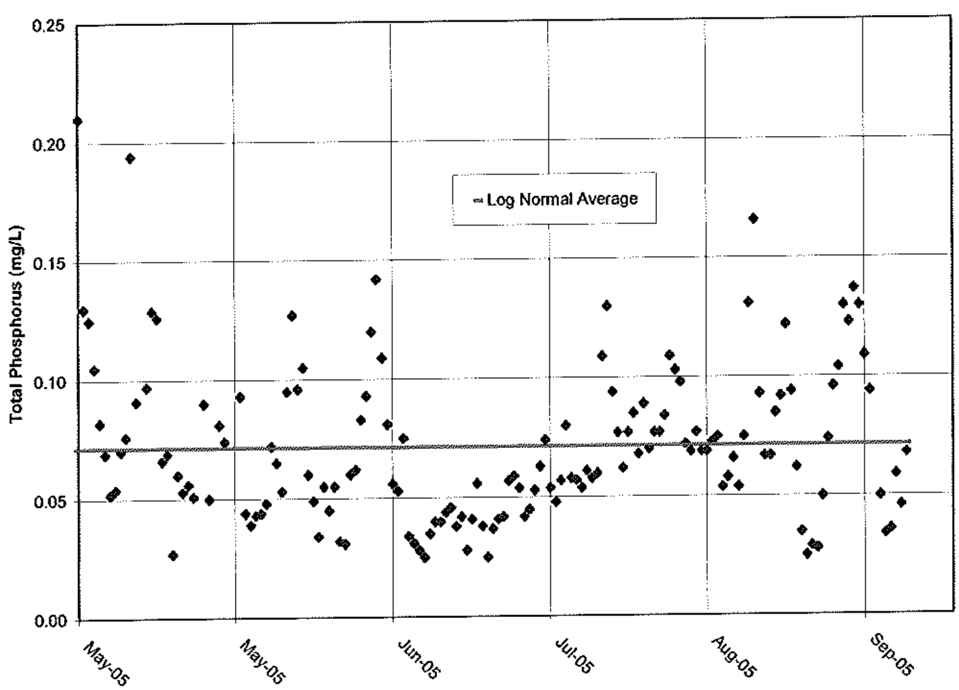


Figure 7. 2005 Rock Creek, Oregon Effluent Phosphorus



Durham, Oregon

The Durham facility located in Tigard, Oregon is operated by Clean Water Services of Washington County (District). The plant was designed to operate as a biological phosphorus removal plant in either UCT or A^2O mode and typically operated in A^2O. Alum can be added upstream of the primary, secondary, and tertiary treatment processes to meet the seasonal total phosphorus limit.

The biological nutrient removal process follows screening, grit removal, and primary clarification. Lime is added for alkalinity control. Denitrification is practiced to recover alkalinity and oxygen but there is no total nitrogen control requirement in the effluent discharge permit. The tertiary process consists of chemical clarifiers using alum and polymer, followed by sand media filters. Sodium hypochlorite is used for disinfection and sodium bisulfate is used for dechlorination.

Primary sludge is fermented in a two-stage fermenter/thickener, and volatile fatty acids (VFAs) are elutriated and returned to the secondary treatment process. Waste-activated sludge and chemical sludge are thickened using centrifuges. Primary, waste activated and chemical sludges are anaerobically digested and centrifuge dewatered prior to land application. Dewatering centrate is returned to the primary effluent pump station upstream of the aeration basins. Ferric can be added to the anaerobic digester feed for odor and struvite control.

The Durham plant discharges to the Tualitin River and operates under a watershed NPDES discharge permit that includes multiple treatment plants. Discharge permit limits are seasonal and the plant is required to remove phosphorus and ammonia nitrogen (nitrification) between the months of April and November. During the summer months, the plant must an effluent phosphorus concentration of 0.110 mg/L and an effluent ammonia nitrogen concentration of 1 mg/L on a monthly median basis.

Daily Durham plant effluent phosphorus data was reviewed from May 10 to October 20, 2004 and from May 9 to July 29, 2005. The data is shown graphically in Figures 8 and 9. The log normal mean of the daily effluent data for 2004 was 0.102 mg/L and for 2005 was 0.073 mg/L.

The solids process consists of waste solids thickening with a membrane sludge thickener, followed by aerobic digestion, and centrifuge dewatering of digested sludge.

Cauley Creek, Georgia

The Cauley Creek Wastewater Reclamation Facility is located in North Fulton County, Georgia and consists of nitrification, denitrification, and both biological and chemical phosphorus removal. The treatment process consists of preliminary treatment with screening and grit removal, followed by secondary treatment with pre-anoxic, anaerobic and aerobic sequences for nitrogen and phosphorus removal and membrane biological reactor (MBR) for liquid and solids separation, and UV disinfection. A ferric dose of 15 to 20 mg/L is added before the flow reaches the MBR tank for chemical enhanced phosphorus to meet the effluent total phosphorus limit.

Figure 8. 2004 Durham AWWTP Effluent TP

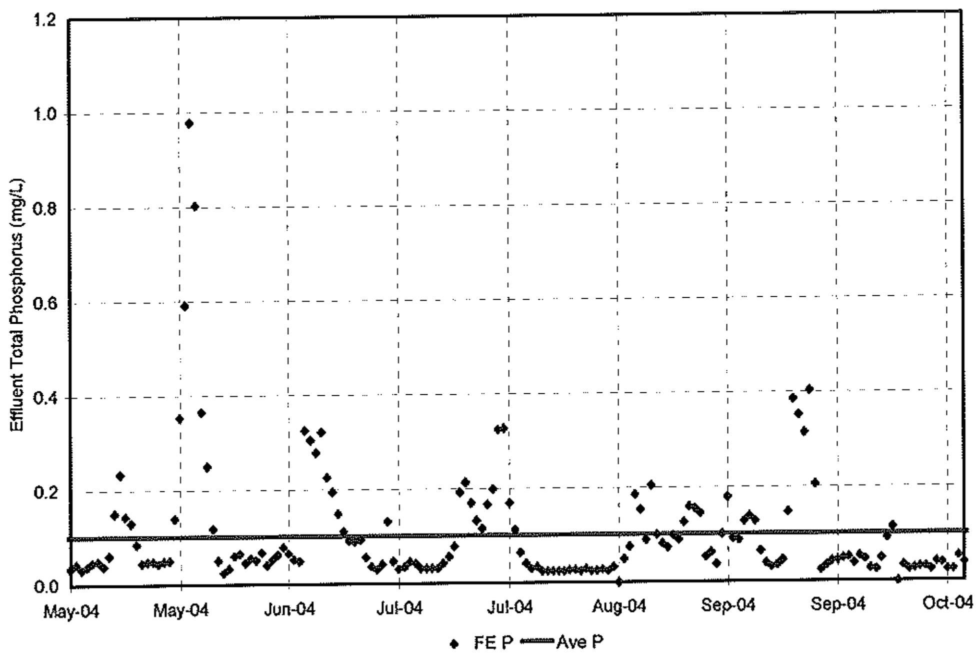
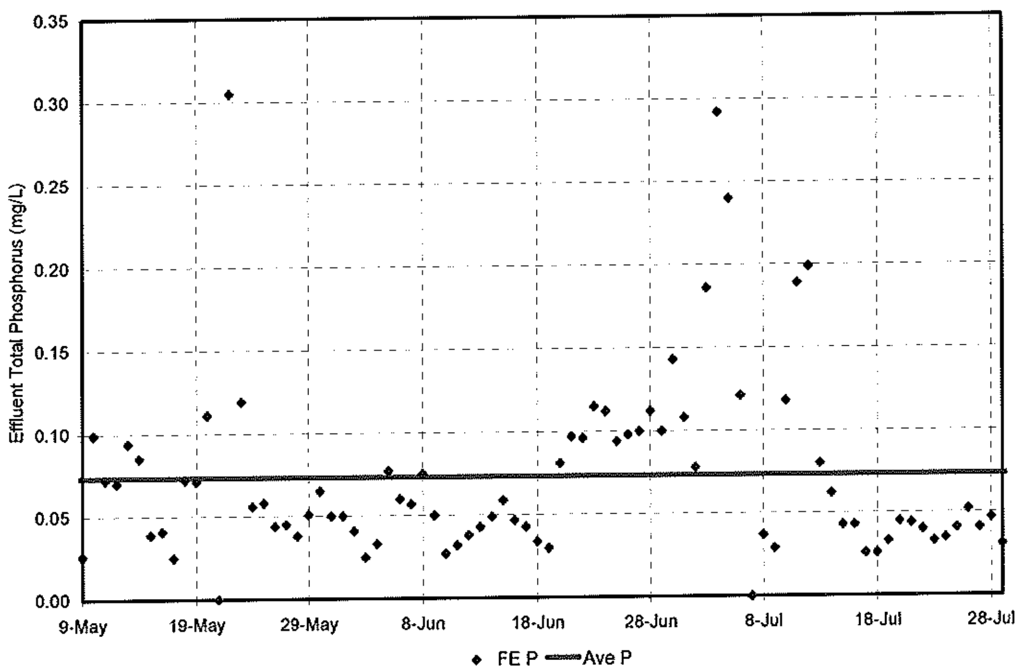


Figure 9. 2005 Durham AWWTP Effluent TP



Fulton County sells much of the reclaimed wastewater from the Cauley Creek plant for reuse to local customers, such as golf courses. Unsold treated wastewater is either used to irrigate on-site hayfields or stored on-site in effluent holding ponds. During the cold weather season, the facility can discharged treated effluent to Cauley Creek, a tributary to the Chatahoochee River. Effluent discharge requirements for total phosphorus are

<0.13 g/L. There are also effluent requirements for turbidity (<0.5 NTU), BOD (<2.9 mg/L), TSS (<5 g/L), total nitrogen (<10 mg/L), and ammonia nitrogen (<0.5 mg/L).

Daily Cauley Creek plant effluent phosphorus data was reviewed from September 10 to December 31, 2004 and from January 20 to January 31, 2005. This data is shown in Figures 10 and 11. The log normal mean of the daily effluent data for 2004 was 0.123 mg/L and for 2005 was 0.086 mg/L.

Figure 10. 2004 Cauley Creek Effluent TP

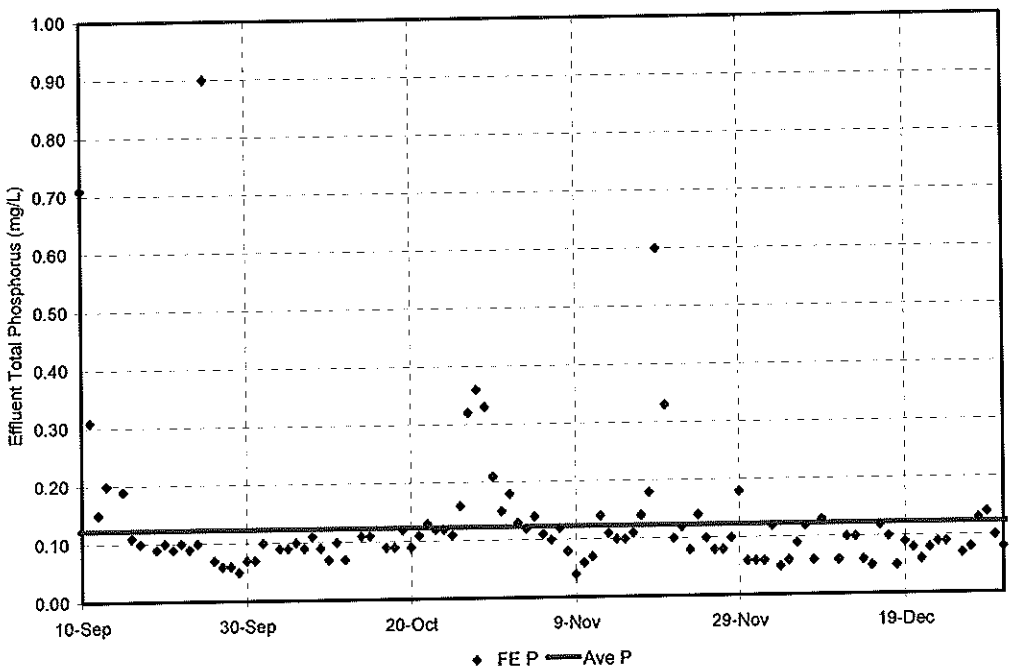
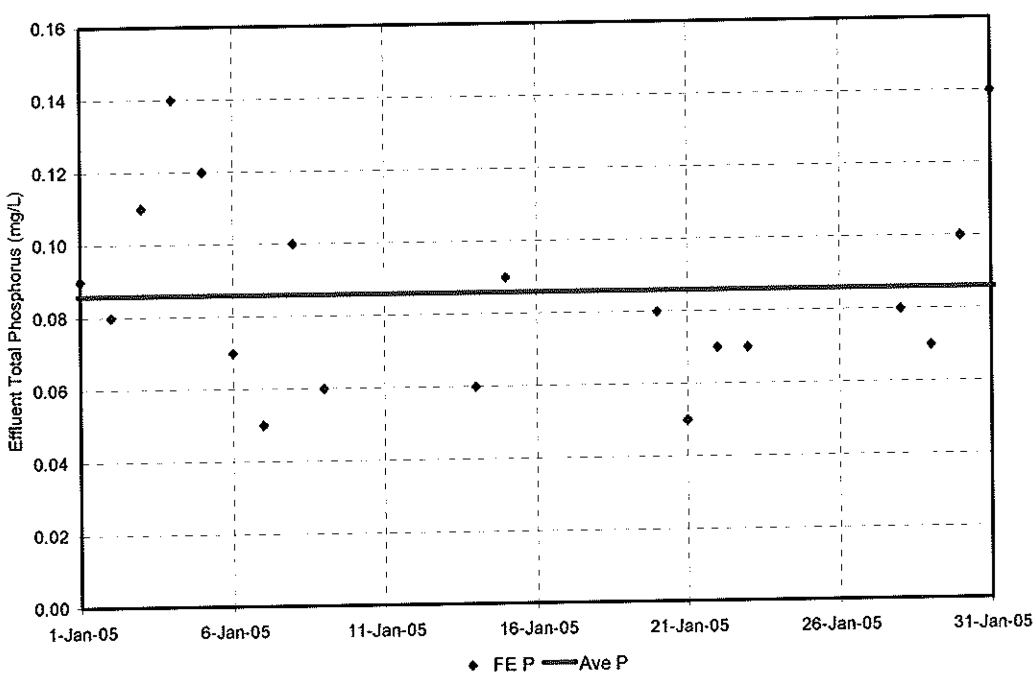


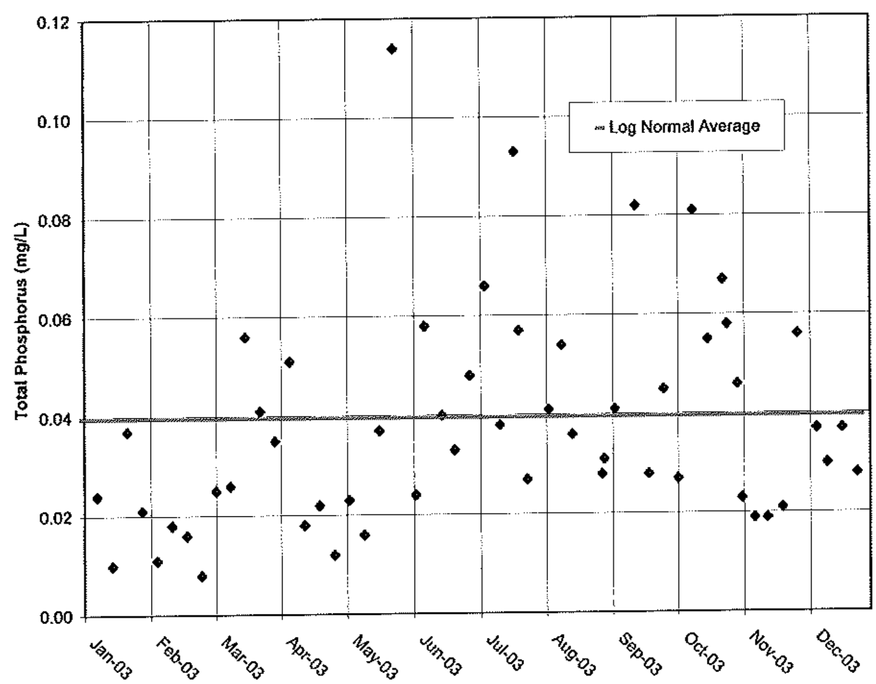
Figure 11. 2005 Cauley Creek Effluent TP



Lone Tree, Colorado

Lone Tree WWTP has a capacity of 2.4 mgd. It serves Arapahoe County Colorado in the Denver area. Zenon membranes in a bioreactor activated sludge process using ferric chloride to precipitate phosphorus are used for phosphorus removal. Solids are processed using aerobic digestion and dewatering. Effluent total phosphorus in 2003 and 2004 are shown in Figures 12 and 13. Effluent total daily phosphorus limit is reportedly 50 µg/L. Total effluent phosphorus log normal average concentration was 40 µg/L in 2003 and 30 µg/L in 2004. Daily results frequently exceed 50 µg/L. Lone Tree is a small WWTP and the effluent sampling frequency is once per week. There are periods of time where final effluent total phosphorus is 20 µg/L or less, but there are other times when the total phosphorus is much higher.

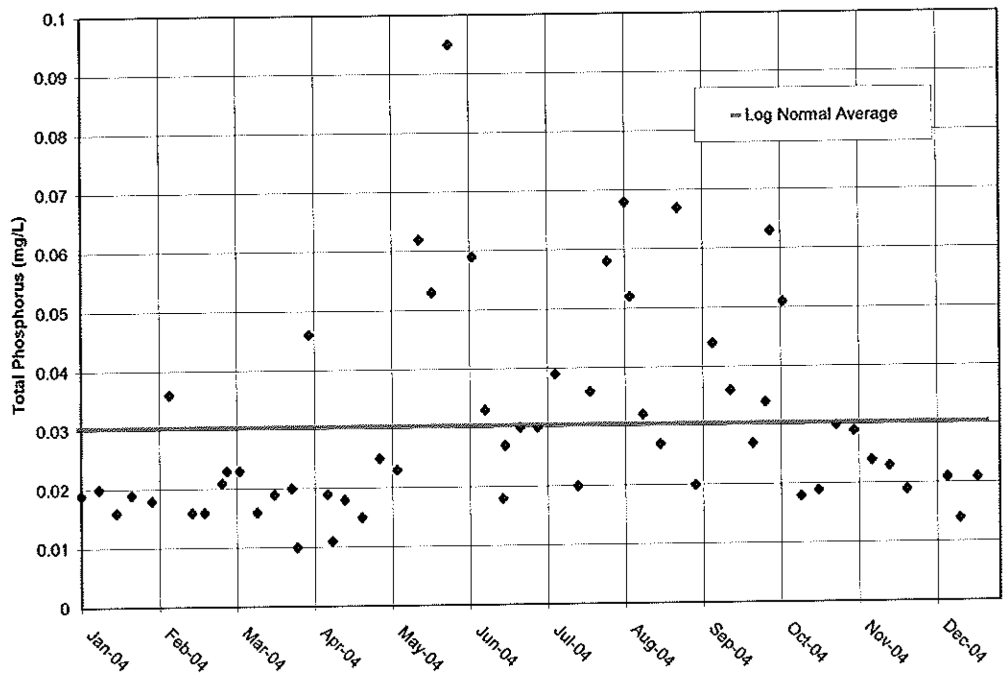
Figure 12. 2003 Lone Tree (Arapahoe County), Colorado Effluent Phosphorus



Walton, New York

The Village of Walton facility is an activated sludge treatment plant with dual sand filtration of the secondary effluent. The dual sand process uses two Parkson DynaSand™ continuous backwash upflow filters in series. The first filter is approximately 2 meters in depth and uses coarse sand media. The second filter is approximately 1 meter in depth and uses fine sand media. A coagulant is added before the first stage filter to precipitate soluble phosphorus and a lamella settler is used to capture solids between stages and improve process throughput. A variety of coagulants have been used in this process including PASS®

Figure 13. 2004 Pine Tree (Arapahoe County), Colorado Effluent Phosphorus



(Poly-aluminum-silicate-sulfate), manufactured by Handy Chemical (now Eaglebrook, Inc.). The plant has an influent equalization basin and chlorine disinfection of the effluent.

Waste solids are aerobically digested, dewatered in a belt filter press, and landfilled.

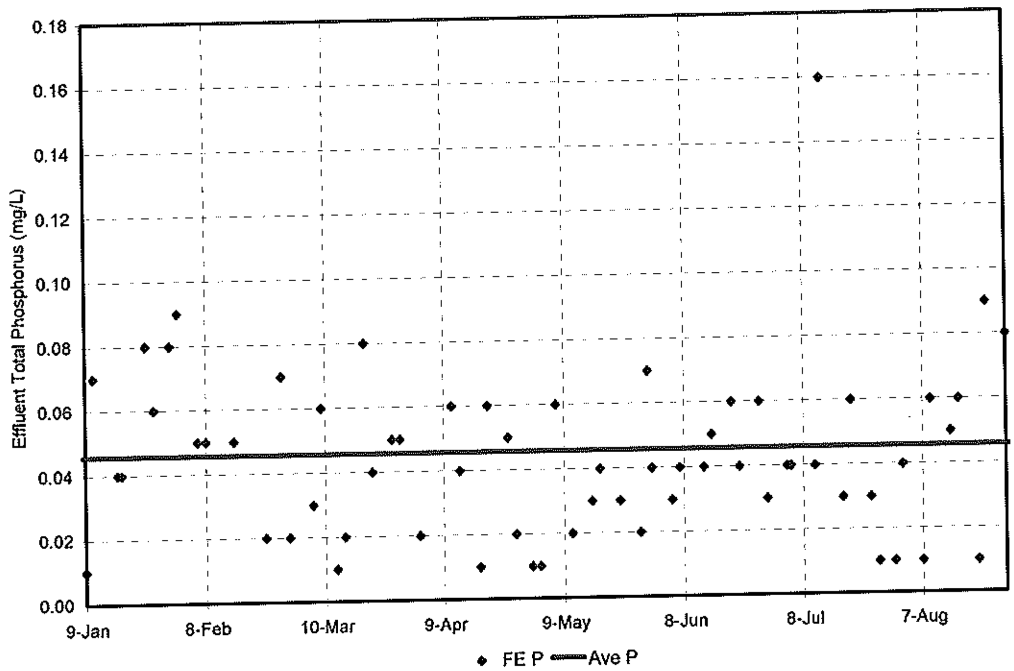
The Walton plant discharges to the New York City watershed where effluent phosphorus limits are between 1.0 mg/L and 0.2 mg/L depending upon plant flow. The Walton permit was recently revised to lower the monthly average phosphorus limit to 0.15 mg/L, based on a 24-hour composite sample taken once a week, in order to increase permitted flows to 1.55 mgd. There is also a mass loading limit for phosphorus of 1.95 lbs/day which was based on the historically permitted flow rate of 1.17 mgd and an effluent limit of 0.2 mg/L.

Walton plant effluent phosphorus data taken weekly from January 9 to August 28, 2005 was reviewed and are shown in Figure 14. The log normal mean of the weekly effluent data for 2005 was 0.046 mg/L. The effluent data ranged from 0.01 to 0.49 mg/L in 2005.

Iowa Hill, Colorado

The Iowa Hill WWTP has a design capacity of 1.5 mgd. It serves the Breckenridge area. Phosphorus removal is accomplished in three steps. First, phosphorus is removed biologically using activated sludge with an anaerobic zone. Then phosphorus is removed using alum with chemical clarification in proprietary process known as the Densadeg process. Settled solids are recirculated in the Densadeg process. The final step is filtration using Parkson Dynasand effluent filters. Solids are not processed at the WWTP as they are sent to another WWTP for processing.

Figure 14. 2005 Walton WWTP Effluent TP



Figures 15 and 16 show daily and log normal average final effluent total phosphorus in 2003 and 2004. The average in both years is reported to be less than 10 µg/L. As discussed earlier, the large number of laboratory observations less than 10 µg/L is in apparent conflict with RPWRF laboratory experience and Iowa Hill laboratory procedures should be reviewed in detail before the results are accepted as fact.

Pinery, Colorado

The Pinery WWTP has a capacity of 1.0 mgd. It removes phosphorus initially using a five-stage biological activated sludge process called the Bardenpho process. The phosphorus is removed using alum in U.S. Filter's Trident process consisting of adsorption clarification followed by multimedia filtration.

Figures 17 and 18 show daily and log normal average final effluent total phosphorus in 2003 and 2004. The average for both years is approximately 30 µg/L. They are easily meeting their NPDES effluent total phosphorus of 50 µg/L for a monthly average and 100 µg/L for a maximum day. The coefficient of variation is low for both years indicating very stable and consistent operation with small variation.

Stamford, New York

The Village of Stamford facility is an activated sludge treatment plant with dual sand filtration of the secondary effluent. The dual sand process uses two Parkson DynaSand™ continuous backwash upflow filters in series. The first filter is approximately two meters in depth and uses coarse sand media. The second filter is approximately one meter in depth

Figure 15. 2003 Iowa Hill (Breckenridge), Colorado Effluent Phosphorus

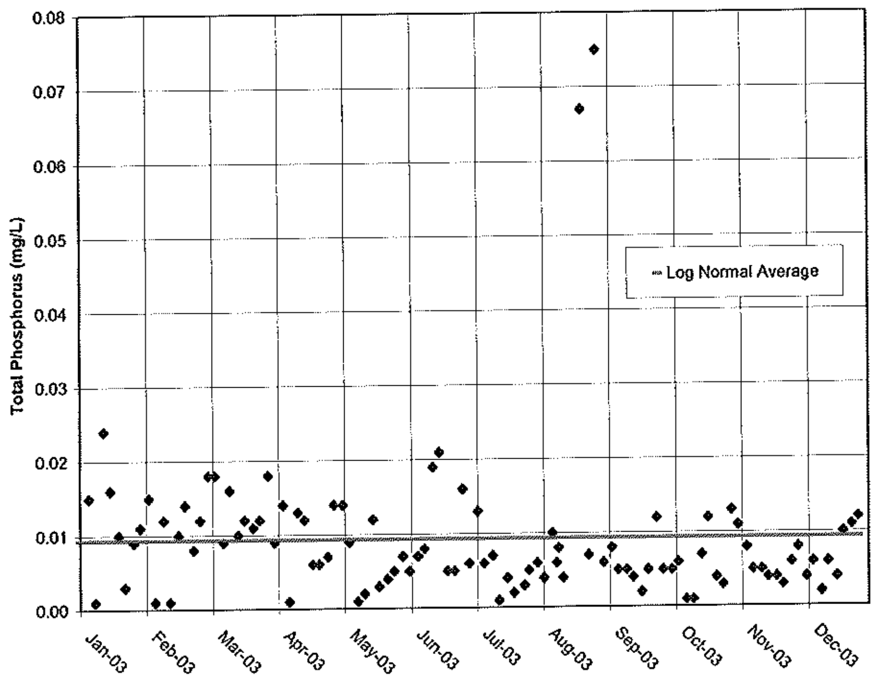


Figure 16. 2004 Iowa Hill (Breckenridge), Colorado Effluent Phosphorus

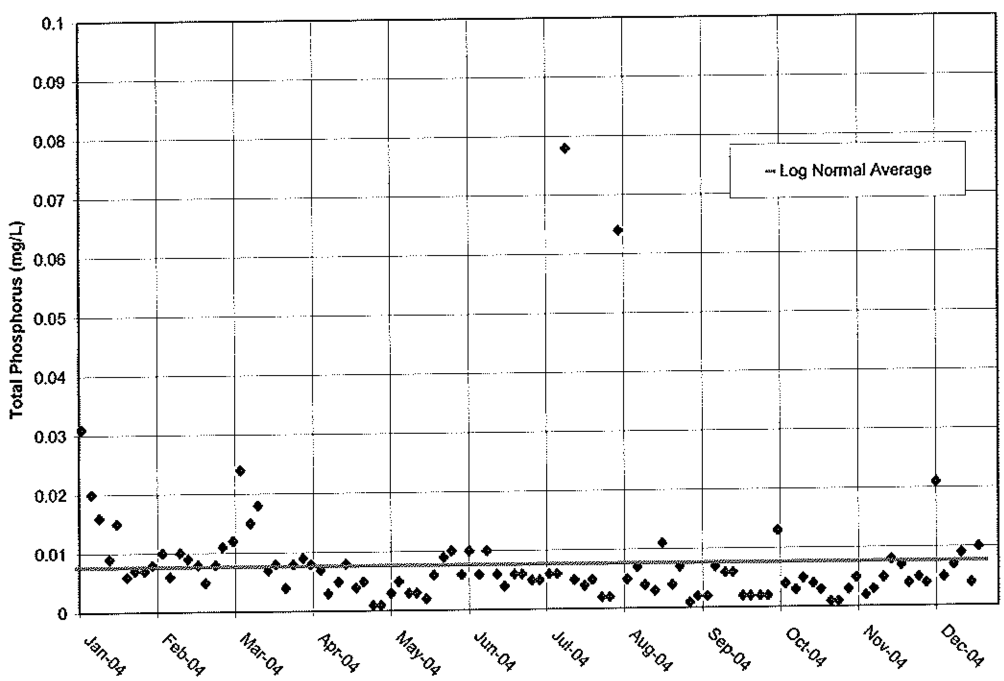


Figure 17. 2003 Pinery, Colorado Effluent Phosphorus

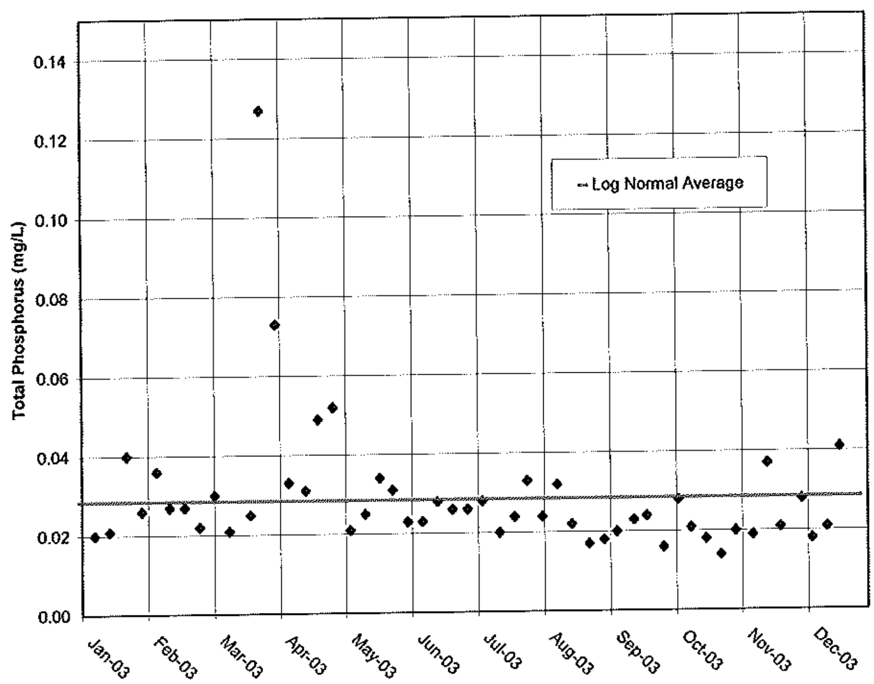
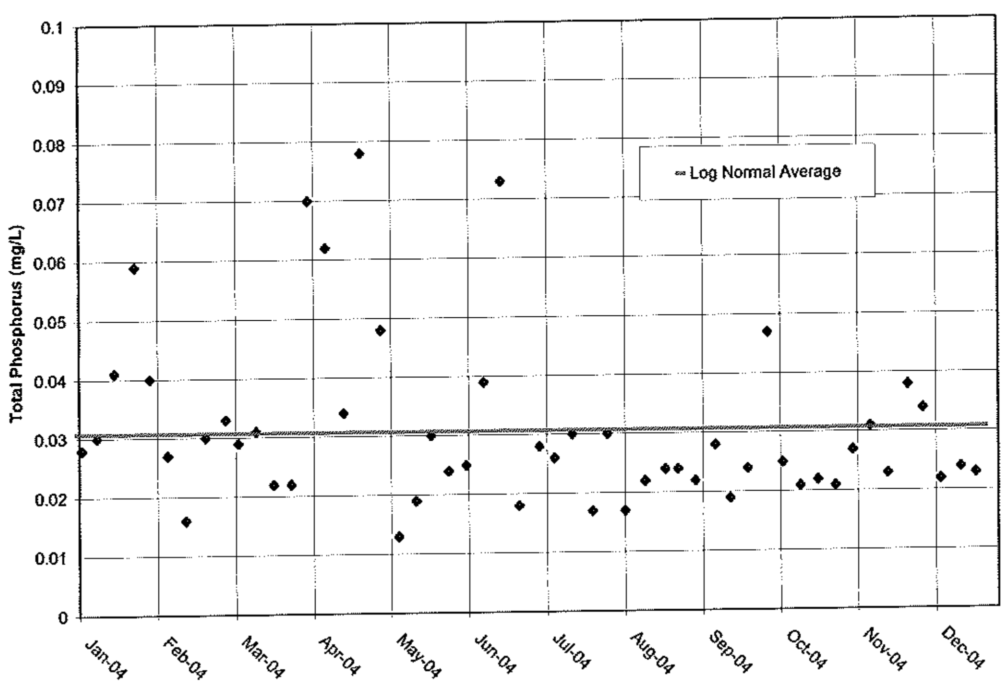


Figure 18. 2004 Pinery, Colorado Effluent Phosphorus



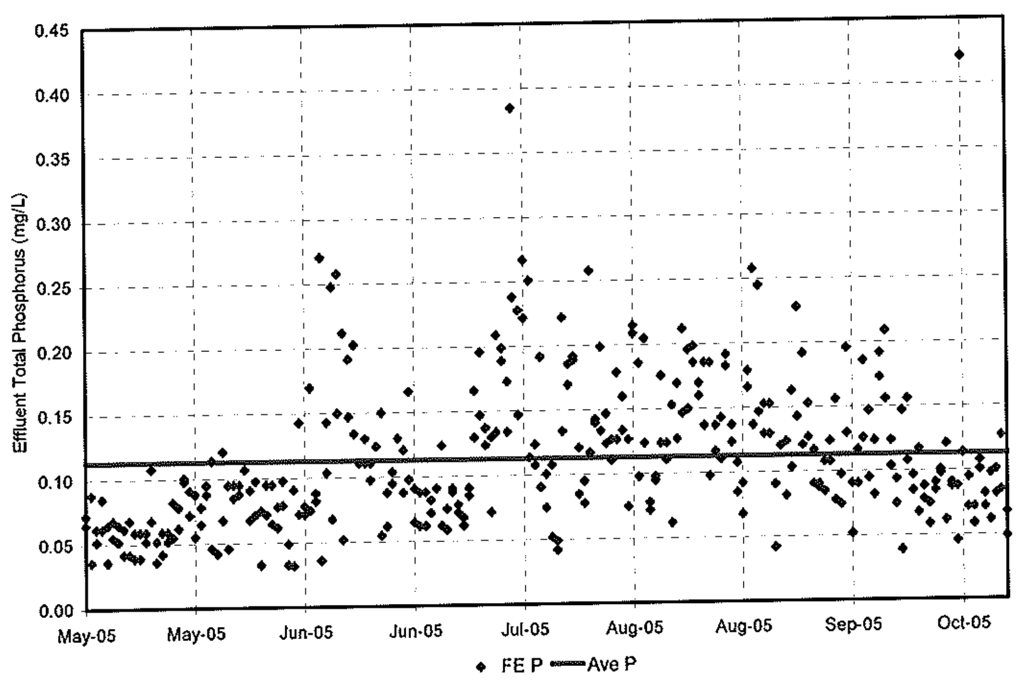
and uses fine sand media. A coagulant is added before the first stage filter to precipitate soluble phosphorus and a lamella settler is used to capture solids between stages and improve process throughput. A variety of coagulants have been used in this process including PASS® (Poly-aluminum-silicate-sulfate), manufactured by Handy Chemical (now Eaglebrook, Inc.). The plant has chlorine disinfection of the effluent.

Waste solids are aerobically digested, dewatered in a belt filter press, and landfilled.

The Village of Stamford plant discharges to the New York City watershed where effluent phosphorus limits are between 1.0 mg/L and 0.2 mg/L depending upon plant flow. The Stamford permit has a monthly average phosphorus limit to 0.20 mg/L, based on a 6-hour composite sample taken twice a month.

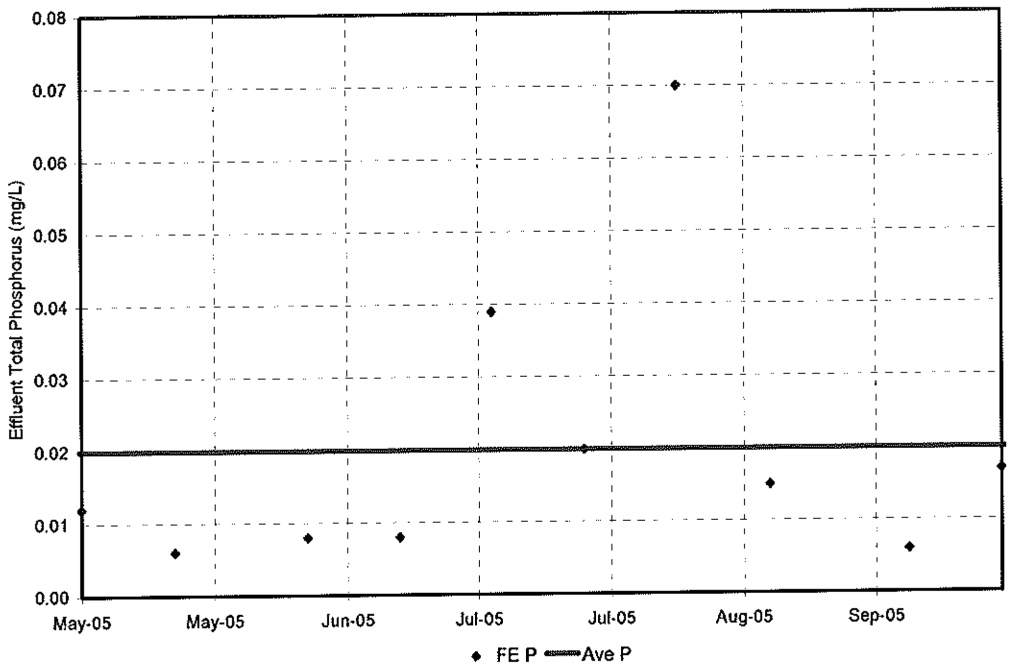
Stamford plant effluent ortho phosphorus data from field test kit analysis of morning and afternoon grab samples taken from May 1 to October 16, 2005 (335 data points) was reviewed and is shown in Figure 19. The log normal mean of the grab sample effluent data for 2005 was 0.113 mg/L. The effluent data ranged from 0.03 to 0.42 mg/L in 2005.

Figure 19. 2005 Stamford WWTP Effluent Ortho-P (AM and PM Grab Samples and Field Tests)



From January through August 2005, the average effluent phosphorus reported by the Stamford plant was 0.015 mg/L based on certified laboratory analysis of the twice monthly 6-hour composite samples. Examination of 10 Stamford data points from May through September from certified laboratory testing of 6 hour composite samples taken twice show a range from 0.006 to 0.039 mg/L. This is shown in Figure 20. The log normal mean of the twice monthly samples from the summer of 2005 was 0.02 mg/L. These values for total phosphorus are significantly lower than the orthophosphate values from the field test kit grab samples.

Figure 20. Stamford WWTP Effluent TP (Lab Samples)



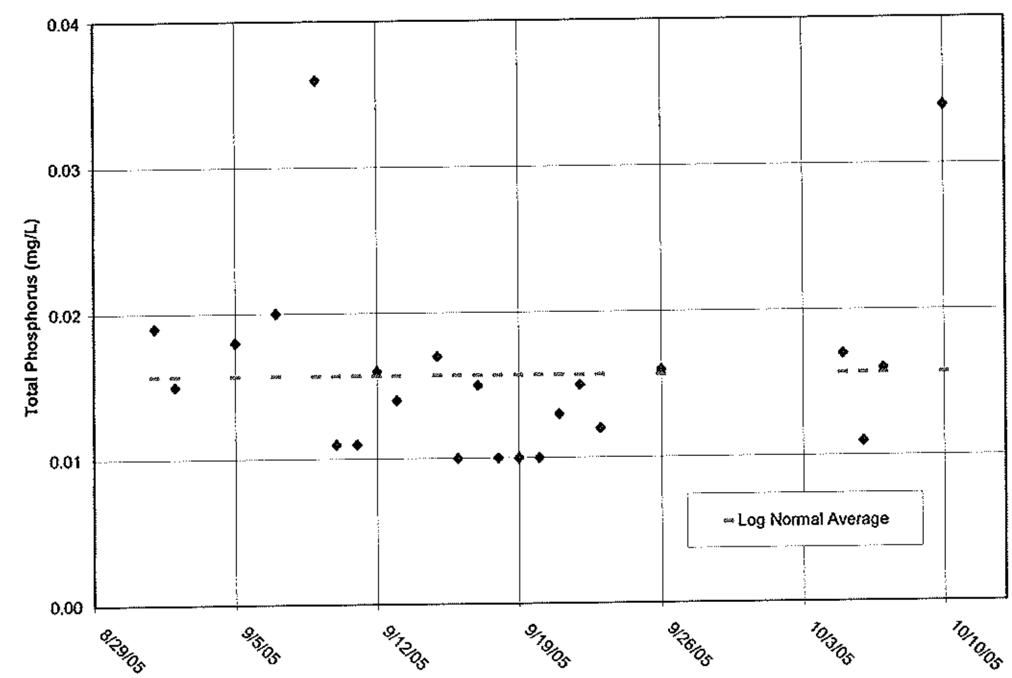
Fall 2005 RPWRF Phosphorus Removal Technology Pilot Testing

Pilot testing of phosphorus removal technologies was conducted in September and October of 2005 at the RPWRF operated by the City of Spokane. Parkson Dynasand D2 filtration, US Filter Microfloc Trident and Zenon membrane filtration each operated pilot facilities for approximately 1 month each. These technologies were previously identified as having the potential to achieve the lowest total phosphorus in the final effluent. Final effluent phosphorus was analyzed by the RPWRF laboratory and some samples were split with Anatek, a privately owned laboratory in the Spokane area.

Parkson Dynasand D2 filtration consists of alum precipitation of phosphorus followed by filtration by two Parkson continuous backwash sand filters operated in series. The first stage filter uses larger sand grain size than the second stage filter. It has been applied in New York state and reportedly can reduce total phosphorus to as low as 10 µg/L. Figure 21 summarizes the pilot test results of the Parkson Dynasand D2 filtration technology. The log normal average of all the data is 16 µg/L. Some of the individual data were as low as 10 µg/L and a couple were greater than 30 µg/L. Pilot testing was conducted from September 1 to October 10, 2005 and 24 samples were analyzed.

US Filter Microfloc Trident consists of alum or ferric chloride precipitation of phosphorus followed by an adsorption clarifier. The adsorption clarifier uses plastic beads in an upflow clarifier to flocculate and remove solids. The plastic beads reduce the size of the clarifier. The clarifier is followed by a multimedia conventional filter. Figure 22 summarizes the pilot results for the Trident technology. The log normal average of all the data is 18 μg/L.

Figure 21. Parkson DynaSand D2 Filtration Pilot Effluent Phosphorus



Individual data were as low as 9 μg/L and one was nearly 50 μg/L. Pilot testing results are for the period August 18 to October 7, 2005 and 20 samples were analyzed. Additional pilot testing was conducted late in October 2005, but the results were not available at the time this memorandum was prepared.

Zenon membrane filtration consists of alum precipitation of phosphorus, flocculation and filtration through immersed ultrafiltration membranes. The pores size of the membranes is smaller than suspended solids, pathogenic parasites and ova, bacteria and some virus. Figure 23 summarizes the pilot results for the Zenon technology. The log normal average for all the data is 16 μg/L. Individual data were as low as 8 μg/L and one was greater than 30 μg/L. Pilot testing was conducted from September 26 to October 19, 2005 and 17 samples were analyzed. The pilot testing was ongoing at the time this memorandum was prepared and additional data gathered after October 19 are not included in this evaluation.

Application of Pilot Testing Results to Predict Performance of Full Scale WWTPs

The pilot testing conducted in the fall of 2005 demonstrates the lowest concentrations achievable by state-of-the-art coagulation with metal salts and filtration with sand filters in series, multimedia filters or ultrafiltration membranes. The minimum average total

Figure 22. US Filter Microfloc Trident Pilot Effluent Phosphorus

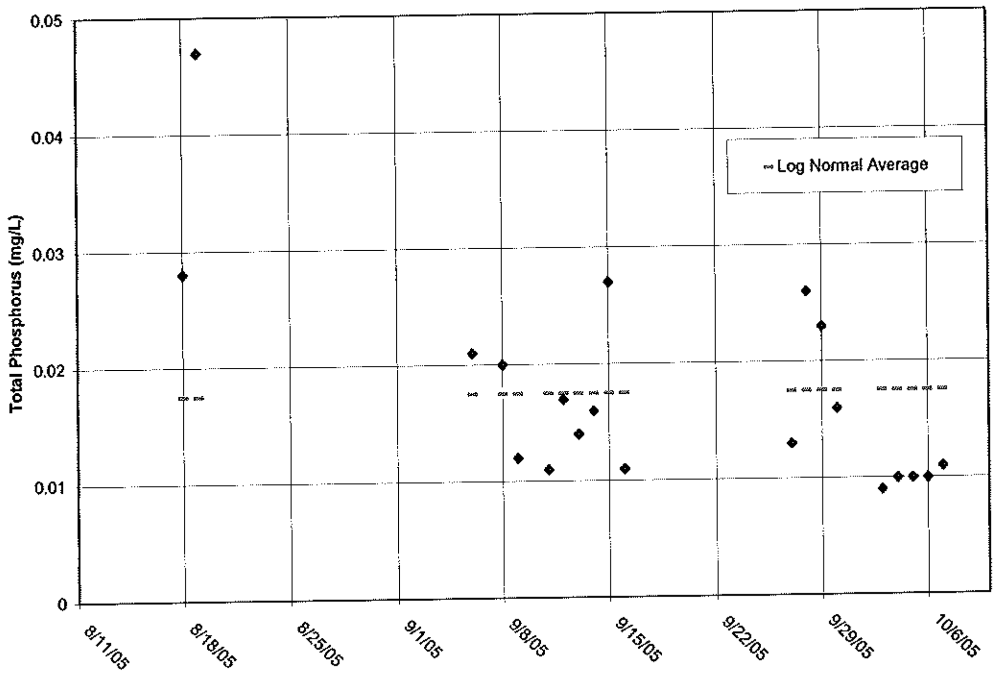
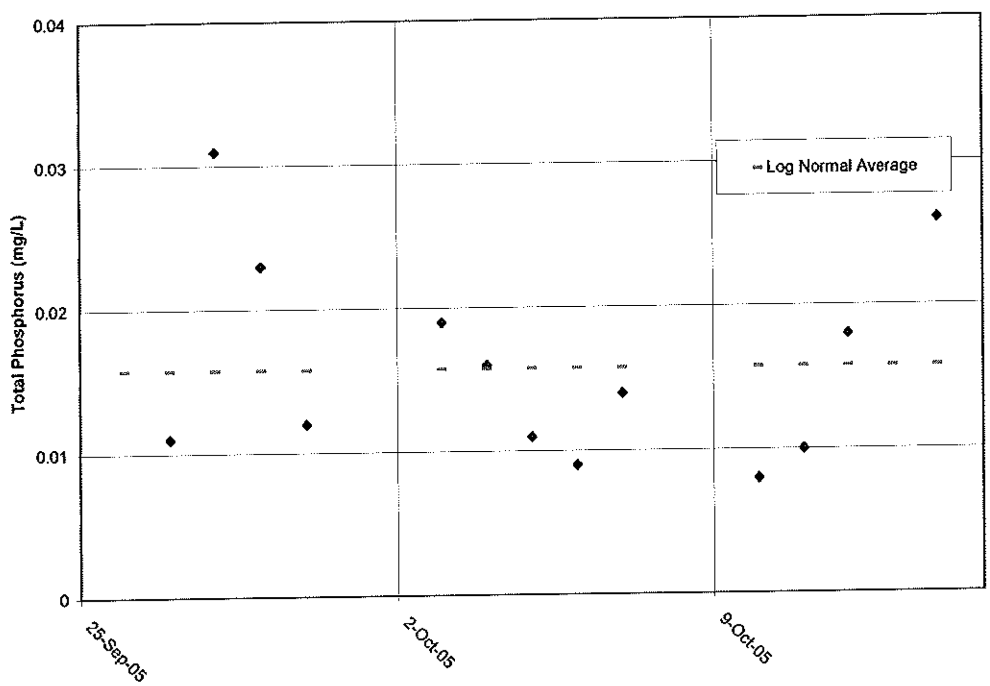


Figure 23. Zenon Membrane Filtration Pilot Effluent Phosphorus



phosphorus concentration appears to be approximately 20 µg/L. All technologies could achieve total phosphorus concentrations of 10 µg/L on occasion, but all had samples much greater than 20 µg/L. These results were achieved over a short period of time using a very small pilot system operated by a highly trained technician with a very high incentive to be successful and no constraints were imposed on the quantity of coagulant chemicals used.

A full-scale facility must achieve results 200+ days per year with greatly varying influent conditions that may challenge standard operating strategies on occasion. Often the cause of poor results will be unknown and the changes to achieve success will also be unknown resulting in periods of operation by trial and error. This will lead to periods of poorer performance that can be observed in the full-scale facility data presented earlier and probably contributes to the variation in performance observed in the pilot testing. This is one reason why the full-scale facility will likely not be able to match the performance of the pilot facilities for at least periods of time.

A full-scale facility will have much larger individual process units and have many parallel trains of these process units. The pilot facility consisted of a single small process unit. A small unit is more likely to have "ideal" characteristics than a larger unit. The larger unit may not perform as well as the smaller unit because of the differences from "ideal" characteristics. In addition, many of these larger units must be operated in parallel. Additional process units increase the potential of a failure or partial failure of an individual unit that can reduce treatment performance. The requirement for multiple parallel process units and the need to respond to major changes in flow due to rainfall or snowmelt adds the potential for human error that can reduce treatment performance. These are additional reasons why a full-scale facility will likely not match the performance of the pilot facilities.

A full-scale facility requires a large number of trained operation and maintenance personnel of varying ability and motivation. A large facility requires 365 day per year, 24-hour-per-day operation and maintenance. There are five different crews needed to perform the operation and a large maintenance crew. The phosphorus removal process is an essential process, but only a part of the overall wastewater treatment plant facility. The level of attention provided by the pilot plant operating technician can not be duplicated by a full-scale facility because the labor costs would be exorbitant. With a large team of people there is inherently variation in skill levels and motivation compared to the pilot plant operating technician who is specifically trained to make the pilot unit perform and has no other duties. This will also contribute to the lower performance of the full-scale facility compared to the pilot facilities.

Last, the full-scale facility will have to treat the entire flow and deal with the recycle streams and impacts from anaerobic digestion that the pilot facility did not need to because it operated only a short time on a small fraction of the total flow. It is impossible to quantify the impact of these effects, but given the very low final effluent total phosphorus concentrations that are desired, small and subtle changes could be significant.

The only way to determine what minimum effluent concentrations of total phosphorus are reliably achievable is to operate the full-scale facilities for a period of time to gather operating data. Pilot testing is valuable for providing data to quantify what is possible with a given technology and to help evaluate competing technologies. The uncertainties associated with scaling up from pilot testing to full-scale operation are greater than the desired final effluent total phosphorus concentration. Therefore, it is recommended that final total phosphorus limits be established after 5 years of full-scale operation using the final 2 years of operation to establish the limits. The first 3 years will be needed to work through the construction and startup issues and to optimize the process so that the next 2 years reflect the best operation possible.

WWTP evaluation by CH2MHill 11-21-05.DOC

Footnote 3

From: Nickel.Brian@epamail.epa.gov
To: Mann.Laurie@epamail.epa.gov; DMOO461@ECY.WA.GOV; John Tindall; Robert Steed; JROS461@ECY.WA.GOV; butler@spokanetribe.com; PHAL461@ECY.WA.GOV; gdar461@ecy.wa.gov; crossley@spokanetribe.com; Cope.Ben@epamail.epa.gov;
cc: Croxton.David@epamail.epa.gov;
Subject: Draft Phosphorus Memo for Agency Discussion
Date: Friday, March 13, 2009 6:43:48 PM
Attachments: DRAFT P Technical Memo 090313.doc

Spokane TMDL Team,

As requested, I've completed a draft memo, in which I attempt to identify an "attainable" phosphorus limit to inform the TMDL process. I provide a range (as opposed to a single number) which is 35 - 50 ppb, as an average monthly limit. I also point out that there are some notable examples of even better performance, but 35 ppb is the lowest number for which I can point to several real-world facilities with lots of available data.

Please read it with a critical eye, and provide me any comments you may have ASAP. I'm sorry the memo is rather long (just a hair over 13 pages without appendices), but unfortunately this is a complex subject that I can't condense to three pages. The goal is to send this and several other work products out to stakeholders by the middle of next week. I wish I could have completed this (and sent it to you all) sooner, and thus given you more time to review it. This version reflects comments from inside Region 10.

Thanks,

Brian Nickel, E.I.T.

Environmental Engineer
US EPA Region 10 | Office of Water and Watersheds | NPDES Permits Unit
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Nickel.Brian@epa.gov
http://epa.gov/r10earth/waterpermits.htm
Please conserve natural resources by not printing this message.

Footnote 4 –

No Document Cited

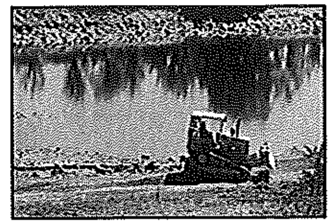
Footnote 5

SPOKESMANREVIEW.COM Tuesday, September 11, 2007

Scientist's departure taints river cleanup plan

Long in the works, state to unveil proposal on Wednesday

James Hagengruber
Staff writer
September 9, 2007



The Washington Department of Ecology is capping three acres of land at the Murray Road site on the Spokane River with one foot of material because of high levels of lead, arsenic, cadmium and zinc.The Spokesman-Review (Holly Pickett The Spokesman-Review)

A multihundred-million-dollar plan aimed at cleaning up the Spokane River and returning life to vast dead zones deep in Long Lake will be unveiled Wednesday.

But the Washington Department of Ecology scientist who spent the last year writing the plan abruptly quit at the end of August, claiming the proposal is scientifically indefensible and will violate state water quality laws.

"I have never authored anything that's not defensible," Drea Traeumer said in a recent interview. "My recommendations on how to proceed defensibly were disregarded."

With her resignation, Traeumer becomes at least the third government scientist involved with river cleanup strategy in recent years to have jumped ship over concerns that the plan is too weak.

News of Traeumer's departure has prompted jitters for city and business officials as they prepare to spend huge amounts of money to meet the plan's requirements. The city of Spokane alone expects to spend nearly a half-billion dollars to more thoroughly purify wastewater dumped into the river.

For environmentalists, Traeumer's exit has become powerful ammunition in an increasingly heated battle for a tougher river cleanup plan. "This is not going to hold up – when the staff itself is raising these red flags," said Rick Eichstaedt, an attorney for the Center For Justice, a Spokane public interest law firm representing the Sierra Club.

At a glance

What's next

Public meeting: The proposed water quality improvement plan for the Spokane River will be explained at a meeting hosted by the Washington Department of Ecology.

When: Wednesday at 6:30 p.m.

Where: Spokane Falls Community College, Student Union Building, 3410 W. Fort George Wright Dr.

Workshop: The Sierra Club will help people understand and comment on the river cleanup plan.

When: Sept. 24 at 6:30 p.m.

Where: Community Building, 35 W. Main St. in Spokane.

Nine years in the making

Fed by rain and snowmelt from the Idaho Panhandle, the Spokane River flows west out of Lake Coeur d'Alene, through Post Falls and downtown Spokane, and eventually into the Columbia River. Each day, about 75 million gallons of treated wastewater – mostly from municipal sewage treatment plants, but also from Kaiser Aluminum and Inland Empire Paper Co. – is dumped into the river. Inland Empire Paper is owned by the same company that owns The Spokesman-Review.

Although the sewage and industrial effluent is treated, it contains a variety of pollutants, including about 200 pounds a day of phosphorus, according to reports from Ecology. Phosphorus acts as a fertilizer for aquatic plants, which has resulted in massive algae blooms – including toxic forms of blue-green algae – downstream in Long Lake, the Spokane River reservoir also known as Lake Spokane. When the algae dies, it sinks and decomposes, sucking oxygen out of the water that's needed by fish and insects for breathing.

To meet federal law and downstream water quality standards of the Spokane Tribe of Indians, the state has spent nine years coming up with a plan to reduce the amount of phosphorus in the river.

A 2004 cleanup proposal from the Department of Ecology would have brought the river into compliance with federal law and was widely supported by environmental groups, but the plan was criticized by cities and factories along the river as being too expensive and likely unreachable. Ecology then began working with polluters – as well as the environmental groups – to come up with an acceptable plan.

Polluting decision

Among the changes was a decision by state and federal agencies to consider water flowing across the Washington-Idaho border as being essentially free of human-caused contaminants, even though the water contains phosphorus from wastewater treatment plants in Coeur d'Alene and Post Falls, said Rachael Paschal Osborn, an environmental activist and Spokane public interest attorney who has been closely involved in the process. The change allowed more pollution to be dumped in Washington.

"Basically, you fiddle with the parameters until you get the answers you want," Osborn said.

Numerous scientists at Ecology and the U.S. Environmental Protection Agency – the federal agency that must approve any state cleanup plan – raised red flags over the proposed changes, saying they would result in a lesser cleanup and were possibly illegal.

EPA engineer Dave Ragsdale, who had been involved in the cleanup plan since 1999, said he told supervisors of his concerns, particularly the cumulative impact of pollution from Idaho. Ragsdale also published a study that refuted the cost concerns expressed by cities and businesses along the river.

Ragsdale, a 30-year veteran of the EPA, is no longer working on the Spokane River cleanup plan. He declined to say why.

"They came up with a new process and I'm not supposed to talk about it," Ragsdale said, adding only, "I have a difference of opinion than the official agency perspective."

Before Traeumer worked as Ecology's lead cleanup plan scientist, the job was held by Ken Merrill, who continues to work for the agency but is no longer involved with the Spokane River. Merrill declined to provide details of his job transfer – "I can't go into it," he said – saying only that he was not formally taken off the job, but that he was no longer invited to participate in the process. "They didn't like the way I was doing it," he explained.

When pressed to elaborate, Merrill said, "I was trying to make it legally, scientifically and technically defensible. Management decided to go a different route from the route we developed."

Traeumer also declined to comment, beyond issuing a statement in which she said the proposed cleanup plan would not be defensible either in court or in scientific journals. Traeumer said she sought the advice of outside scientists before tendering her resignation.

Ecology spokeswoman Jani Gilbert said Traeumer's departure has put the agency in a difficult position.

"You never like somebody to leave nine-tenths of the way through a project," Gilbert said.

But Gilbert denied accusations the plan was flawed.

"It's an excellent water quality improvement plan. We arrived at it with the help of the community in the collaborative process," Gilbert said. "It's not only a good plan, but it's a very legal plan."

As for the issue of polluted water flowing over the state line, Gilbert said that under proposed changes, Idaho contributes roughly 5 percent of the human-caused phosphorus going into the river. "It's almost negligible," she said.

Attorneys with the Center For Justice see it differently. The proposed plan might offer vast improvements for the river, but it doesn't go far enough and doesn't include any enforceable standards for the first 20 years, Eichstaedt said.

"In their zeal to come out with a plan, they don't even care about how legal the plan is," he said. "Close doesn't count. It's not horseshoes or hand grenades."

Center For Justice attorney Bonne Beavers reviewed a draft copy of the plan Friday and was "astonished" by its lack of standards, as well as a provision she said would allow the city of Liberty Lake to discharge additional phosphorus-tainted wastewater into the river.

"My jaw's on the floor," Beavers said. "You can't make it worse while you're trying to make it better. These permits allow them to make it worse. It's crazy."

Both Beavers and Eichstaedt said the proposed plan is not acceptable and would likely be appealed. Concerns expressed by agency scientists could help potential legal challenges, Eichstaedt said. "All of this will be part of the record if and when a judge reviews this. It will be fairly obvious that this approach is simply flawed."

Anxiety for communities

The prospect of lawsuits is prompting some anxiety for communities and factories along the river preparing to invest hundreds of millions of dollars in wastewater purification technology.

"The city has some concerns about how all this plays out in the end," said Lloyd Brewer, environmental program manager for the city of Spokane, which expects to spend at least $400 million on wastewater treatment plant improvements.

"I'm a little uneasy," said Spokane County Commissioner Todd Mielke. The county expects to spend between $100 million and $150 million on a new wastewater treatment plant. Mielke also praised Ecology for attempting to develop a cleanup plan with achievable standards.

Within a decade, the proposed cleanup plan will result in a 95 percent reduction in the amount of phosphorus dumped into the river, said Gilbert, with the Department of Ecology. "If the Center For Justice wants to appeal (the plan), it will just delay improving the river," Gilbert said. "It will put everything on hold."

Eichstaedt, with the Center For Justice, said it's not just environmentalists who are uneasy with the cleanup being offered for the Spokane River. He said the state should have spent more time listening to its own experts.

"Someone shouldn't have to quit and shouldn't have to come out to the press in order for a proper cleanup to occur," he said. "It's embarrassing our Department of Ecology is continuing to ignore her concerns and the concerns of others."

Footnote 6

EPA 910-R-07-002

United States
Environmental Protection
Agency

Region 10
1200 Sixth Avenue
Seattle WA 98101

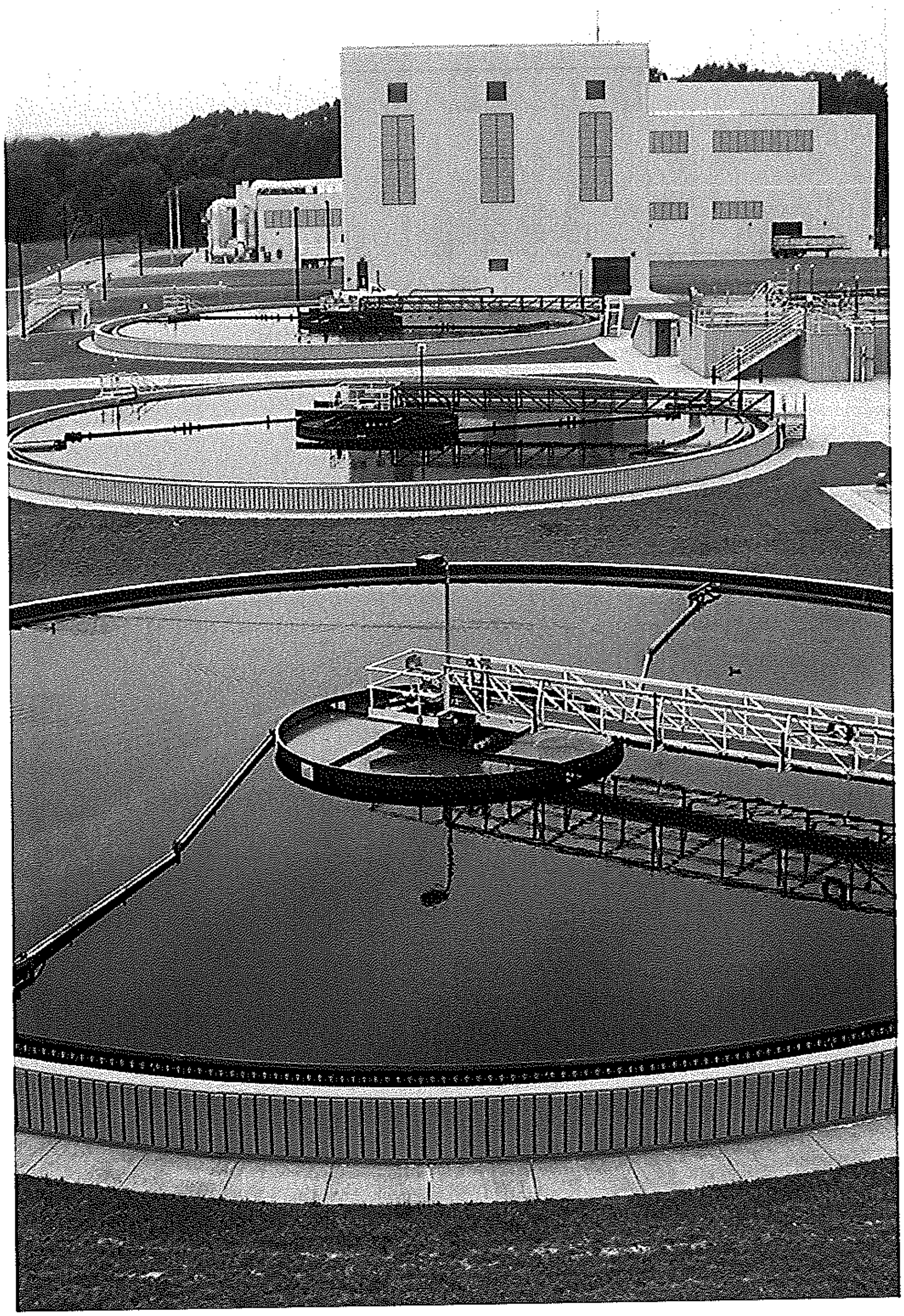
Alaska
Idaho
Oregon
Washington

Office of Water and Watersheds

April 2007

EPA

Advanced Wastewater Treatment to Achieve Low Concentration of Phosphorus



Acknowledgements

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Abstract

In this report, EPA Region 10 presents observations of advanced wastewater treatment installed at 23 municipalities in the United States. These facilities employ chemical addition and a range of filtration technologies which have proven to be very effective at producing an effluent containing low levels of phosphorus.

Observations from this evaluation include:

- Chemical addition to wastewater with aluminum- or iron-based coagulants followed by tertiary filtration can reduce total phosphorus concentrations in the final effluent to very low levels. The total phosphorus concentrations achieved by some of these WWTPs are consistently near or below 0.01 mg/l.

- The cost of applying tertiary treatment for phosphorus removal is affordable, when measured by the monthly residential sewer fees charged by the municipalities that operate these exemplary facilities. The monthly residential sewer rates charged to maintain and operate the entire treatment facility ranged from as low as $18 to the highest fee of $46.

- There appeared to be no technical or economic reason that precludes other dischargers from using any of the tertiary treatment technologies that are employed at these WWTPs. Any of these technologies may be scaled as necessary to fulfill treatment capacity needs after consideration of site specific conditions.

- Other pollutants that commonly affect water quality such as biochemical oxygen demand, total suspended solids, and fecal coliform bacteria are also significantly reduced through these advanced treatment processes.

- WWTPs which utilize enhanced biological nutrient removal (EBNR) in the secondary treatment process can often reduce total phosphorus concentrations to 0.3 mg/l or less prior to tertiary filtration. While employing EBNR is not essential to achieving high phosphorus removal rates, EBNR enhances the performance and reduces operating costs (especially chemical use) of the subsequent tertiary filtration process. Recently published studies report that the longer solids retention times used in BNR processes also removes a significant amount of other pollutants contained in municipal wastewater, including toxics, pharmaceuticals, and personal care products.

- The low effluent turbidity produced by tertiary filtration allows for efficient disinfection of final effluent without chlorination through the use of ultraviolet treatment.

- The treatment processes and quality of the final effluent produced by tertiary filtration for phosphorus removal typically meet state criteria for wastewater reclamation. Reuse of this high quality effluent can be an attractive alternative to direct discharge into surface waters in situations where restrictive NPDES permit limitations apply.

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Nutrients and Water Quality Problems

Phosphorus and nitrogen are nutrients that are essential for aquatic plant and algae growth. Most waters naturally contain enough of these nutrients to support native aquatic life. However, an over-abundance of these nutrients can over-stimulate plant and algae growth such that they create water quality problems. Over 1,000 waterbodies in Idaho, Oregon and Washington are identified as being impaired due to excessive nutrient loading and are included on state Clean Water Act 2004 §303(d) lists for water quality problems. The problems caused by nutrient enrichment of lakes, stream, and rivers are not unique to the Northwest states as many other waterbodies across the United States have also been identified as impaired by nutrients. Nutrient impairments affect the survival of many aquatic species such as salmon; affect the safety of drinking water supplies; affect the aesthetics of recreational areas, and the ability to navigate through rivers and lakes.

In freshwater systems, phosphorus is typically the nutrient that is in short supply relative to biological needs, which means that the productivity of aquatic plans and algae can be controlled by limiting the amount of phosphorus entering the water. Many streams and lakes in the Northwest are documented to have very little capacity to assimilate phosphorus loading during the "critical" warm and dry summer period without significant water quality degradation. Large diurnal swings in pH and dissolved oxygen may occur as excessive amounts of nutrients are metabolized by aquatic plants and algae. The range of these swings is often measured to exceed the state water quality criteria established to protect fish and other aquatic organisms in their various life stages. Therefore, the amount of phosphorus currently entering these waters exceeds the seasonal loading capacity and must be reduced if these water quality problems are to be resolved.

The sources of phosphorus loading vary depending on the human activities and conditions in a specific watershed. In the Northwest, phosphorus loading into streams and lakes from nonpoint sources (e.g. agriculture, pet waste) is often minimal during the summer months because there is typically very little rainfall runoff to flush pollutants into receiving waters. The discharges of treated wastewater can be the most significant source of phosphorus loading during these critical summer months. To address these water quality problems, state environmental agencies and the Environmental Protection Agency (EPA) are requiring dischargers to reduce the amount of phosphorus in their effluent.

Achieving very low phosphorus levels in treated wastewater will require the installation of additional treatment. A number of water quality studies in Northwest states have determined waste load allocations which will require dischargers to achieve total phosphorus effluent concentrations that range from as low as 0.009 to 0.05 mg/l. Even as WWTP operators in the Northwest consider installing additional treatments to address water quality problem, they are also planning to upgrade capacity of their plants to accommodate rapid population growth. With many other interests competing for limited public and private resources, resolving water quality problems is often contentious and slow. Implementation of water quality improvement plans (called Total Maximum Daily Loads (TMDLs)) have been significantly delayed by arguments about the availability and cost of treatment technologies capable of achieving very low phosphorus targets.

In response to these discussions, EPA – Region 10 initiated a project to evaluate municipal wastewater treatment plants which have demonstrated exemplary phosphorus removal through their treatment processes. The primary goal of this project was to obtain and share information about the technology, performance and costs of applying advanced wastewater treatment for phosphorus removal.

Evaluation Considerations

The WWTPs included in this project were selected because monitoring results have demonstrated their treatment to be very effective at removing phosphorus. The reported performance at each of these facilities has been well documented by monitoring conducted over periods of several years. EPA attempted to include a variety of treatment technologies and facilities of different sizes in this evaluation. However, not all facilities that achieve exemplary phosphorus removal nor all filtration technologies could be presented in this report. A number of the WWTPs that are currently achieving good phosphorus removal are planning treatment upgrades that will allow them to also meet a total nitrogen limitation of 3 mg/l. Some information about treatment to remove nitrogen is presented in the description of the LOTT, Budd Inlet WWTP.

Treatment performance is characterized by discharge monitoring information required by the National Pollutant Discharge Elimination System (NPDES) permits which authorize these facilities to discharge treated wastewater. Monitoring of the final effluent per NPDES permit requirements is conducted and reported in accordance with EPA approved analytical methods and quality control procedures. This monitoring information provides the best readily available information with which to characterize WWTP performance. EPA presents the average and range of reported monthly average phosphorus concentrations to indicate long term treatment performance. These monthly average values may not be representative of daily fluctuations in effluent quality experience by these WWTPs. Effluent concentrations are sometimes reported as zero or less-than values on discharge monitoring reports when the monitored concentrations are well below permit limitations or laboratory reporting limits for phosphorus. The actual effluent phosphorus concentration in the final effluent of these facilities may be significantly better than characterized in discharge monitoring reports.

Although each of the WWTPs are very well maintained and operated, very few are being pressed by stringent NPDES limitations to optimize treatment to achieve the best phosphorus removal possible. The table under Summary of Observations lists the applicable NPDES permit phosphorus limitations for each of the facilities evaluated. The lowest phosphorus limitation established for any of these WWTPs was a monthly average limitation of 0.05 mg/l. Operators at many of these WWTPs conveyed that if necessary, even better phosphorus removal performance could be achieved through operational changes to the existing treatment system. This is a consideration that should not be overlooked by dischargers, consultants and regulators as they consider treatment options.

Summary of Observations

Information about treatment technology, performance and residential sewer treatment fees for each of the 23 WWTPs evaluated is summarized in the following table.

Facility Name and Location	NPDES Permit Number	Capacity	Advanced Phosphorus Treatment Technology	NPDES Permit Limitation for Phosphorus	*Average Effluent Phosphorus Concentration	Range of Monthly Average Phosphorus Concentrations	Monthly Residential Sewer Rate
Sand Creek WWRP Aurora, CO	CO0026611	5 mgd	BNR,filtration	None	0.1 to 0.2 mg/l	N/A	$2.38 + $4.50 / 1,000 gal used
Breckenridge S.D., Iowa Hill WWRP, CO	CO0045420	1.5 mgd	BNR, chemical addition, tertiary settlers and filtration	0.5 mg/l daily max & 225 lbs/year	0.055 mg/l	0.017 to 0.13 mg/l	$19
Breckenridge S.D., Farmers Korner WWTP, CO	CO0021539	3 mgd	BNR, chemical addition, tertiary settlers and filtration	0.5 mg/l daily max & 225 lbs/year	0.007 mg/l	0.002 to 0.036 mg/l	$19
Summit County Snake River WWTP, CO	CO0029955	2.6 mgd	BNR, chemical addition, tertiary settlers and filtration	0.5 mg/l daily max & 340 lbs/year	0.015 mg/l	<0.01 to 0.04 mg/l	$36
Pinery WWRF Parker, CO	CO0041092	2 mgd	BNR, chemical addition, two-stage filtration	0.05 mg/l & 304 lbs/year	0.029 mg/l	0.021 to 0.074 mg/l	$18
Clean Water Services, Rock Creek WWTP, OR	OR0029777	39 mgd	Chemical addition, filtration	0.1 mg/l (monthly median limitation)	0.07 mg/l	0.04 to 0.09 mg/l	$16.07 + $1.11/ccf
Clean Water Services, Durham WWTP, OR	OR0028118	24 mgd	BNR, chemical addition, filtration	0.11 mg/l (monthly median limitation)	0.07 mg/l	0.05 to 0.1 mg/l	$16.07 + $1.11/ccf
Stamford WWTP Stamford, NY	NY0021555	0.5 mgd	Chemical addition, two-stage filtration	0.2 mg/l	<0.011 mg/l	<0.005 to < 0.06 mg/l	$10**
Walton WWTP Walton, NY	NY0027154	1.55 mgd	Chemical addition, two-stage filtration	0.2 mg/l	<0.01 mg/l	<0.005 to <0.06 mg/l	$10**
Milford WWTP Milford, MA	MA0100579	4.8 mgd	Multi-point chemical addition, filtration	0.2 mg/l	0.07 mg/l	0.04 to 0.16 mg/l	$27.50
Alexandria Sanitation Authority AWWTP, Alexandria, VA	VA0025160	54 mgd	BNR, Multi-point chemical addition, tertiary settling and filtration	0.18 mg/l	0.065 mg/l	0.04 to 0.1 mg/l	$4.17 + $4.49 / 1,000 gal used
Upper Occoquan Sewerage Authority WWTP, VA	VA0024988	42 mgd	Chemical (high lime) and tertiary filtration	0.10 mg/l	<0.088 mg/l	0.023 to <0.282 mg/l	$3.03 to $4.09/1,000 g
Fairfax County, Noman Cole WWTP, VA	VA0025364	67 mgd	BNR, chemical addition, tertiary clarification and filtration	0.18 mg/l	<0.061 mg/l	<0.02 to <0.13 mg/l	$3.28/1,000 g

Facility Name and Location	NPDES Permit Number	Capacity	Advanced Phosphorus Treatment Technology	NPDES Permit Limitation for Phosphorus	*Average Effluent Phosphorus Concentration	Range of Monthly Average Phosphorus Concentrations	Monthly Residential Sewer Rate
BluePro Treatment Pilot results at Hayden WWTP, ID	N/A	N/A	Iron coated sand in two-stage Centra-Flo Filters.	N/A	0.013 mg/l	N/A	N/A
CoMag Treatment Pilot results at Concord WWTP, MA	N/A	N/A	Chemical addition, ballast sedimentation, magnetic polishing	N/A	0.04 mg/l	N/A	N/A
WWTPs not visited for this evaluation :							
Delhi, NY	NY0020265	0.82 mgd	Activated sludge, chemical addition, filtration	0.11 mg/l	0.04 mg/l	<0.02 to 0.085 mg/l	$10 **
Pine Hill WWTP, NY	NY0026557	0.5 mgd	RBC, sand filters, chemical addition, microfiltration	0.2 mg/l	0.06 mg/l	0 to 0.12 mg/l	$10 **
NYC DEP-Grand Gorge STP, NY	NY0026565	0.5 mgd	RBC, sand filters, chemical addition, microfiltration	0.2 mg/l	< 0.04 mg/l	0 to 0.05 mg/l	$10 **
Hobart – V PCF, NY	NY0029254	0.18 mgd	Activated sludge, sand filters, chemical addition, microfiltration	0.5 mg/l	< 0.05 mg/l	0.026 to 0.07 mg/l	$10 **
Snyderville Basin Water Reclaimation District, UT	UT0020001	4 mgd	BNR, chemical addition, filtration	0.1 mg/l	0.04 mg/l	0.03 to 0.06 mg/l	$30
Ashland WWTP Ashland, OR	OR0026255	2.3 mgd ADWF	Oxidation Ditch, chemical addition, membrane filtration	1.6 lb/day (= 0.083 mg/l)	0.07 mg/l	0.05 to 0.12 mg/l	$11.55 + $1.73 per 100 cf used
McMinneville WWTP McMinneville, OR	OR0034002	5.6 mgd ADWF	Oxidation Ditch (BNR), Chemical addition, multi-media traveling bed filtration	0.07 mg/l	0.058 mg/l	0.036 to 0.092 mg/l	$46.15 (average based on 700 cf used)
Facility Name and Location	**NPDES Permit Number**	**Capacity**	**Advanced Nitrogen Treatment Technology**	**NPDES Permit Limitation for Total Inorganic Nitrogen (TIN)**	***Average Effluent TIN Concentration**	**Range of Monthly Average TIN Concentrations**	**Monthly Residential Sewer Rate**
LOTT WWTP Olympia, WA	WA0037061	28 mgd	Biological Nutrient Removal	3 mg/l	2.2 mg/l	1.23 to 2.81 mg/l	$25.50

* This is the average of monthly average measurements achieved as reported by the facility on NPDES discharge monitoring reports. The period for which these averages were determined is identified in the discussion about each facility. Many facilities have seasonal water quality-based limitations for phosphorus.
** The costs of construction, operation and maintenance of WWTPs discharging into the Delaware River watershed are partially subsidized by the City of New York.

Summary of Observations (continued)

- Tertiary filtration aided by chemical addition can reduce total phosphorus concentrations in the final effluent to very low levels. This treatment is employed at all but one of the WWTPs included in this evaluation. To achieve very low phosphorus concentrations, chemicals must be added to wastewater to associate phosphorus with solids that can then be successfully removed through filtration. Aluminum- or iron-based coagulants and polymer are the chemicals most commonly used for this purpose.

- Traveling sand bed filters, mixed- media gravity filters, Dynasand filters and variations of these filtration technologies are used by all of the WWTPs evaluated. Filtration has been employed for many years to treat drinking water and more recently applied to treat wastewater. Filtration technologies for treating wastewater are rapidly evolving as water quality agencies and dischargers strive to protect sensitive receiving waters from potential impacts of pollutants in the treated effluent. With proper design, there are no apparent reasons why any of these filtration technologies may not be installed in either small or large scale applications. Selection of a filtration technology includes the usual considerations such as: desired effluent quality; reliability of treatment equipment; capital, operating and maintenance costs; equipment footprint, and future expandability.

- Application of two-stage filtration processes produced the lowest phosphorus levels observed in this evaluation. Two-stage treatment may be achieved through use of a first and second stage filter or by providing tertiary clarification prior to filtration. The Walton and Stamford WWTPs achieved the lowest measured phosphorus concentration in their effluent (about 0.01 mg/l or less) by utilizing two-stage Dynasand filters from Parkson Corporation. Excellent treatment results were also obtained by Breckenridge WWTPs, the Snake River WWTP and the Alexandria AWWTP using a two-stage treatment process consisting of chemical addition with tertiary settling in advance of their sand bed filters. Modular two-stage filters from US Filter Corporation installed at the Pinery WWTP employs a synthetic media in the first stage and sand media in the second stage. The Fairfax County, Noman Cole WWTP utilizes large tertiary clarifiers followed by filtration through sand beds.

- Table 1 identifies which of the WWTPs include in this evaluation have also incorporated *enhanced biological nutrient removal* (EBNR) into their secondary treatment processes to remove phosphorus. An EBNR treatment system promotes the production of phosphorus accumulating organisms which utilize more phosphorus in their metabolic processes than a conventional secondary biological treatment process. The average total phosphorus concentrations in raw domestic wastewater is usually between 6 to 8 mg/l and the total phosphorus concentration in municipal wastewater after conventional secondary treatment is routinely reduced to 3 or 4 mg/l. Whereas, EBNR incorporated into the secondary treatment system can often reduce total phosphorus concentrations to 0.3 mg/l and less. Facilities using EBNR significantly reduced the amount of phosphorus to be removed through the subsequent chemical addition and tertiary filtration process. This improves the efficiency of the tertiary process and can significantly reduce the costs of chemicals used to remove phosphorus. Staff at the Fairfax County WWTPs reported that their chemical dosing was cut in half after EBNR was installed to remove phosphorus.

- The treatment provided by these WWTP also removes other pollutants which commonly affect water quality to very low levels. Biochemical oxygen demand (BOD) and total suspended solids are routinely less than 2 mg/l and fecal coliform bacteria less than 10 fcu/100 ml. Turbidity of the final effluent is very low which allows for effective disinfection using ultraviolet light, rather than chlorination. Recent studies report finding that WWTPs using EBNR also significantly reduce the amount of pharmaceuticals and health care products from municipal wastewater, as compared to the removal accomplished by conventional secondary treatment.

- Only four of the WWTPs included in this evaluation utilize anaerobic digesters to stabilize removed solids. Facilities which utilize anaerobic digesters need to consider the potential that a significant phosphorus load might be released from the removed solids and thereafter returned to the wastewater being treated. The Clean Water Services WWTPs manages the phosphorus loading associated with the use of anaerobic digesters by equalizing the flow of these return streams (supernatant and centrate) over time. Other studies indicate that phosphorus removed with alum does not resolubilize in anaerobic digesters, whereas phosphorus removed with iron salts may solubilize in the absence of adequate iron. Operators have identified the amount of alum or iron necessary to control resolubilization of phosphorus in anaerobic digesters to be a cost consideration.

- Applying advanced water treatment to remove phosphorus is affordable for most municipalities as demonstrated by the monthly residential sewer fees charged by the WWTPs included in this evaluation. These fees are listed in the Summary of Observations Table and are typically less than $30. EPA intended to identify in more detail the costs incurred by these WWTPs to install and operate tertiary treatment for phosphorus removal. However, it was soon determined that separating the costs of the tertiary treatment from overall facility operating costs was beyond the resources and time available to complete this project. EPA instead presents the monthly residential sewer fees charged by each of these WWTPs as an indicator of the costs to construct, maintain and operate these facilities, including the tertiary treatment for phosphorus removal.

City of Aurora - Sand Creek Wastewater Reuse Plant

Contact Information:
Mailing address:
18301 EAST QUINCY AVENUE
Aurora, Colorado 80010
303-326-8807

NPDES permit No. CO0026611, expiration date December 31, 2002

Receiving water: Sand Creek or reclaimed for irrigation use

Sand Creek WWRP Treatment:

Raw Wastewater → Primary Clarification → Biological Nutrient Removal → Secondary Clarification → Effluent Filtration (Parkson Dynasand Filters) → UV Disinfection

Treatment capacity: 5 mgd average daily flow

Aurora WWRP Performance Information:

Parameter	Limitation	Avg of monthly averages	Range of monthly averages	Maximum individual measurement	Reporting period
TSS	30/45 mg/l	1.0 mg/l	0.5 to 1.84 (6/04)	7.0 mg/l	4/01 to 5/06
N-NH3	None	*<0.14 mg/l	*<0.1 to <0.33 mg/l	1.7 mg/l	8/03 to 5/06
BOD	30/45 mg/l	* <2.3 mg/l	<2.2 to <4.0 mg/l	6.1 mg/l (6/05)	4/01 to 5/06
Phosphorus	none		**0.1 to 0.2 mg/l		4/01 to 5/06

* Most of these measurements were reported as less than (<) values

Monthly Sewage Service Charge: $2.16 plus a usage fee of $1.99 per 1,000 Gallons water used.

Facility description:

The City of Aurora is east of the City of Denver in Colorado. This facility began operation in 2001 and either discharges treated effluent to Sand Creek or the wastewater is reused for irrigation on public lands, such as parks and golf courses. Some of the irrigation sites are as far as 17 miles away from the WWTP. Although this is a long distance to pump water, the high demand for the water in this arid area causes the value of reclaimed wastewater to be nearly the price of potable water!

Treatment at this WWTP involves screening and grinding; primary clarification; biological nutrient removal (BNR) in the contact basins; secondary clarification; filtration through single pass Dynasand filters (four cells with 4 filters per each cell); UV disinfection. Solids removed during the course of treatment are routed back into the sewer main where they are ultimately treated at the Denver, Metro WWTP. BNR is accomplished by exposing wastewater through sequential anoxic, anaerobic and aerobic zones maintained in the contact basins.

Direct discharge from this WWTP is into the Cherry Creek watershed. The Cherry Creek watershed includes a reservoir that is currently impaired due to excessive loading of nutrients. The Aurora WWTP currently does not have any effluent limitation for phosphorus. At the time of this visit, the NPDES permit for this facility was expired and WWTP operators expected that phosphorus limitations might be included in the proposed permit reissuance. Monitoring for total phosphorus is conducted weekly and analyses achieve an analytic reporting level of 0.05 mg/l.

No chemicals are currently used at the plant to enhance phosphorus removal. Nevertheless, the final effluent typically contains between only 0.1 to 0.2 mg/l total phosphorus. Influent BOD and ammonia nitrogen were reported to be approximately 200 to 300 mg/l and 30 mg/l, respectively. Effluent BOD concentrations average about 2.2 mg/l and ammonia nitrogen is less than 0.1 mg/l.

Operational considerations:

- The single pass Dynasand filters used as tertiary treatment at the Aurora WWTP include four cells, each with four continuous backwashing upflow sand media filters. The surface area of each filter measures seven by seven feet and the filters are 16 feet deep.
- Plant operators state they had encountered no serious maintenance or operational problems with the DynaSand filters. WWTP operators also responded that they were unaware of any reason why application of these filters could not be "scaled-up" to accommodate a much larger treatment capacity than the 5 mgd currently being treated through the Aurora facility. Additional filters will likely be added in the future to accommodate increasing treatment capacity needs in the service area.

Breckenridge Sanitation District - Iowa Hill Wastewater Reclamation Plant

Contact Information:
District Office:
1605 Airport Road
Breckenridge, CO 80424

Phone: 970-453-2723
Fax: 970-453-2013

Mailing Address:
PO Box 1216
Breckenridge, CO 80424

NPDES Permit No. CO0045420, expiration date 31 December 2004

Receiving water: Blue River (tributary to Dillon Reservoir)

Iowa Hill WWTP Performance Information:

Parameter	NPDES Limitation	Avg of monthly averages	Range of monthly averages	Maximum individual measurement (date)	Reporting period
BOD	30 mg/l	1.55 mg/l	0.64 to 3.02 mg/l	12.6 mg/l (4/00)	4/00 to 12/02
TSS	30 mg/l	2.07 mg/l	0.49 to 6.2 mg/l	18.1 mg/l (4/00)	4/00 to 12/02
N-NH3	10 mg/l	0.41 mg/l	0.16 to 1.8 mg/l	8.2 mg/l (4/00)	4/00 to 12/02
Phosphorus	0.5 mg/l daily max & 225 lb/year	0.55 mg/l	0.017 to 0.13 mg/l	0.13 mg/l (6/00)	5/00 to 12/02

Iowa Hill WWTP Process:

Influent → Screening (Scalping Plant) → Activated & Grit Removal → Biological Sludge Biological Treatment → Aerated Filter (IDI "BioFor") → Chemical Addition (Alum) → Mixing & Settling (Densadeg) → Filtration (Parkson DynaSand Filter) → Disinfection

Design Treatment Capacity: 1.5 MGD average dry weather flow

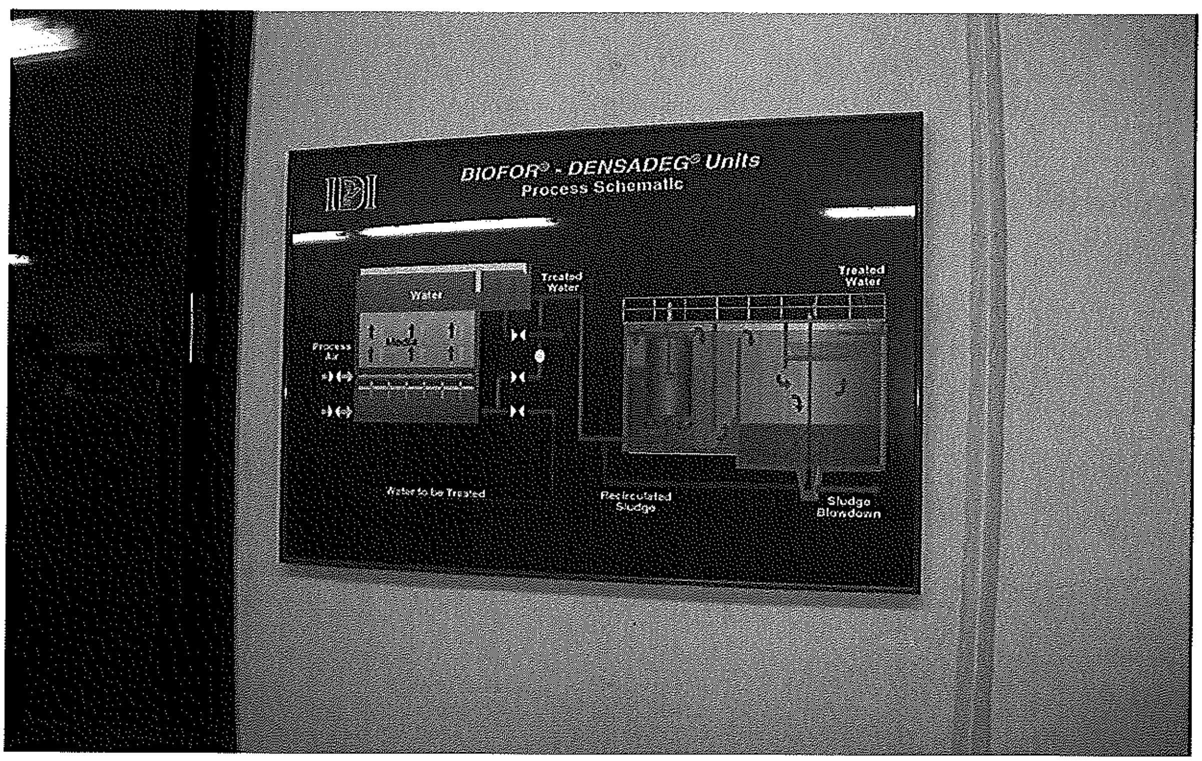
Monthly household sewer use fee: $19/month

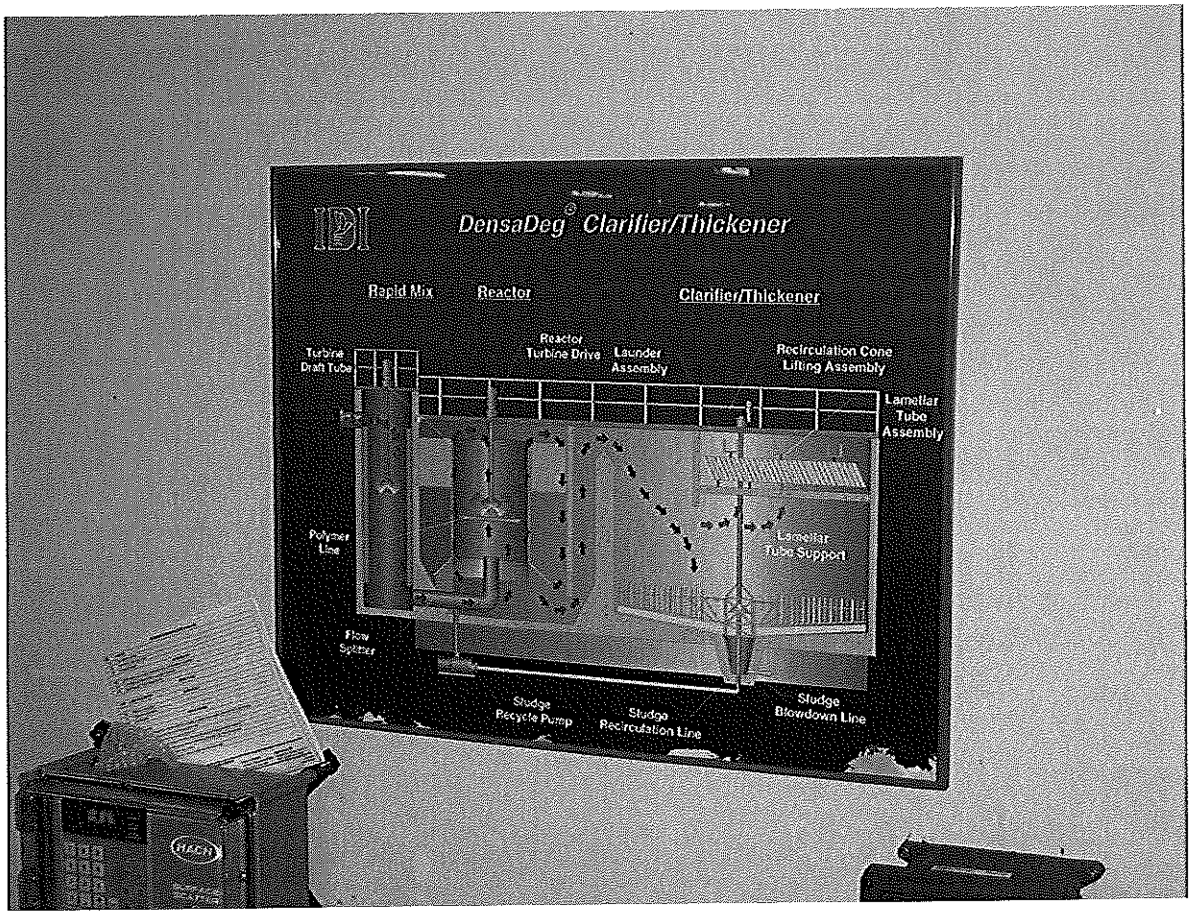
Facility description:

The Breckenridge Sanitation District collects wastewater from the town of Breckenridge and the surrounding area. The District operates three (3) wastewater treatment facilities including the Iowa Hill WWTP and the Farmers Korner WWTP which were visited as part of this evaluation. A small package plant is also operated by the district. The Iowa Hill WWTP was newly constructed in 1999 and has since been widely cited for its quality of effluent, especially its low effluent total phosphorus. Influent flow to the plant is "scalped" from the main District interceptor in the Blue River Valley. Solids removed during treatment at the Iowa Hill WWTTP are routed back into the interceptor for treatment at the Farmers Korner WWTP.

Discharge from both of these facilities enters Dillon reservoir which is used to supply drinking water to the Metropolitan Denver area. To prevent eutrophication of Dillon reservoir, an annual maximum mass loading limitation of 225 pounds per year and daily maximum concentration of 0.5 mg/l for total phosphorus were established. Facility operators target achieving an effluent concentration of 0.01 to 0.02 mg/l total phosphorus to meet the annual loading limitation.

Treatment at this WWTP is accomplished by screening and grit removal in the headworks; activated sludge biological treatment; biological aerated filter (IDI "BioFor" for nitrification); chemical coagulation using alum; flocculation and clarification using tube settler (IDI "Densadeg"); filtration (single stage Parkson "Dynasand" filters); disinfection and dechlorination. The Dynasand filter reject rate is reported to be about 15 to 20%. The Dynasand filters are configured in four, two-cell units for a total of 8 filters beds which are each 8 feet deep.





Influent concentrations of total phosphorus were measured to be about 6 mg/l during the time of this visit (winter) which is very a typical value for untreated domestic wastewater. The aeration basins are operated with an anoxic zone to provide for biological removal of phosphorus. About sixty percent of the influent phosphorus was reported to be removed through the biological treatment process.

Sodium sulfate is added to maintain alkalinity through the treatment process for phosphorus removal. Approximately 100 to 120 mg/l sodium sulfate is applied to the wastewater just upstream of where alum is added. Alum is used to precipitate phosphorus. The alum dose at the time of this visit was approximately 135 mg/l and is used with 0.5 to 1.0 mg/l cationic polymer.

Operational considerations:

- The District representative indicated that construction to double the current 1.5 mgd treatment capacity at this plant is being considered to accommodate growth in the service area.
- It was reported that the airlift tube in the Parkson (Dynasand) filters had to be replaced because of wear caused by sand abrasion.
- Backwashing of the BioFor unit and improved hydraulic controls in the Densadeg unit presented some operational difficulties.

- Fecal coliform levels in the final effluent are so low (0 to 10 colonies/100 ml) that they typically meet permit limitations without disinfection. Accordingly, the use of chlorine and sodium bisulfite (for dechlorination) are minimal.
- Facility operators prefer the more conventional flocculation-clarification units with tube settlers and bed filters that are installed at the Breckenridge Sanitation District, Farmers Korner WWTP. The Farmers Corner WWTP effluent quality is reported to be as good as that produced by the Iowa Hill WWTP with less operational attention.

Breckenridge Sanitation District - Farmers Korner Wastewater Treatment Plant

Contact Information:
District Office:
1605 Airport Road
Breckenridge, CO 80424

Phone: 970-453-2723
Fax: 970-453-2013

Mailing Address:
PO Box 1216
Breckenridge, CO 80424

NPDES permit No. CO0021539 expiration date 31 July 2008

Receiving water: Blue River (tributary to Dillon Reservoir)

Design Treatment Capacity: 3.0 MGD average dry weather flow

Farmers Korner Treatment Processes:

Influent→Screening & Grit Removal→Activated Sludge (with BNR)→Secondary Clarification→Chemical Addition→ Tertiary Clarification (tube settlers)→ Filtration→ Disinfection

Residential sewer use fee: $19/month

Farmers Korner WWTP Performance Information:

Parameter	NPDES Limitation	Avg of monthly averages	Range of monthly averages	Maximum individual measurement	Reporting period
BOD5	30 mg/l	1.0 mg/l	0.57 to 2.40 mg/l	5.78 (Dec 03)	Aug 03 thru Apr 06
TSS	30 mg/l	1.07 mg/l	0.3 to 3.10 mg/l	5.2 (Dec 05)	Same
NH3-N	10 mg/l	3.36 mg/l	0.31 to 16.66 mg/l	21.88 (May 05)	Same
Total Phosphorus	225 lb/yr & 0.5 mg/l daily max	0.007 mg/l	0.002 to 0.036 mg/l	0.06 (Dec 05)	Same

Facility Description:

The Breckenridge Sanitation District collects wastewater from the town of Breckenridge, Colorado and the surrounding area. The District operates three wastewater treatment facilities including the Iowa Hill and Farmers Korner WWTPs which were visited as part of this evaluation. Facilities at the Farmers Korner WWTP were upgraded in 1999 to the present treatment configuration. Influent flow to this plant includes municipal wastewater from the service area and removed solids from the District's Iowa Hill WWTP.

Discharge from the Farmers Korner WWTP enters Dillon reservoir which is used to supply drinking water to the Metropolitan Denver area. To prevent eutrophication of Dillon reservoir, the NPDES permit established an annual maximum mass loading limitation of 225 pound/day and a daily maximum concentration of 0.5 mg/l for total phosphorus. Facility operators target achieving an effluent concentration of 0.01 to 0.02 mg/l total phosphorus to ensure meeting the annual loading limitation.

Treatment at Farmer Korner WWTP consists of screening and grit removal; biological nutrient removal; chemical coagulation and flocculation using polymer and alum; clarification via tube settlers; filtration though mixed media bed filters; disinfection with chlorine and dechlorination (using sodium bisulfite). Solids removed during treatment are routed to an aerated storage tank, dewatered by centrifuge; and the solids utilized at a mine reclamation site. Caustic soda is added to maintain alkalinity though the treatment process.

Operational Considerations:

- Ten operators are employed to run the three Breckenridge District wastewater treatment plants and also maintain 20 pump stations in the collection system.
- Fecal coliform levels in the final effluent are so low (0 to 10 colonies/100 ml) that they typically meet permit limitations without disinfection. Accordingly, the amount of chemicals used for disinfection are minimal.
- The alum dose applied at the time of this visit was approximately 135 mg/l and is used with 0.5 to 1.0 mg/l cationic polymer.

Snake River Wastewater Treatment Plant

Contact information:
Summit County Board of Commissioners
Snake River Wastewater Treatment Plant
4344 Swan Mountain Road
Dillon, Colorado 80435-8474
970-468-5794

Chuck Clause, Utility Director
Stoner Turner, Chief Operator

NPDES Permit No. CO0029955, expiration date JanAN-31-2008

Receiving water: Dillon Reservoir

Snake River WWTP Process:

Influent →Screening →Aeration Basins → Secondary Clarifiers → Chemical Coagulation → Flocculation →Clarification →

→Filtration→ Disinfection

Snake River WWTP Performance Information:

Parameter	NPDES Limitation	Avg of monthly averages	Range of monthly averages	Maximum individual measurement (date)	Reporting period
BOD	30/45 mg/l	0.7 mg/l	0.3 to 2 mg/l	3 mg/l (8/03)	2/03 to 5/06
TSS	30/45 mg/l	0.6 mg/l	0.2 to 2 mg/l	4 mg/l (8/04)	2/03 to 5/06
N-NH3	5.8 mg/l	0.25 mg/l	<0.01 to 1.82 mg/l	9.85 mg/l (7/04)	
Phosphorus	340 lb/year total & 0.5 mg/l daily max	0.015 mg/l	<0.01 to 0.04 mg/l	0.08 (2/84)	2/03 to 5/06

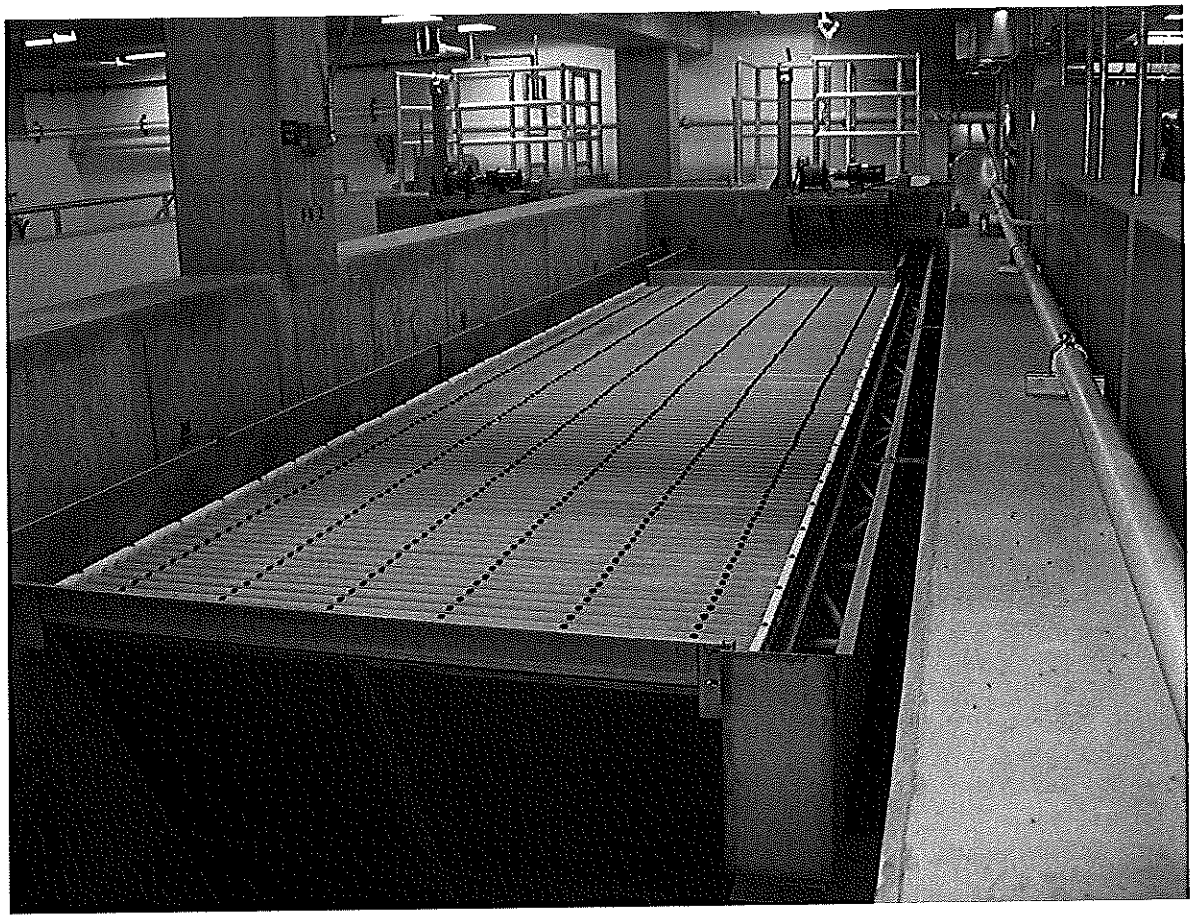
Design Treatment Capacity: 2.6 MGD

Residential sewer use fee: $36/month ($108 quarterly)

Facility Description:

The Snake River WWTP treats domestic wastewater collected from a service area that is south and east of the Dillon Reservoir. Treated effluent is discharged into Dillon Reservoir which is used as a drinking water supply for the Denver Metropolitan area. Water quality-based effluent limitations for phosphorus have been established in the NPDES permit issued to this WWTP and other dischargers into the reservoir to prevent eutrophication. Construction to upgrade treatment and capacity of the plant was completed in 2002.

Treatment at the Snake River WWTP includes screening and grit removal; aeration basins; secondary clarification; chemical coagulation and flocculation using with alum and polymer; tertiary clarification (rectangular conventional with inclined plate settlers); mixed media bed filters (5 feet deep); and disinfection (the filtration process removes enough fecal coliform so that conventional disinfection is not normally required). The average alum dose is 70 mg/l in the wastewater and is reported to vary from 50 to 180 mg/l. A greater dose of alum is applied during the winter period. The operator reported the polymer dose concentration to be about 0.1 mg/l. Removed solids are routed to an aerobic digester from which waste solids are dewatered by centrifuge and utilized for mine site reclamation.



Empty rectangular clarifier with inclined plate settlers at Snake River WWTP

Operational considerations:

- Air supplied to the aerobic digesters is turned off for 2 hours three times a day to raise the pH.
- Recycle streams that are routed to the headworks make up about 40 percent of the total plant flow, including grit screenings wash water, WAS thickener decant mixed-media filter backwash waste water, aerobic digester decant and centrate.
- Plant operators are very pleased with operation of the upgraded plant. Good phosphorus removal is achieved through the aeration basins without EBPR. Total phosphorus concentrations measured in the secondary effluent range from 0.5 to 3.0 mg/l. Facility operators speculated the variability of phosphorus in the secondary effluent is possibly because chemical sludge that is recycled to head of plant aids removal of phosphorus through the biological process and secondary clarification. Return streams include WAS thickener decant, aerobic digester decant and centrate.
- Essentially complete nitrification of wastewater is achieved in the aeration basins.
- The filtration process removes enough fecal coliform so that conventional disinfection is not normally required.

Pinery Wastewater Reclamation Facility

Contact Information:
Pinery Water and Wastewater District
6516 North State Highway 83
Parker, Colorado 80134

Mailing address:
P.O. Box 1660
Parker, Colorado 80134

Telephone: 303-841-2797

NPDES Permit No. CO0041092, expiration date Sept 30, 2010

Receiving water: Groundwater in Cherry Creek Reservoir subbasin

Design Treatment Capacity: 2.0 MGD

Treatment Processes:

Influent → Screening & Grit Removal → EBNR (BardenPho 5 stage) → Secondary Clarification → Chemical Addition → Filtration "Memcor" → UV Disinfection

Pinery WWTP Treatment Performance:

Parameter	NPDES Limitation (monthly average)	Average of monthly averages	Range of monthly averages	Maximum measurement (date)	Reporting period
BOD	30 mg/l	1.1 mg/l	0.36 to 5.2 mg/l	6.4 mg/l (8/05)	1/03 to 9/05
TSS	30 mg/l	2.2 mg/l	0.6 to 13.3 mg/l	33.3 mg/l (4/04)	1/03 to 9/05
Phosphorus	0.05 mg/l & 304 lbs/year	0.029 mg/l	0.021 to 0.074 mg/l	0.234 mg/l (11/05)	1/03 to 9/05

Monthly residential sewer use fee: $18 month ($36 bimonthly, plus additional fee for water usage over 6,000 gallons)

Facility Description:

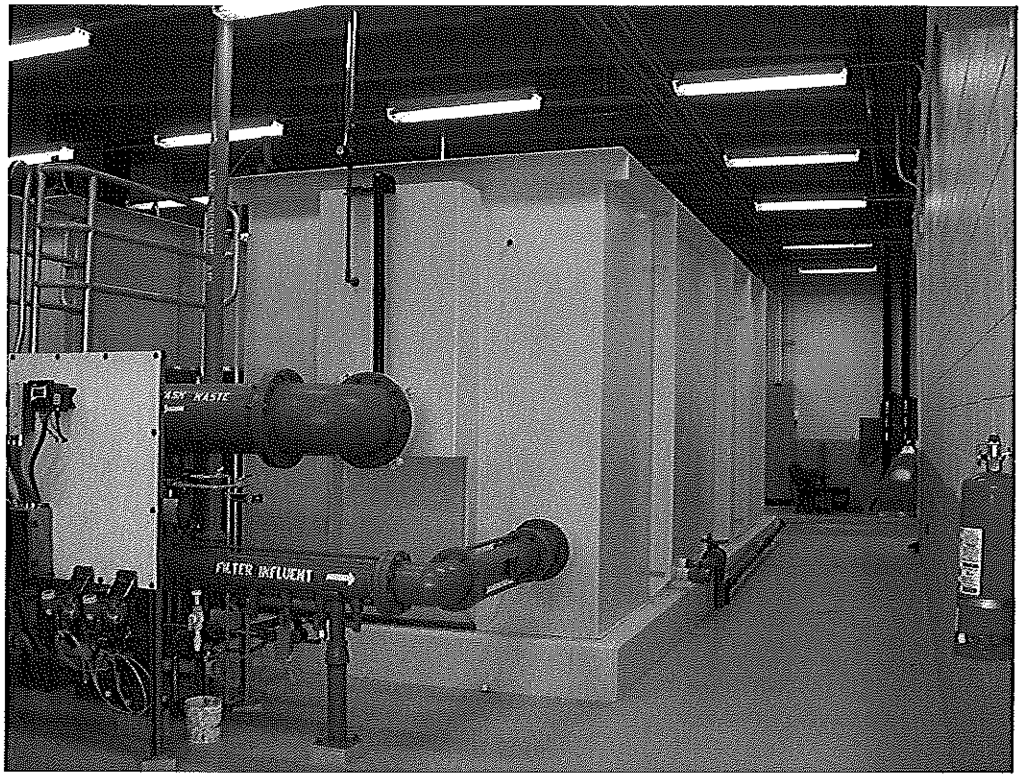
The Pinery Wastewater Treatment Plant was originally constructed in 1990 and upgraded in 2005. The plant treats domestic wastewater from a service area located south of Parker

Colorado. Discharge from the treatment plant is directed into Cherry Creek. Water quality-based limitations for phosphorus and other pollutants have been established in the NPDES permit to protect the shallow Cherry Creek aquifer and the reservoir. The enhanced biological nutrient removal process utilized at the Pinery Plant is recognized as being very well operated and has been studied and cited numerous times as an example of exemplary application of this technology.

Treatment consists of screening and grit removal; BNR Activated Sludge (BardenPho 5 Stage [Anaerobic Basin, Anoxic Basin, Oxidation Ditch Aeration Basin, Anoxic Basin, Reaeration Basin]); Clarifiers [2 parallel rectangular]; Chemical addition using alum and polymer; Effluent Polishing and filtration [using 4 US Filter Memcor filter modules] ; and UV disinfection. The US Filter units utilize two-stage filtration in which the first stage is upflow through a plastic media with air scour. The second stage filtration is through a downflow, mixed media with backwash cleaning. The concentration of alum used for coagulation was reported to be 95 mg/l. Residuals solids removed during treatment are routed to aerobic digester tanks. These solids are dewatered on a belt filter press and dried/composted for land application.

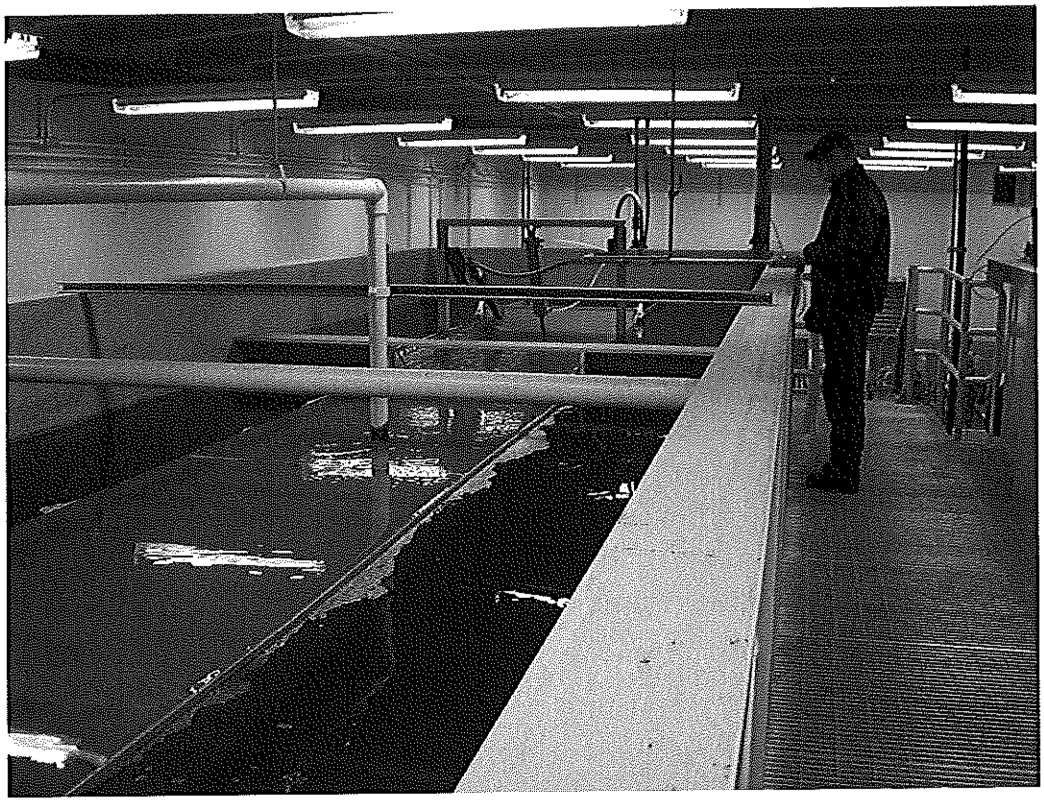
Operational Considerations:

- The concentration of total phosphorus in the plant influent is high (8 to 10 mg/l) because phosphoric acid is used in the District's water supply for corrosion control.
- Ortho-P is monitored by on-line instrumentation (Hach series 5000 Low-Range) in the influent to the chemical treatment system and the final filter effluent. This equipment is capable of measuring phosphorus to concentrations as low as 0.01 mg/l.
- The Memcor filters used for effluent polishing are upflow through plastic media (adsorption) and downflow through an anthracite sand media filter. Backwash of the filter unit components is automatically initiated when a preset head loss is measured. The total flow of backwash water used to clean the filters is about 15%. Flushing and backwash water is equalized and introduced to the reaeration basin ahead of the secondary clarifiers.
- Sulfuric acid is used for pH control in the treatment process as optimum $AlPO_4$ precipitation occurs when the pH = 6.0.



Modular Memcor Filter (US Filter Company) at Pinery WWRP. Each of these modules has a treatment capacity of approximately 0.5 mgd.

Metering equipment used for chemical addition at Pinery WWRP



Memcor filter module at Pinery WWRP undergoing backwash

- The laboratory TP and Ortho-P procedures use a Hach DR4000 colorimeter with 1" cuvettes which can achieve total phosphorus detection levels to less than 0.01 mg/l.
- Chemical sludge does not settle well in the secondary clarifiers at the Pinery WWTP, so a portion goes over the weirs and is removed again in effluent filter system.
- Water conservation measures and the progressive water and sewer use fee are working in the District. The result is that water consumption is decreasing and the concentration of influent wastewater is increasing.
- Operators have found measuring the oxidation-reduction potential (ORP) of wastewater in the plant to be an effective parameter for managing the biological treatment system.

Clean Water Services, Rock Creek Advanced Wastewater Treatment Plant

Contact Information:
Clean Water Services
Rock Creek Advanced Wastewater Treatment Plant
3235 SW River Road
Hillsboro, OR 97123
503-648-8774

NPDES Permit No. OR0029777, expires 31-JAN-2009

Design capacity: 39 mgd dry weather treatment

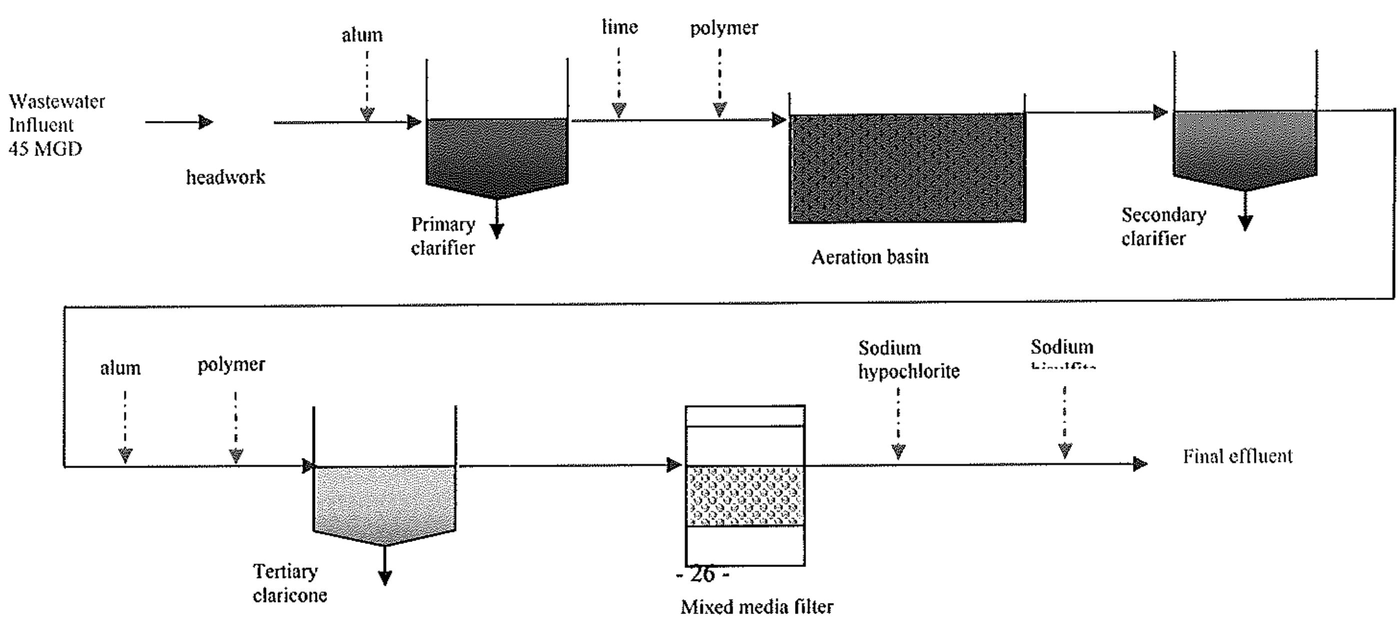
Receiving water: Tualatin River

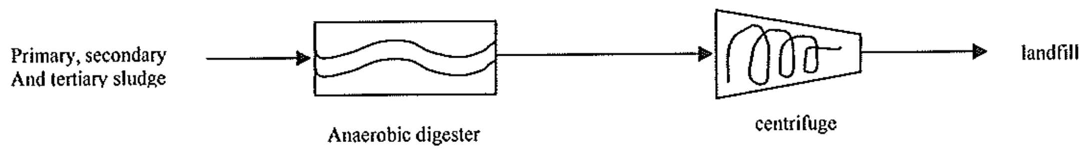
Clean Water Services, Rock Creek AWWTP Performance Information:

Parameter	NPDES Limitation (monthly avg)	[1]Avg of monthly averages	[1]Range of monthly averages	[1]Maximum individual measurement (date)	Reporting period
CBOD	8 mg/l (seasonal)	1.4 mg/l	1.3 to 1.5 mg/l	1.6 mg/l (5/05)	5/05 to 10/05
TSS	8 mg/l (seasonal)	1.2 mg/l	0.9 to 1.8 mg/l	1.8 mg/l (8/05)	5/05 to 10/05
Phosphorus	*0.10 mg/l	0.07 mg/l	0.04 to 0.09 mg/l	0.09 mg/l (9/05)	5/05 to 10/05

* Limitation established as a monthly median concentration
[1] Monitoring information from dry season when nutrient limitations apply (May through October

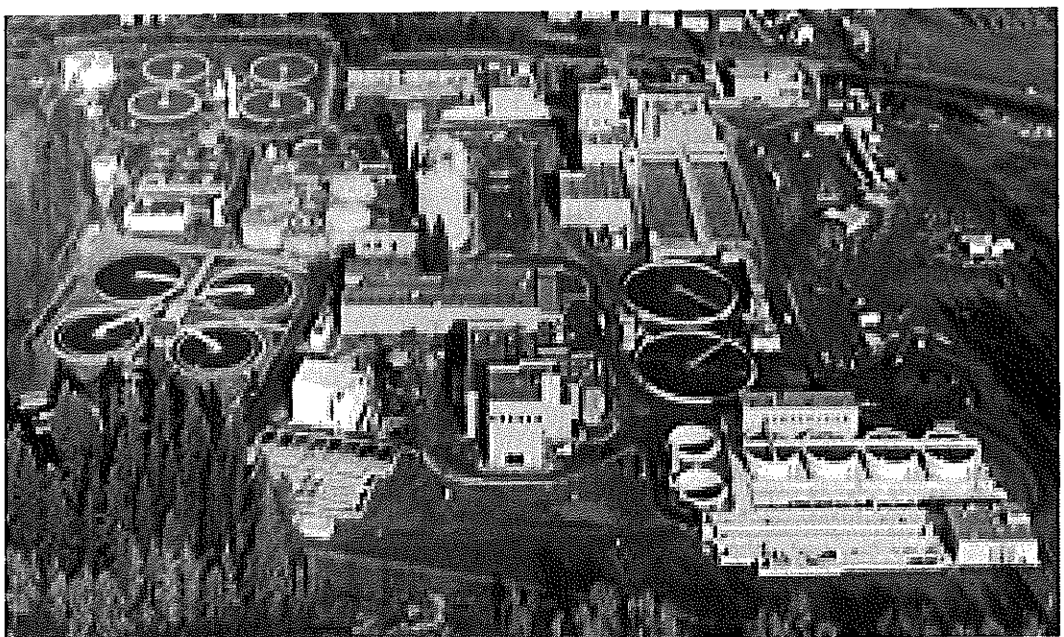
Rock Creek AWWTP Treatment Processes:





Monthly residential sewer use fee: $16.07 plus $1.11/ccf/month. The average monthly residential fee is $27.

<u>Facility Description:</u>



Clean Water Services Rock Creek AWWTP (from CWS informational publication)

Clean Water Services operates four wastewater treatment plants with a service area that includes over 800 miles of collection system piping in Washington County, Oregon. The largest of these WWTPs is the Rock Creek facility which discharges into the Tualatin River. These Clean Water Services plants are staffed by well trained operators with support from knowledgeable operations analysts. Numerous upgrades to treatment have been installed at the Rock Creek WWTP over time. The most recent upgrade to improve phosphorus removal was installed in 1993. The Tualatin River contains natural background levels of phosphorus that are significantly higher than observed in many other northwest watersheds. Because the water quality of the Tualatin River was impaired by excessive nutrient loading from various sources in the watershed, a TMDL was established which includes a wasteload allocation for phosphorus loading from the Rock Creek AWWTP. The wasteload allocation is equivalent to the natural background concentration of phosphorus in the River at the point of discharge. This wasteload allocation is expressed in the NPDES permit as a monthly median limitation of 0.1 mg/l which applies seasonally from May through October.

Wastewater flow is divided for treatment through the east and west side treatment trains. Treatment at the Rock Creek WWTP consists of screening and grit removal; alum addition; primary clarification; extended aeration; secondary clarification; flocculation using alum and polymer; tertiary clarification; filtration; disinfection (with chlorine) and dechlorination. Four 60 foot diameter ClariCone tertiary clarifiers are used on the east treatment train to provide contact time and settling after addition of polymer and alum. Filtration on the east train is accomplished with six monomedia anthracite gravity flow bed filters. The west treatment train uses conventional clarifiers for tertiary settling followed by filtration through four dual media gravity flow bed filters.

Phosphorus is removed in four locations within the Rock Creek treatment system: alum enhanced removal in the primary clarifiers; biological removal in the aeration basins; chemical flocculation and removal in the tertiary clarifiers; and removal through filtration. Treatment upgrades to install enhanced biological nutrient removal of phosphorus are being considered as a means for reducing the current cost of chemicals used for phosphorus removal. Clean Water Services maintains an informative website (http://www.cleanwaterservices.org/AboutUs/Wastewater/TreatmentProcess.aspx) which provides additional information about current treatment and planned upgrades of this facility.

Operational Considerations:

- The average concentration of total phosphorus in the raw plant influent is 6 mg/l.
- Lime is added to maintain pH and alkalinity through the treatment process. The cost of lime used for treatment is about $150,000 per year.
- System analysts have determined that the phosphorus limitation will usually be met if the total suspended solids concentration is 1.5 mg/l or less in the final effluent. A strong empirical relationship has also been observed that when the aluminum to total phosphorus ratio is 5:1 to 7:1 in the secondary effluent, that the total phosphorus concentration in the final effluent will be less than 0.1 mg/l.
- A ratio (not stoichametric) of about 50:1 dry alum to phosphorus is the target dose rate in the tertiary clarifiers. Alum use during May through October (when phosphorus limitations apply) costs about $250,000, based on acquiring alum at $172 per dry ton. This usage of alum equates to a cost of approximately $1,500 per day, or about $50 per mgd of wastewater treated.
- The formation of struvites (ammonium, magnesium, phosphorus crystals) has been an operational problem in some of the slow velocity piping, such as in the heat exchanger recirculation.
- Resolubization of phosphorus in return streams from anaerobic handling of removed solids represents about 20 percent of the phosphorus and ammonia-nitrogen loading to the plant. The loading from these return streams is managed by storage and flow equalization back into the treatment system.

- The secondary effluent that goes to tertiary treatment typically has the following characteristics: total phosphorus < 0.5 mg/l; orthophosphorus <0.1 mg/l; TSS < 10 mg/l; COD < 50 mg/l and N-NH3 <0.01 mg/l.

- Performance records kept by Clean Water Services staff document that the 50th percentile of monthly average total phosphorus concentrations achieved over the previous eight years is 0.071 mg/l. Concentration of total phosphorus in the final effluent have been reduced to as low as 0.032 mg/l. CWS systems analysts expect that better phosphorus removal could be achieved if more effective final filtration equipment were installed. They estimate that if a final effluent TSS concentration of 0.5 mg/l were achieved, the total phosphorus concentration would be about 0.03 mg/l.

Aeration basin at Clean Water Services, Durham AWWTP. The basins at the Rock Creek WWTP may be modified in the future to also provide enhanced biological phosphorus removal.

Clean Water Services, Durham Advanced Wastewater Treatment Plant

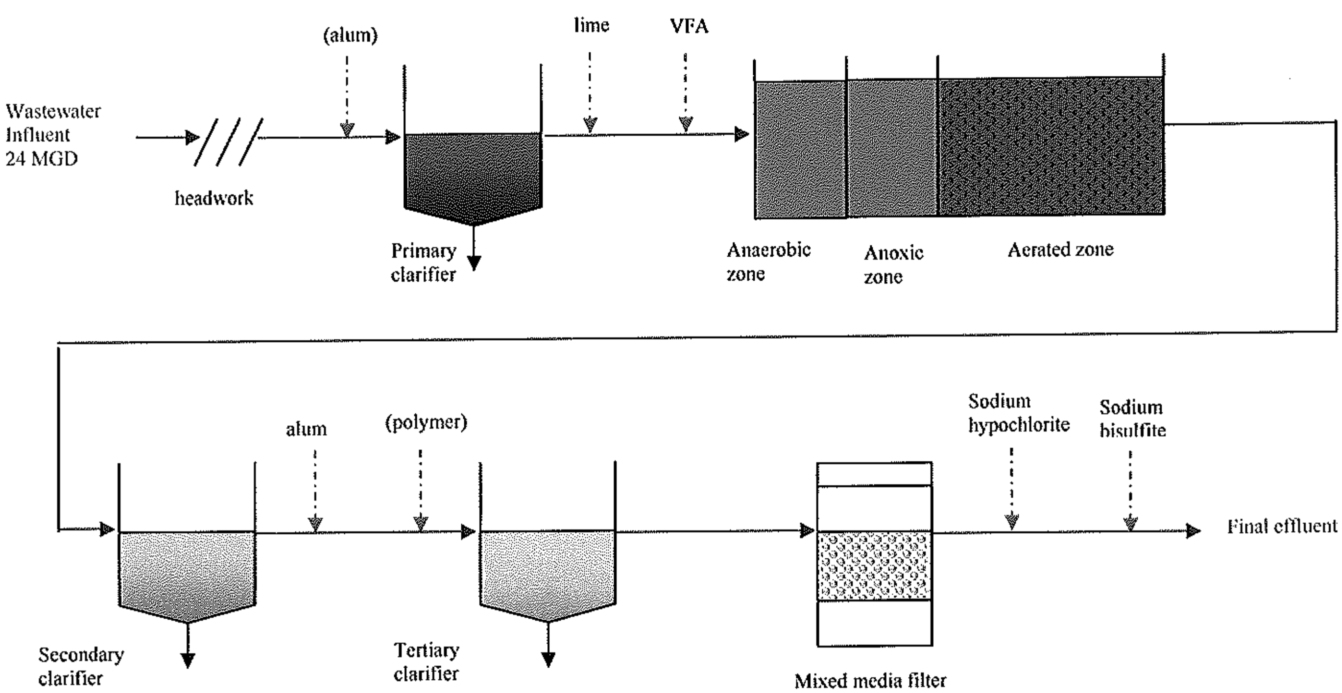
Contact Information:
Clean Water Services
Durham Advanced Wastewater Treatment Plant
16580 SW 85th Street
Tigard. OR 97224
Phone No. 503.831.3600

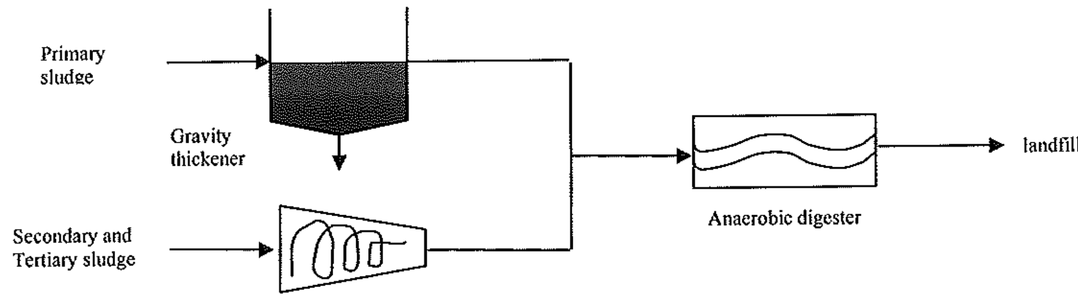
NPDES Permit No. OR0028118, expiration date JAN-31-2009

Design capacity: 24 mgd average dry weather treatment flow

Receiving water: Tualatin River

Durham AWWTP Treatment Process:





Clean Water Services, Durham AWWTP DMR information:

Parameter	NPDES Limitation (monthly avg)	[1]Avg of monthly averages	[1]Range of monthly averages	[1]Maximum individual measurement (date)	Reporting period
CBOD	8 mg/l (seasonal)	2.2 mg/l	1.7 to 2.6 mg/l	4.2 mg/l (6/05)	5/05 to 10/05
TSS	8 mg/l (seasonal)	1.8 mg/l	1.7 to 2.8 mg/l	2.8 mg/l (5/05)	5/05 to 10/05
Phosphorus	*0.11 mg/l	0.07 mg/l	0.05 to 0.1 mg/l	0.1 mg/l (9/05)	5/05 to 10/05

* Limitation establishes as a monthly median concentration
[1] Monitoring information from period when seasonal nutrient limitations apply (May through October)

Monthly sewer use fee: $16.07 plus $1.11/ccf/month. The average monthly residential fee is $27.

Facility Description:

Clean Water Services operates four wastewater treatment plants with a service area that includes over 800 miles of collection system piping in Washington County, Oregon. These Clean Water Services plants are staffed by well trained operators with support from knowledgeable operations analysts. The Durham Advanced Wastewater Treatment Plant is the second largest of the four WWTPs and discharges treated effluent into the Tualatin River. This plant was constructed in 1976 and upgraded to the existing treatment configuration in 1989. Maximum daily wet weather treatment capacity is about 80 mgd.

The Tualatin River reportedly contains natural background levels of phosphorus that are significantly higher than observed in many other northwest watersheds. Because the water quality of the Tualatin River was impaired by excessive nutrient loading from various sources in the watershed, a TMDL was established which includes a wasteload allocation for phosphorus loading from the Durham AWWTP. The wasteload allocation is equivalent to the estimated natural background concentration of phosphorus in the River. This wasteload allocation is expressed in the NPDES permit for this facility as a monthly median limitation of 0.11 mg/l which applies seasonally from May through October.

Treatment at the Durham AWWTP consists of screening and grit removal; primary clarification; biological treatment with enhanced biological nutrient removal; secondary clarification:

chemical addition of alum and polymer for phosphorus removal; tertiary clarification; filtration through dual media gravity bed filters and disinfection. Lime is added to the biological process to maintain pH and alkalinity. Removed solids are anaerobically digested, dewatered by centrifuge, and utilized as fertilizer. A two-stage fermenter is operated to produce volatile fatty acids which are added to the biological contact basins. The enhanced biological nutrient removal process at times reduces total phosphorus to levels that are less than the 0.11 mg/l permit limitation. However, this performance is not achieved during the entire period when the seasonal phosphorus limitations are in effect. The tertiary treatment with chemical addition and filtration provides assurance that the final effluent is of consistently good quality. Some of the treated effluent is reclaimed for irrigation.

Operational considerations:

- Nitrate-nitrogen may interfere with biological phosphorus removal if sufficient volatile fatty acids (VFAs) are not maintained. Therefore, creation of volatile fatty acids (VFAs) is necessary for the enhanced biological phosphorus removal process to work properly. Operators route solids from the primary clarifier to a two-stage fermenter system. The fermenter produces 500 mg/l VFAs when provided a two and one half day solids retention time. For good biological removal of phosphorus, the optimal relationship for VFAs to phosphorus in the contact basins is about 5:1.

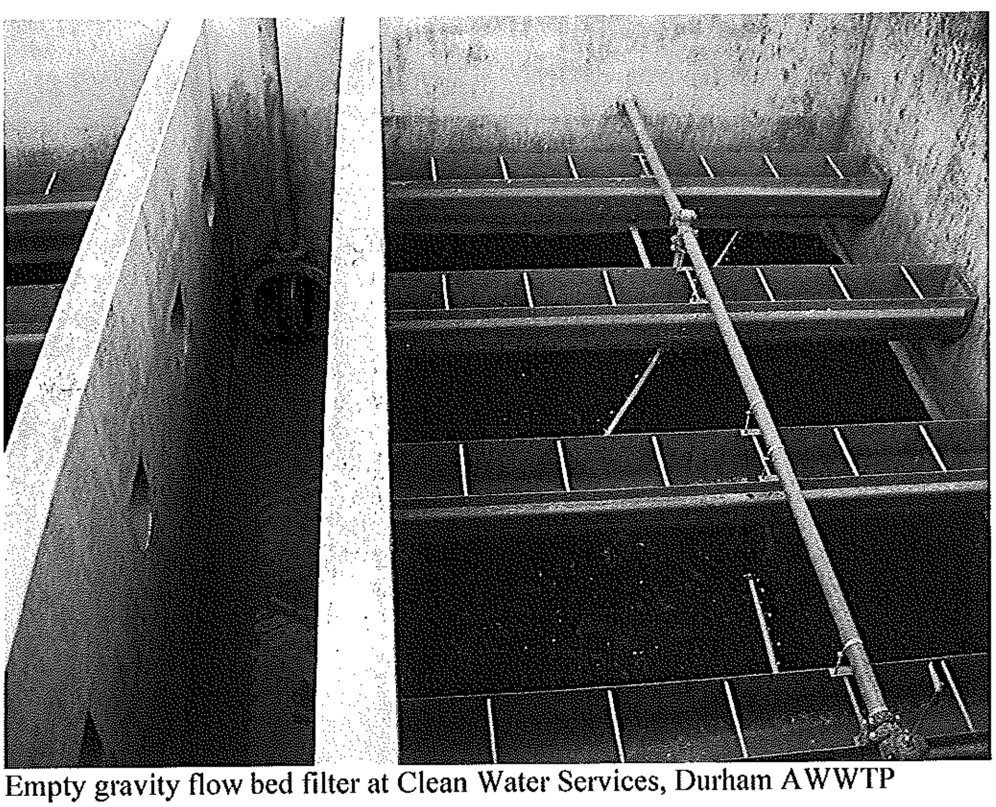
- Operators have determined that orthophosphorus comprises about 75 to 80 percent of the total phosphorus. Automatic sampling equipment provides continuous, low level orthophosphorus information that can be used to adjust treatment as necessary. A target of 0.02 mg/l orthophosphorus was identified as representing optimal treatment performance by the current treatment configuration.

- Secondary effluent quality information is used to operate the biological phosphorus removal process. Operators target achieving a final effluent concentration of 0.07 mg/l by reducing total phosphorus in the secondary effluent to 0.50 mg/l or less.

- The amount of biosolids generated by biological phosphorus removal is somewhat more than would be produced by using only chemical treatment for phosphorus removal.

- Return streams from anaerobic handling of removed solids (supernatant from digesters and centrate from centrifuges) comprises about 20 percent of the total phosphorus loading to the plant. The loading from these return streams is managed by storage and equalizing its flow back into the treatment system.

Empty tertiary clarifier at Clean Water Services, Durham AWWTP



Empty gravity flow bed filter at Clean Water Services, Durham AWWTP

Stamford Wastewater Treatment Plant

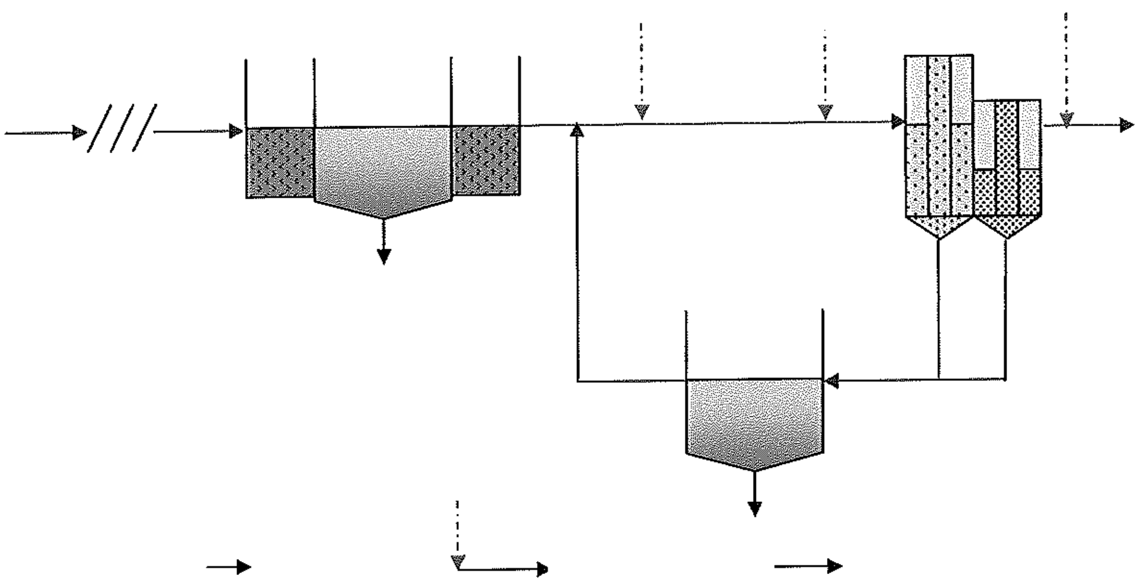
Contact Information:
Village of Stamford Wastewater Treatment Plant
Railroad Avenue
Stamford, New York 12167
Telephone: 607-652-3172

Operated by: Delaware Operations

NPDES Permit No. NY0021555, expiration date JUL-01-2009

Receiving water: West Branch Delaware River Watershed

Stamford WWTP Treatment Process:



Stamford WWTP Performance Information:

Parameter	NPDES Limitation	Average of monthly averages	Range of monthly averages	Maximum individual measurement	Reporting period
Phosphorus	0.2 mg/l	*<0.011 mg/l	<0.005 to < 0.06 mg/l	0.06 (11/05)	2/03 to 5/06
N-NH3	2.5 mg/l	*<0.98 mg/l	<0.03 to 0.63 mg/l	0.63 (7/05)	7/04 to 5/06
TSS	30 mg/l	*<3.3 mg/l	< 2 to 8 mg/l	8 (3/03)	2/03 to 5/06
CBOD	25 mg/l	*<4.5 mg/l	<3.5 to 8 mg/l	8.5 (8/04)	7/04 to 5/06

* Almost all measurements were reported as less than (<) values

Design Treatment Capacity:_ 0.5 MGD (requested certification for 0.7 mgd pending @ New York State Department of Environmental Conservation (NYSDEC)

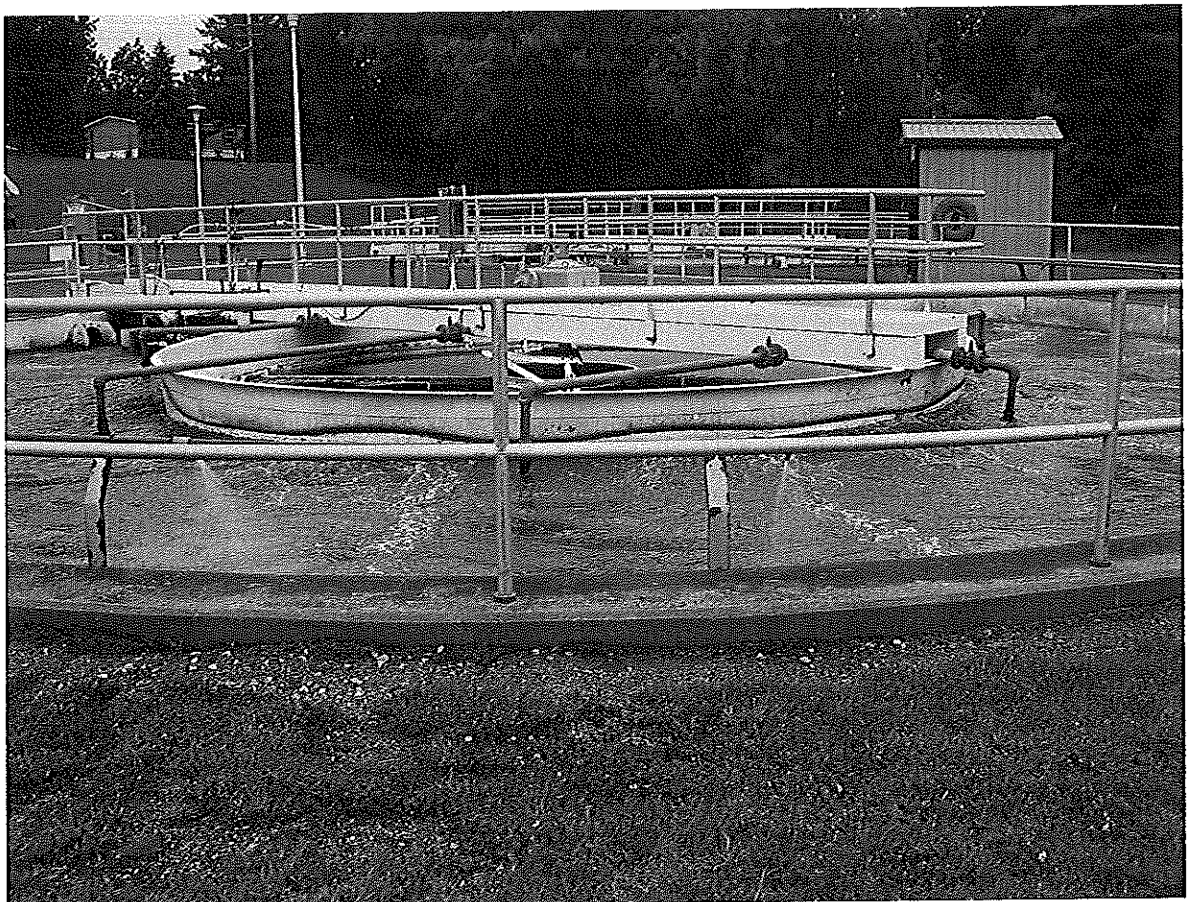
Monthly household sewer use fee: $10 /month

Note about sewer fees: The costs of construction, operation and maintenance of any and all unit processes (which are in excess of New York State standards at this and other WWTPs discharging into the Delaware River watershed) are subsidized by the City of New York. The Stamford WWTP unit processes funded by the City of New York include the chemically-enhanced tertiary filtration, redundant disinfection, dechlorination systems, emergency stand-by power generation, telemetry and alarm systems, and sludge dewatering. The incremental O&M cost increase of these unit processes, as well as additional operations staffing and accounting personnel, are funded annually by the City of New York.

Facility Description:

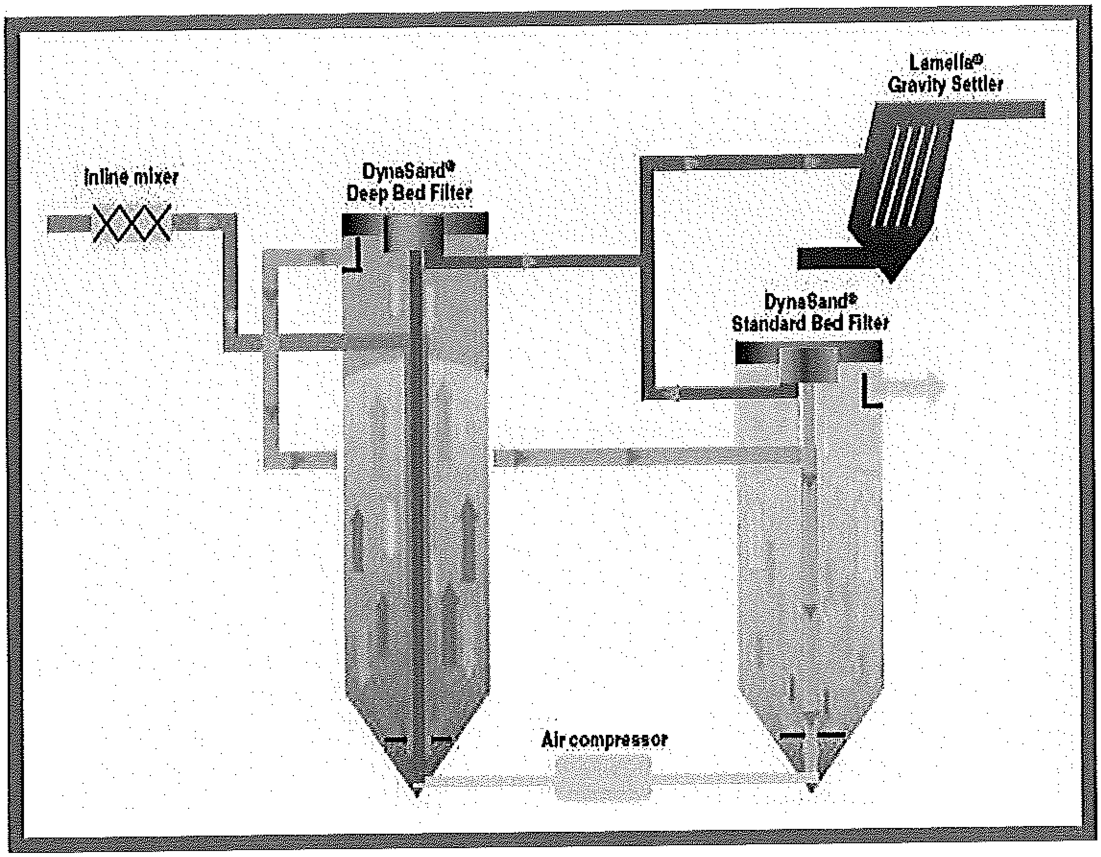
The Village of Stamford wastewater treatment plant (Stamford) receives municipal wastewater from residences and a number of businesses in this community. Delaware Operations is contracted to operate this facility for Stamford. Discharge of treated effluent from Stamford is into the 2,000 square mile New York City Watershed, including the Delaware River watershed, which is a primary drinking water supply for the City of New York. To protect the quality of this receiving water, the City of New York provides funding for municipal dischargers in the watershed to construct and operate advanced wastewater treatment. In return for this financial assistance, these municipalities must maintain and operate their facilities to produce high quality effluent. Design criteria for tertiary treatment and NPDES permit limitations are established by the New York State Department of Environmental Conservation.

Wastewater treatment at the existing Stamford WWTP was upgraded and became fully operational in 2003. Treatment consists of grit removal and screening; extended aeration and secondary clarification (in combined aeration basin/clarifier); chemical addition for flocculation using PASS and filtration through two-stage Dynasand filters. Removed solids are routed to an aerobic digester. Waste solids are dewatered in a belt press and sent to a landfill. There are also large equalization basins available to which raw wastewater may be routed for storage during times of high influent flow.



Combined aeration basin and clarifier (in center of unit) at Stamford WWTP

The DynaSand filters installed at Stamford were obtained from the Parkson Corporation. Both the first stage and the second stage filters operate as continuous backwashing, upflow, sand media filters. There are nine sets of first and second stage filters, each with an approximate surface area of fifty square feet. The sand media in the two meter deep first stage filter has an average diameter of 1.3 millimeters. The second stage sand media is 0.9 millimeters. Secondary treated wastewater is pumped to a distribution header from which it flows by gravity through the first and then the second stage filters. Influent to the first stage filters is chlorinated to inhibit biological growth. Because PASS hydrolyzes so quickly, this flocculant is added to the influent of each first stage filter, rather than being mixed in the distribution header. The reject stream from the filters is routed to a small clarifier and the overflow is returned mixed with influent to the first stage filter. Solids removed in the reject clarifier are routed to a new aerobic digester, into which secondary solids are also mixed, and then dewatered in a newly installed 1.0 meter belt press.



Generic diagram of two stage DynaSand filtration system (courtesy of Parkson Corporation). Note: the Stamford WWTP uses a concrete clarifier in lieu of a lamella settler.

Operational Considerations:

- Analyses for phosphorus, BOD and TSS in the final effluent are conducted using EPA-approved testing methodologies by a NYS-certified laboratory. For data quality control purposes, samples of final effluent are routinely split and sent to a state certified contract laboratory which specializes in achieving extremely low reporting levels for phosphorus. Nevertheless, most of the sample results are reported as less than values (<) on the monthly discharge monitoring. These results routinely demonstrate the effluent as being significantly below permit limitations but do not necessarily accurately characterize the very low phosphorus concentrations in the effluent.
- A correlation between pathogens and turbidity in the effluent was established for municipal dischargers in the watershed. Continuous monitoring of turbidity is a closely watched NPDES permit requirement. Treatment plant operation is optimized to achieve very low effluent turbidity. The excellent removal of other pollutants such as phosphorus, is primarily a by-product of WWTP operation focused on maintaining low turbidity in the final effluent.
- The design hydraulic loading rate specified by New York City for the Parkson Dynasand filters is 3.36 gallon/square foot/minute ($g/ft^2/min$). Operators report the best performance has been achieved at Stamford with a filter loading rate of between 4.0 and

4.5 gpm/sq. ft. but stated that the filters continue to perform very well up to loading rates of over 5.0 gpm/sq.ft.

- The filters in use are routinely rotated based on the amount of time they have been in service. There are nine (9) filter trains at the Stamford WWTP; under typical operating conditions, only 2 filters are running.

- PASS is obtained from the Eaglebrook Company (phone number 450.652.0665) at an approximate cost of $4/gallon. Stamford operators say the addition of PASS is flow paced at a rate of about 30 gallons per one half mgd of wastewater treated. This equates to a cost of approximately $240/day/per mgd for flocculant.

- There is essentially no sand lost from the DynaSand filters during operation.

- The reject rate from the filters is designed and operated to be about 10 percent of the total flow. The percent reject decreases at higher loading rates.

- The overflow rate from each DynaSand filter can easily be adjusted by inserting different size plastic weirs.

Plastic weirs used for adjusting overflow rate from DynaSand Filters

- The turbidity of the effluent was 0.053 NTU at the time of EPA's site visit. Turbidity is closely monitored as it has been determined to be a good surrogate for measuring pathogens potentially present in the discharge. The NPDES permit limit for turbidity is 0.5 NTU.

Walton Wastewater Treatment Plant

Contact Information:
Walton Wastewater Treatment Plant
54 South Street
Walton, New York 13856
Phone Number (607) 865-6993

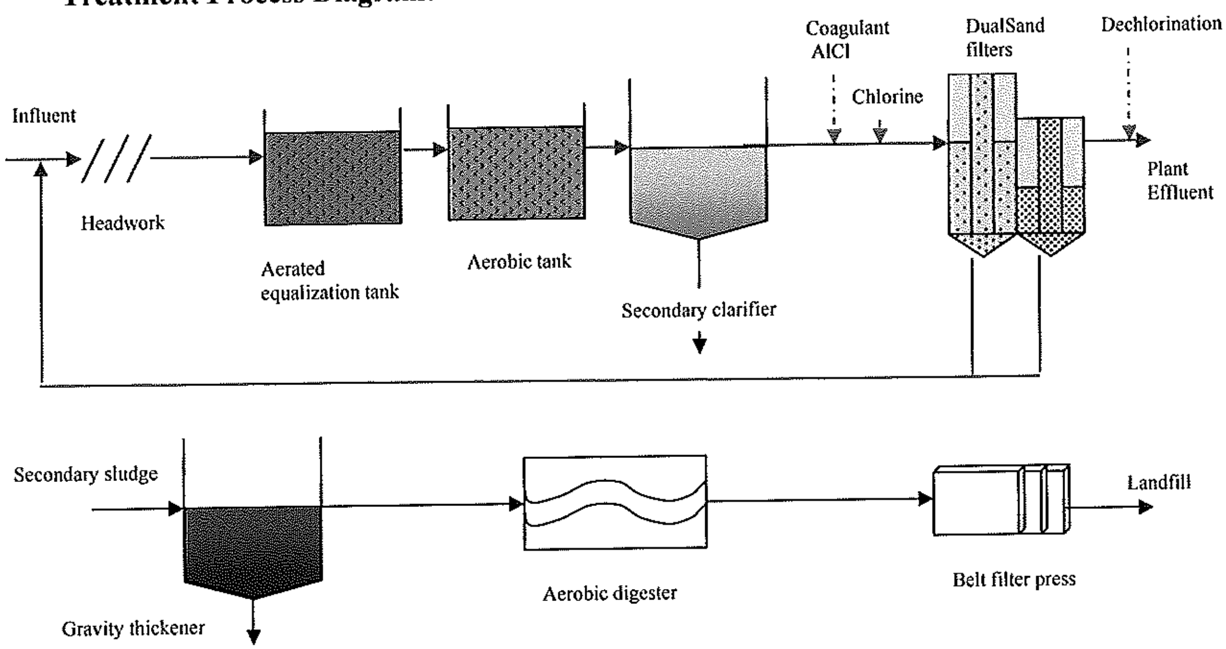
Operated by: Delaware Operations

NPDES Permit No. NY0027154, expiration date Feb 2008

Receiving water: Delaware River Watershed

Design Treatment Capacity: 1.55 mgd (average daily flow)

Treatment Process Diagram:



Walton WWTP Performance Information:

Parameter	NPDES Limitation	Average of monthly averages	Range of monthly averages	Maximum individual measurement	Reporting period
Total P [1]	0.2 mg/l	<0.01 mg/l	<0.005 to < 0.06 mg/l	<0.06 mg/l (3/06)	2/03 to 3/06
N-NH3 [2]	8.8 mg/l	0.24 mg/l	<0.05 to 1.4 mg/l	1.4 mg/l (6/05)	6/03 to 6/06
TSS	30 mg/l	<3.5 mg/l	<2.6 to <4.9 mg/l	<4.9 mg/l (12/05)	2/03 to 3/06
CBOD	25 mg/l	<3.7 mg/l	<2.5 to <4.5 mg/l	<21 mg/l (7/04)	2/3 to 3/06

[1] Almost all phosphorus measurements were reported as less than (<) a specified detection value. The reported detection value was used for summarizing performance, although the actual concentration is lower.
[2] There are seasonal limitations for ammonia nitrogen and performance is summarized for the period when this limitation applies.

Monthly household sewer use fee: $10 month plus charges based on water usage.
(Note: the costs of construction, operation and maintenance of this and other WWTPs discharging into the Delaware River watershed are subsidized by the City of New York.)

Facility Description:

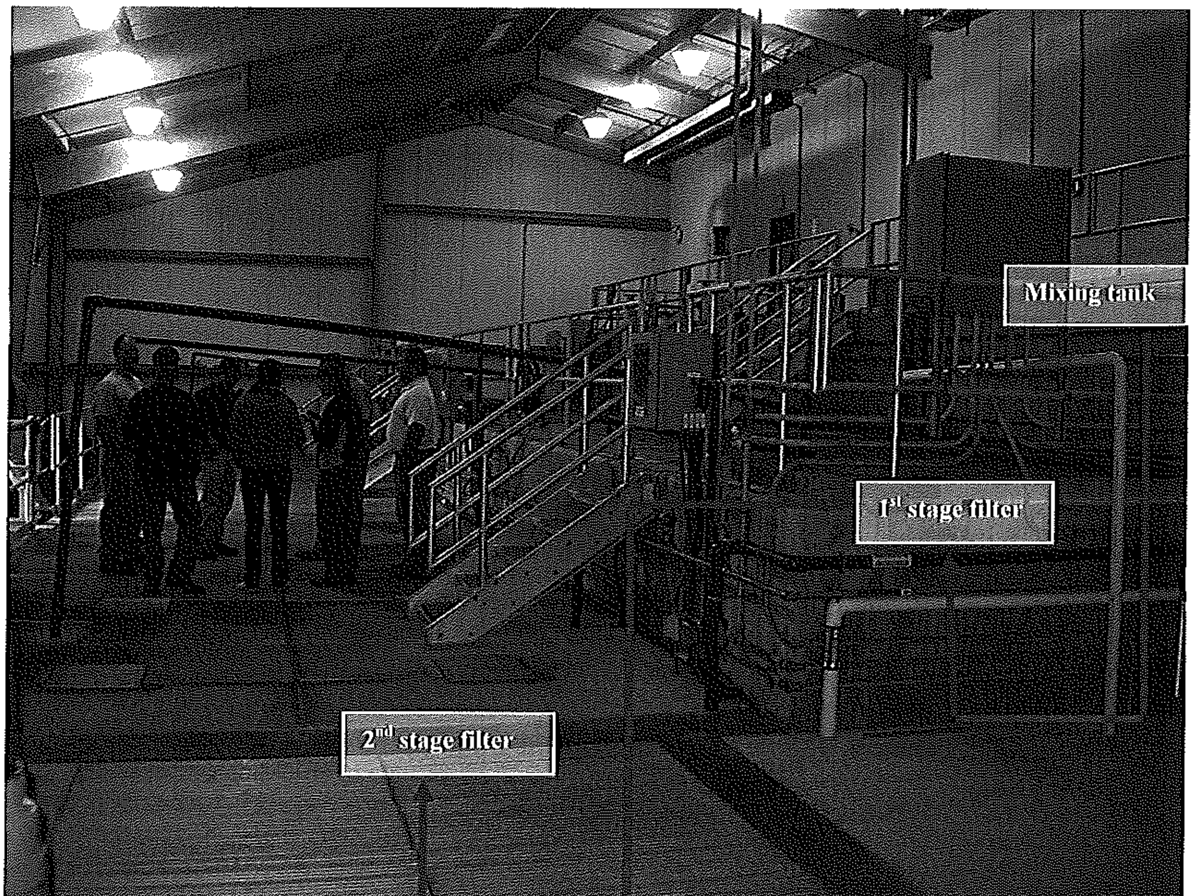
The Walton Wastewater Treatment Plant (WWTP) receives municipal wastewater from residence and a number of businesses in this community plus a significant amount of wastewater from a nearby dairy creamery. Wastewater from the creamery constitutes about 80 percent of the organic loading and 40 percent of the flow into the WWTP. The influent to the WWTP would be characterized as high strength with an average BOD concentration of 350 mg/l. Discharge of treated effluent from Walton is into the 2,000 square mile Delaware River watershed, which is a primary drinking water supply for the City of New York. To protect the quality of this receiving water, the City of New York provides funding for municipal dischargers in the watershed to construct and operate advanced wastewater treatment. In return for this financial assistance, these municipalities must maintain and operate their facilities to produce high quality effluent. Design criteria for tertiary treatment and NPDES permit limitations are established by the New York Department of Environmental Conservation.

Wastewater treatment at the existing Walton WWTP was upgraded and became fully operational in 2003. Treatment consists of grit removal and screening; extended aeration and secondary clarification; chemical addition for flocculation using aluminum chloride (added to the wastewater at both the secondary clarifiers and the distribution header for the DynaSand filters); and filtration through two-stage Dynasand filters; disinfection with chlorine and dechlorination with sulfur dioxide. Chlorine is added to the filter influent to control biological growth in the filters. Removed solids are routed to an aerobic digester. Waste solids are dewatered in a belt press and sent to a land fill.

The DynaSand filters installed at the Walton WWTP were obtained from the Parkson Corporation. Both the first stage and the second stage filters operate as continuous backwashing, upflow, sand media filters. There are five sets of first stage and second stage filter modules.

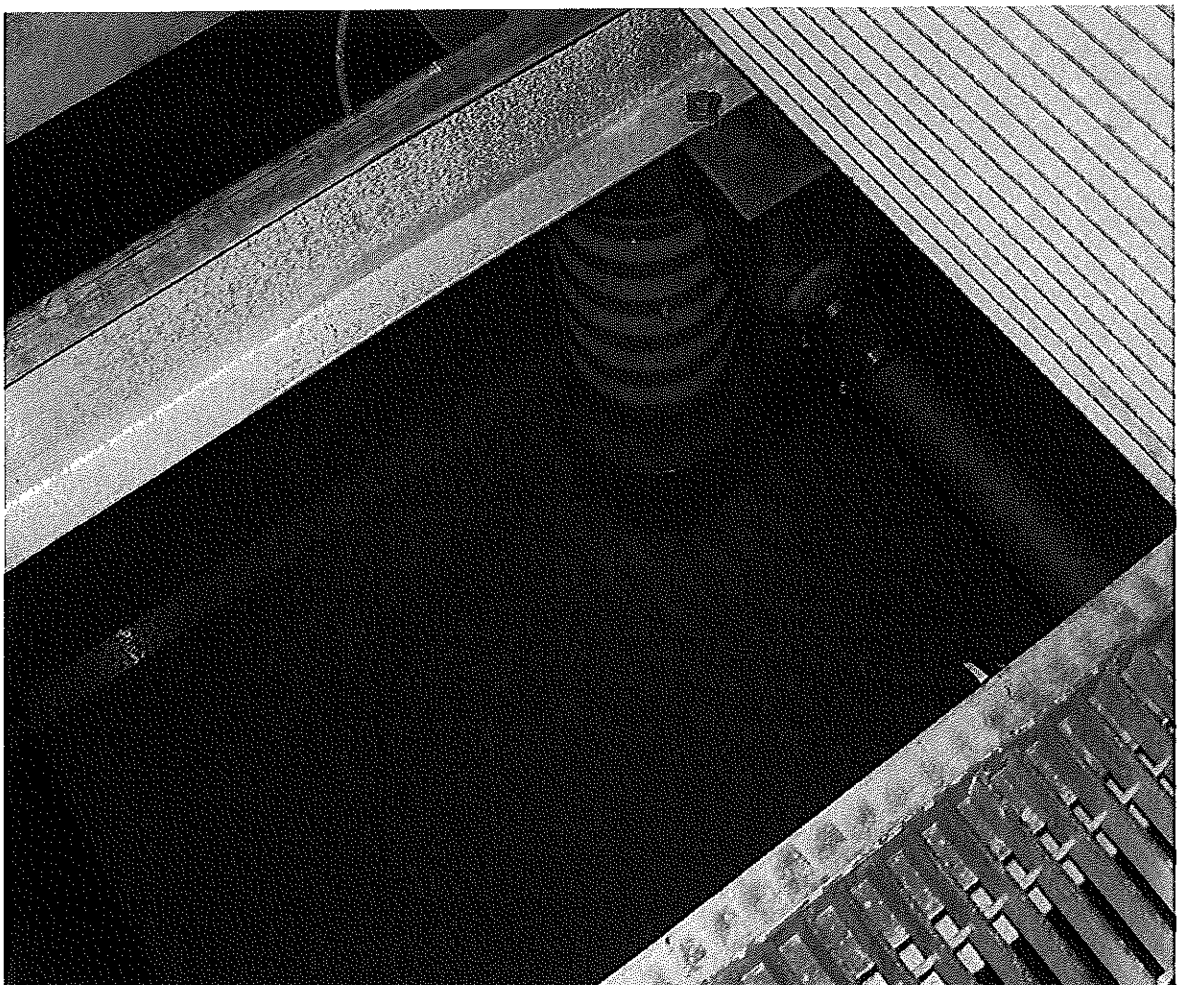
Each module contains four DynaSand filters which have an approximate surface area of two hundred square feet (or eight hundred square feet per module). So, there is total of 40,000 square feet surface area of primary filters and the same amount of secondary filter surface area. The sand media in the two meter deep first stage filters has an average diameter of 1.3 millimeters. The second stage filters are one meter deep and contain sand media of 0.9 millimeter average diameter. The number of filters in use is adjusted as needed to accommodate flow through the plant. The filter modules in use are routinely rotated according to time in service.

Secondary treated wastewater is pumped to a distribution header where aluminum chloride and chlorine is added and from which it flows by gravity through the first and then the second stage filters. The reject stream from the filters is routed to the headworks of the plant.



DynaSand Filters at
Walton WWTP

The above picture shows a side view of the distribution header (far right), first stage and second stage DynaSand filters installed at the Walton WWTP. Flow through the filters is by gravity from the distribution header. The people shown in this picture are standing on grating above the second stage filters. This building houses twenty (2 meter deep) first stage and twenty (1 meter deep) second stage DynaSand filters which have a combined total surface area of about 80,000 square feet. The installation is configured to create five banks of filters which are rotated into use on a time basis. At the time of this visit, two of the five filter banks were being used to treat the entire wastewater flow at this plant.



View into top of DynaSand filter at Walton WWTP. This picture shows sand being returned from washer at top of lift tube in a second stage filter. These filters are designed to wash sand continuously (without any backwash cycle).

Operational Considerations:

- About 80 percent of the loading and 40 percent of the wastewater flow into the Walton WWTP comes from the Kraft Dairy operation.
- Analyses for phosphorus, BOD and TSS in the final effluent are conducted using EPA approved testing methodologies. For data quality control purposes, samples of final effluent are routinely split and sent to a state certified contract laboratory which specializes in achieving extremely low reporting levels for phosphorus. Nevertheless, most of the sample results are reported as less than values (<) on the monthly discharge monitoring. These results routinely demonstrate the effluent as being significantly below permit limitations but do not necessarily characterize the excellent quality of the effluent.

- The turbidity of the effluent was 0.062 NTU at the time of EPA's site visit. Turbidity is closely monitored as it has been determined to be a good surrogate pollutant for measuring the pathogens potentially present in the effluent. The NPDES permit limit for turbidity is 0.5 NTU.
- The maximum treatment capacity of the plant is 3 mgd. The DynaSand filters are not the limiting factor as this flow can be treated by using only 3 of the 5 filter modules.
- Total phosphorus concentrations in the secondary effluent typically range between 1 to 2 mg/l.
- The cost of aluminum chloride to the Walton WWTP was reported to be $4.64/gallon. A streaming current meter (which measures the negative charge of particles in the water) is used to control aluminum chloride dosing. Approximately 50 to 60 gallons of aluminum chloride are used each day which equates to a daily cost of about $250/day at this 1.5 mgd facility.
- The filter press is operated 3 times a week to dewater solids from the aerobic digester. Solids are sent to a landfill and removed liquid is returned to the plant headworks. Operators reported observing no changes in treatment plant performance caused by the solids handling return streams.
- The design hydraulic loading rate specified by New York City for the Parkson DynaSand filters is 3.36 gallon/square foot/minute ($g/ft^2/min$). Operators report they typically run filters at hydraulic loading rate of between 4.0 and 4.5 $g/ft^2/min$ but stated the filters would continue to perform very well up to loading rate of 5.0 $g/ft^2/min$.
- The filters in use are routinely rotated based on the amount of time they have been in service.
- There is essentially no sand lost from the DynaSand filters during operation.
- The reject rate from the filters is designed and operated to be about 10 percent of the total flow.
- The overflow rate from each DynaSand filter can easily be adjusted by inserting different size plastic weirs (pictured in Stamford WWTP description).

Milford Wastewater Treatment Plant

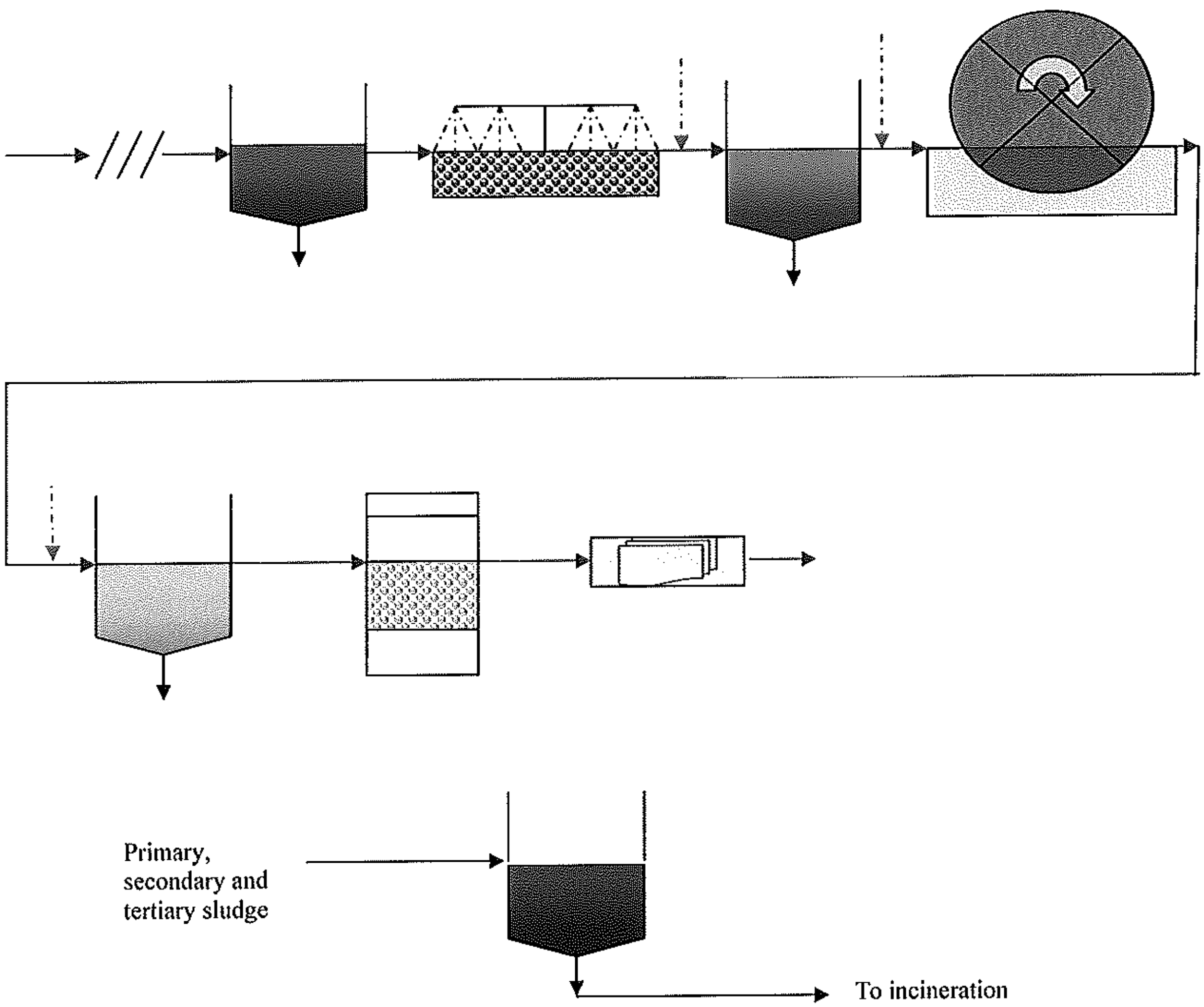
Contact information:
Mailing address:
Milford Wastewater Treatment Plant
P.O. Box 644
Milford, MA 01757
Phone Number: 508-478-0059

NPDES Permit No. MA0100579, expiration date 31-MAR-2010

Receiving water: Headwaters of Charles River

Permitted flow: 4.8 mgd (monthly average)

Milford WWTP Process Diagram:



Milford WWTP Performance Information:

Parameter	NPDES Limitation	Avg of monthly averages	Range of monthly averages	Maximum individual measurement(date)	Reporting period
BOD	30/45 mg/l	3.7 mg/l	1.3 to 7.4 mg/l	9.1 mg/l (4/05)	7/03 to 4/06
TSS	30/45 mg/l	1.7 mg/l	0.48 to 8.0 mg/l	13.6 (2/03)	1/03 to 4/06
N-NH3*	1.0 mg/l	0.26 mg/l	0.05 to 0.48 mg/l	0.19 mg/l (6/03)	6/03 to10/05
Phosphorus*	0.2 mg/l	0.07 mg/l	0.04 to 0.16 mg/l	0.16 mg/l (6/04)	6/03 to10/05

* NPDES limitations for phosphorus and ammonia are seasonal. The 0.2 limit for phosphorus applies April 1 - October 31. The ammonia limitation for the month of May is 5.0 mg/l only and is 1.0 mg/l for the period from June 1 - October 31. The performance information shown is for the periods of each year when these seasonal water quality-based limitations apply.

Monthly residential sewer use fees: $27.50 ($330/year)

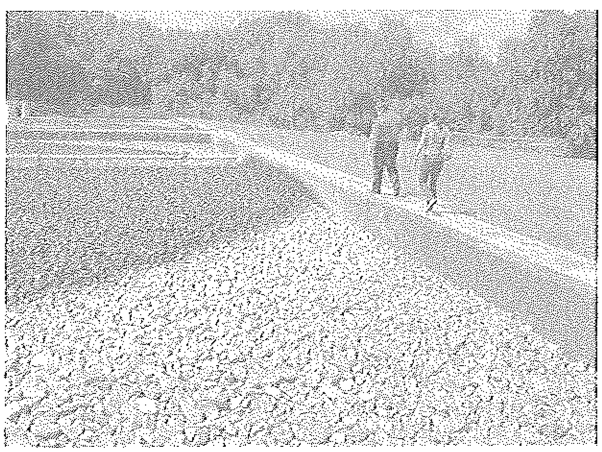
Facility Description:

Wastewater treatment facilities were originally constructed to serve the local community in 1902. Remnants of that original facility and some of the subsequent treatment upgrades may still be observed. The current treatment facility was constructed in 1985 and treats domestic wastewater from the surrounding service area. Discharge is into the headwaters of the Charles River. During the dry period of the year, the discharged effluent constitutes the entire flow at this point of the river. The collection system suffers from inflow and infiltration problems which cause influent flow to the WWTP to be quite high in response to significant rain events. As a result, influent BOD concentrations are sometimes diluted to below 80 mg/l. Severe rainfall during the preceding week resulted in influent flows being greater than 8 mgd at the time of the site visit. Although the permit limitation for flow is 4.8 mgd, the plant has demonstrated the ability to treat these high flows and still produce an excellent quality effluent.

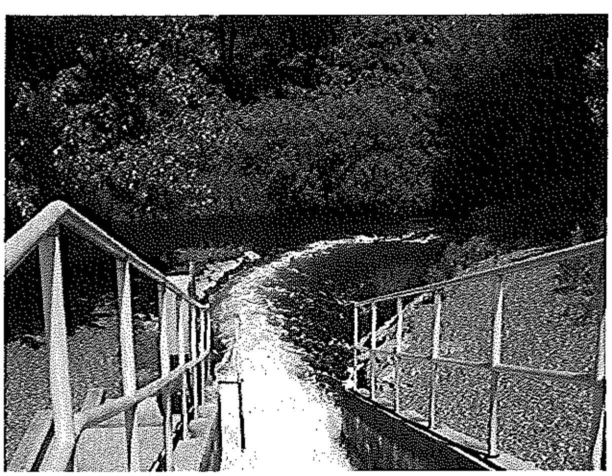
Treatment at the Milford WWTP consists of screening and grit removal; primary clarification; trickling filters; intermediate clarification (with polymer addition to aid settling); rotating biological contactors; secondary clarification; chemical addition using poly-aluminum chloride; filtration through mixed media traveling bed filters; ultraviolet disinfection. The final effluent is discharged down a cascading outfall to achieve reaeration prior to mixing in the receiving water. Approximately 1 mgd per day of the final effluent is utilized by the local power company for cooling water.

Operational considerations:

- A colorimetric method is used for analyzing total phosphorus. The reportable level achieved in the Milford laboratory using this testing methodology is typically about 0.02 mg/l total phosphorus.
- Approximately 17 to 20 gallons of polymer are added prior to the intermediate clarifiers.
- Approximately 300 to 400 gallons per day of PACl are used to flocculate phosphorus. Facility representatives stated the cost of PACl to be $1.50/gallon. So, the total daily cost of PACl ranges from about $450 to $600.
- Removed solids are routed to an aerobic thickener. The concentration of thickened solids coming out of the thickener is only about 3%. Having to haul so much water with these solids represents the largest single cost ($350,000/year) of operating this WWTP.
- The trickling filters and rotating biological contactors appear to be very resilient to increase flows caused by inflow and infiltration. However, the record setting rainfall during the winter months of 2006 had affected treatment removal of ammonia-nitrogen.



Trickling filters at Milford WWTP



Cascading discharge structure into Charles River at Milford WWTP

Alexandria Sanitation Authority (ASA) Advanced Wastewater Treatment Plant

Contact Information:
Alexandria Sanitation Authority
1500 Eisenhower Avenue
Alexandria, VA 22314 1987
Phone: 703-549-3381

Aerial View on ASA Advanced Wastewater Treatment Facility (from ASA staff)

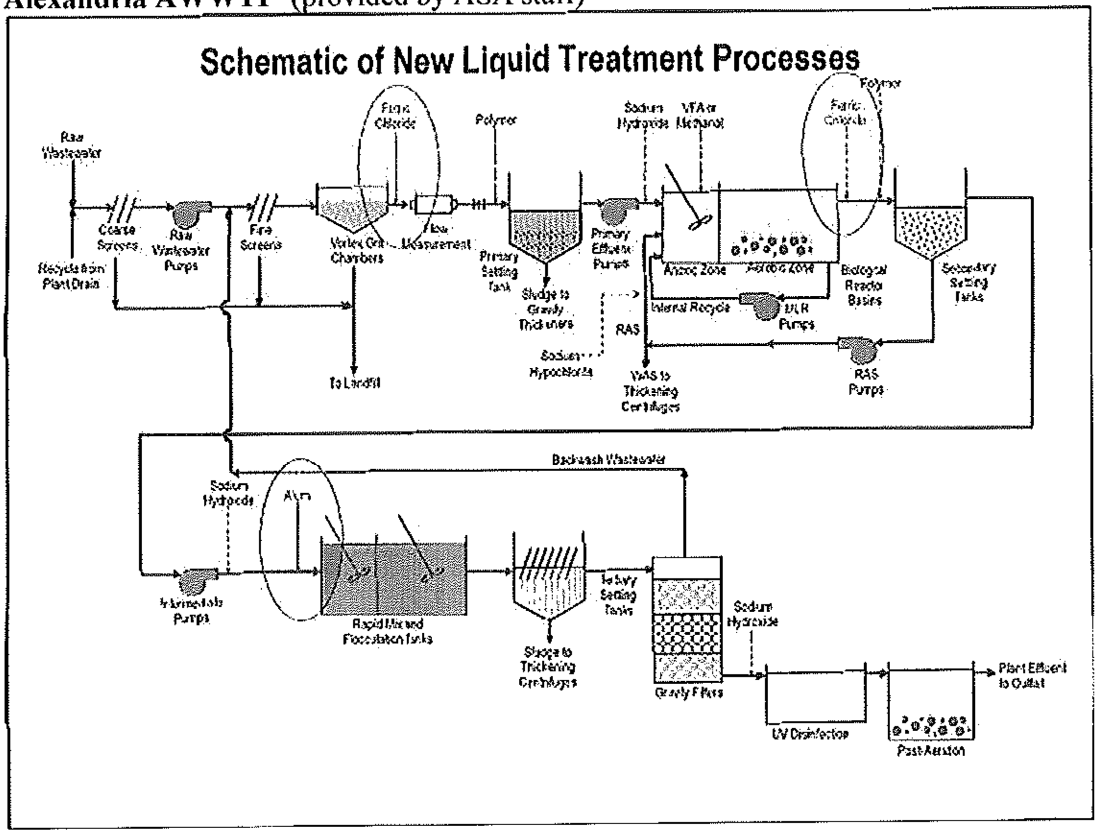
NPDES Permit: No. VA0025160 , expires 20-JAN-2009

Receiving water: Hunting Creek (a tributary to the Potomac River)

Design Treatment Capacity: 54 mgd (average dry weather)

Phosphorus treatment technology: Triple point chemical addition in which ferric chloride is added to primary and secondary settling tank influents and alum is added to the tertiary settling tank influent.

Alexandria AWWTP (provided by ASA staff)



Alexandria Advanced WWTP Performance Information:

Parameter	[1]NPDES Limitation (monthly avg)	Average of monthly averages	Range of monthly averages	Maximum individual measurement	[1]Reporting period
Phosphorus	0.18 mg/l	0.065 mg/l	0.04 to 0.1 mg/l	0.15 mg/l (4/05)	9/04 to 5/06
N-NH3	8.4 mg/l	*<0.1 mg/l	0 to 0.2 mg/l	0.6 mg/l (1/06)	9/04 to 5/06
TSS	6 mg/l	1.5 mg/l	<0.1 to 5.4 mg/l	9.2 mg/l (2/04)	9/04 to 5/06
CBOD	5 mg/l	*<0.1 mg/l	0 to 0.5 mg/l	1.0 mg/l (12/05)	9/04 to 5/06

* Monitoring results during this period were typically reported as zero or less than detection
[1] The summarized monitoring data is inclusive of all values submitted during the reporting period regardless of when seasonal water quality based effluent limitations apply

Monthly household sewer use fee: $4.17 plus $4.49 per 1,000 gallons water used

Facility Description:

The ASA Advanced WWTP treats wastewater with combined storm sewers from a service area of approximately 51 square miles including the City of Alexandria and portions of Fairfax County. The population served is approximately 400,000 people. ASA began construction to upgrade the 54 mgd design flow facilities in 1999 to meet the water quality requirements of the Potomac Embayment Standards and the Chesapeake Bay Agreement. Initial operation of the new Biological Nutrient Removal (BNR) system was achieved in December 2002.

Treatment consists of screening; grit removal; primary settling with possible addition of ferric chloride and polymer; methanol or volatile fatty acid added to biological reactor basins to aid BNR; ferric chloride and polymer addition prior to secondary settling; alum addition and mixing; tertiary clarification with inclined plate settlers; dual media gravity bed filtration; UV disinfection and post aeration. Removed solids are dewatered in centrifuges and the centrate is returned to the primary clarifiers. Then sludge is pre-pasteurized; anaerobically digested; centrifuged again and sent to land application as Class A biosolids. The moisture content of the biosolids after treatment is about 70 percent.

Operational Considerations:

- High influent flows during rain events often exceed 80 mgd. The plant has treated peak influent flows of 108 mgd during extreme storm events.

- The average influent concentration of total phosphorus was reported to be about 4.5 mg/l.

- Operators reported an observed trend of increasing influent concentrations while influent flow has remained steady. Speculation about the cause of these phenomena is that the ASA progressive sewer rates (which are based in part on water usage) have promoted water conservation.

- The facility is currently considering treatment upgrades necessary to achieve a required monthly average effluent target for total nitrogen of 3.0 mg/l.

- Multiple point chemical addition is utilized for phosphorus removal. Ferric chloride is added to primary and secondary settling tank effluents. Alum is mixed into the influent to the tertiary settling tanks. The alum contained in the return stream was reported to aid in phosphorus removal through the plant processes.

- Sodium hydroxide is added to the primary effluent, the secondary effluent and after the gravity filters to increase pH and maintain alkalinity.

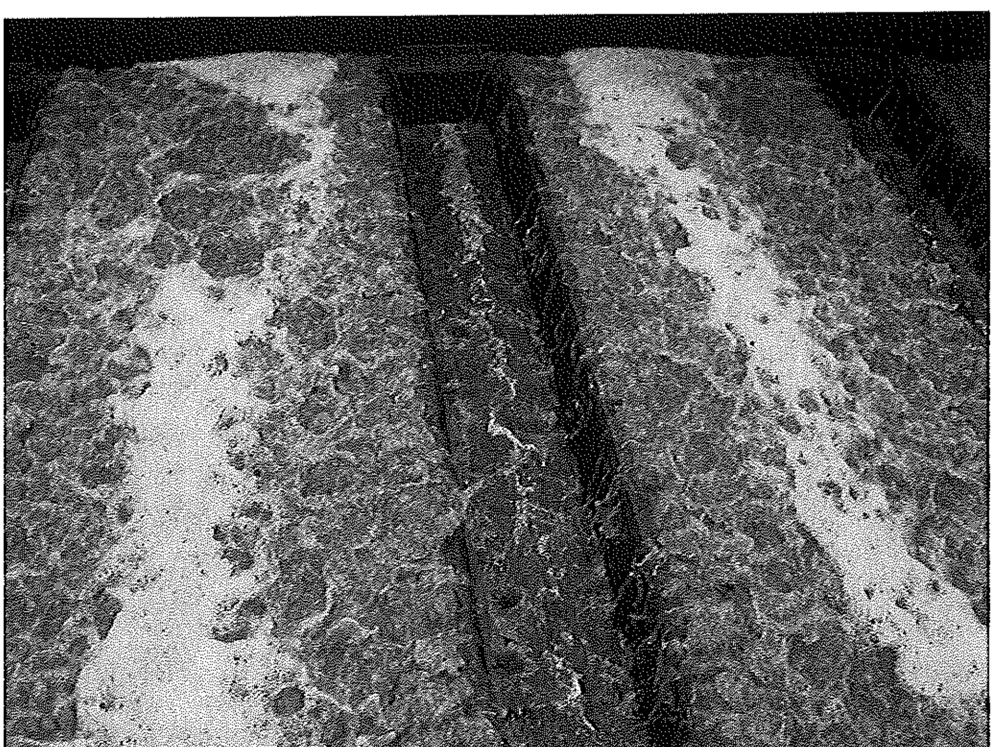
- The concentration of total phosphorus in the secondary effluent is typically about 0.4 to 0.5 mg/l. Facility representatives reported that the average concentration of phosphorus in the final effluent during 2005 was approximately 0.05 mg/l.

- The approximate annual cost for chemicals used in treatment is $2.4 million. This includes $1.4 million for sodium hydroxide, $300,000 each for alum and polymer, and $300,000 for ferric chloride and methanol.

- The plant is equipped with custom-made computerized controls (supervisory control data acquisition system) to enhance the efficiency of operation.

- Biological treatment at ASA includes methanol fed to sequential anoxic and aerobic zones in the secondary process. Primary wastewater is 'step fed' into the secondary basins. A portion of the wastewater from each aerobic zone is recycled back to the preceding anoxic zone.

Chemical mixing paddles in front portion of sedimentation tanks at Alexandria AWWTP



Bed filter undergoing backwash at Alexandria AWWTP

Upper Occoquan Sewage Authority (UOSA)

Millard H. Robbins Regional Wastewater Reclamation Facility

Contact information:
Upper Occoquan Sewage Authority
Millard H. Robbins Regional Water Reclamation Plant
14631 Compton Road
Centreville, VA 20121-2506
Phone No. 703-830-2200

NPDES Permit: No. VA0024988, expiration date FEB-19-2007

Treatment capacity: 42 mgd annual average flow, 128 mgd instantaneous peak flow

Receiving water: Unnamed Tributary of Bull Run Creek (Bull Run is a major tributary of the Occoquan Reservoir)

UOSA WRF Treatment Performance Information:

Parameter	NPDES Limitation	Average of monthly** averages	Range of monthly** averages	Maximum individual measurement	Reporting period
Total Phosphorus	0.10 mg/l	*<0.088 mg/l	0.023 to <0.282 mg/l	0.580 mg/l (2/03)	3/02 to 12/04
TSS	1 mg/l	*<0.549 mg/l	0 to 2 mg/l	NA	3/02 to 9/03 2/05 to 6/06

* estimated average because many measurements were reported as less than (<) values or below detection limit
** Weekly averages for Total Phosphorus

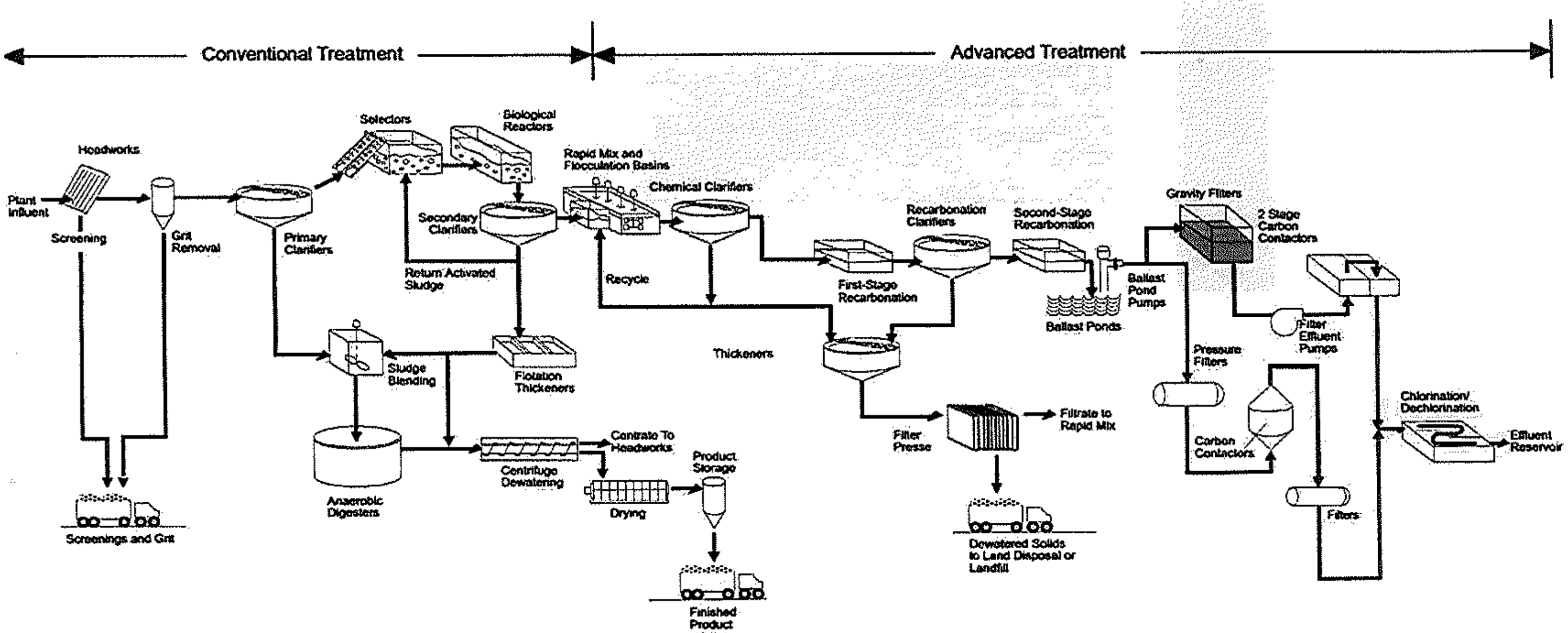
Monthly residential sewer use fees: (of the 4 four UOSA member jurisdictions):

- Fairfax County sewer rates: $3.03/1000 gallons (FY 2004)
- Prince William County sewer rates: $3.75/1000 gallons (FY 2003)
- City of Manassas sewer rates: $4.09/1000 gallons (FY 2004)
- City of Manassas Park sewer rates: $35.00 as monthly Water and Sewer Service Charge (FY 96 through FY 2004)

UOSA Treatment plant schematic (provided by UOSA):
Millard H. Robbins Regional Water Reclamation Plant

Capacity
42 MGD Annual Average flow
54 MGD Peak Month (30-day rolling)
128.4 MGD Peak Instantaneous influent
90 Million gallons on-site emergency storage
7.5 MW emergency generator capacity

Key Permit Requirements	
Chemical Oxygen Demand (COD)	< 10 mg/L
Total Phosphorus (TP)	<0.1 mg/l
Total Suspended Solids (TSS)	<1.0 mg/L
Total Kjeldall Nitrogen (TKN)	<1.0 mg/L
Turbidity	<0.5 NTU



Facility Description:

For nearly 30 years, the Upper Occoquan Sewage Authority (UOSA) has provided advanced wastewater treatment water reclamation for a service area in Virginia that includes portions of Fairfax County, Prince William County, and the cities of City of Manassas, and the City of Manassas Park. Nineteen miles downstream from the UOSA discharge is a drinking water withdrawal from the Occoquan Reservoir that serves approximately 1.3 million people. Around 1972 UOSA selected a biological, physical, chemical treatment process (high lime treatment system) that could reliably produce a high quality reclaimed wastewater that would both protect the quality and augment the amount of water in the reservoir.

The 10 mgd treatment capacity of the original plant has been upgraded in several stages to about 54 mgd since it began operation in 1978. Continuing rapid development and population growth in the service area is again prompting consideration of treatment plant expansion to accommodate the need for additional wastewater treatment capacity. In 1972, the high lime treatment process represented the best technology for consistently achieving the necessary high quality effluent. However, since that time other treatment technologies have evolved that also produce high quality effluent. The next plant expansion may include use of a technology other than high lime treatment.

UOSA maintains and operates this facility with well- qualified staff that routinely provides educational tours of their treatment facility. EPA greatly appreciates that UOSA allowed use of their educational materials for describing the treatment process in this report.

UOSA liquid treatment process is composed of:

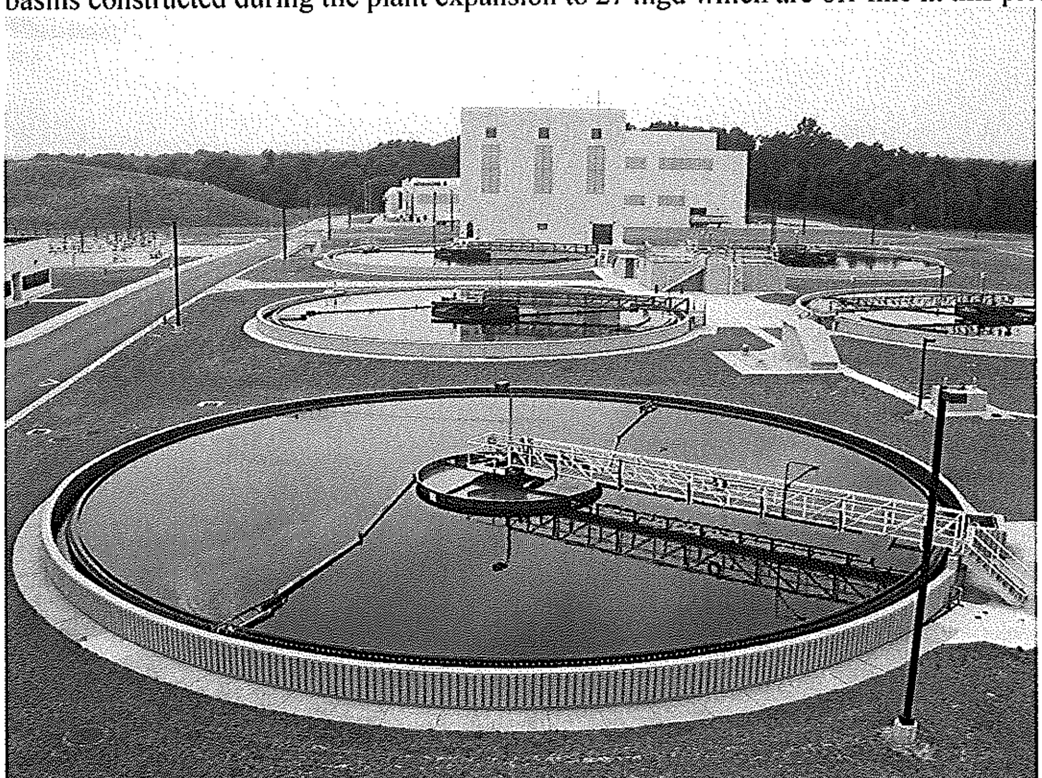
- A conventional treatment that removes 90% of most incoming pollutants: screening; grit removal; primary clarification; aerobic biological selectors; activated sludge aeration basins with nitrification/denitrification processes; secondary clarification.

- A chemical advanced treatment – high-lime process – to reduce phosphorus to below 0.10 mg/l, to capture organics from secondary treatment, to precipitate heavy metals and to serve as a barrier to viruses : lime slurry added to rapid mix basins (to achieve pH of 11); anionic polymer added in flocculation basins; chemical clarification; first stage recarbonation to lower pH to 10; recarbonation clarifiers to collect precipitated calcium carbonate; second stage recarbonation to lower pH to 7; storage in ballast ponds.

- Physical advanced treatment to meet stringent limits for TSS (1 mg/l) and COD (10 mg/l) including alum and/or polymer addition; multimedia filters; activated carbon contactors.

- Disinfection by chlorination/dechlorination process.

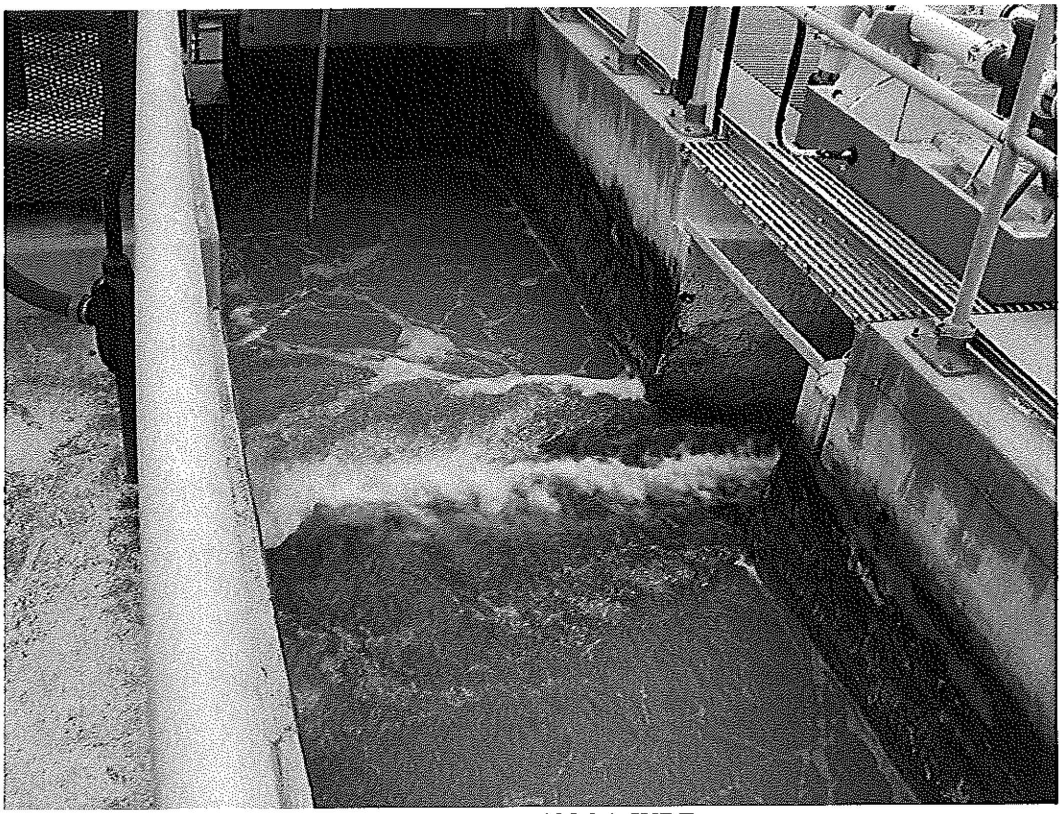
UOSA Water Reclamation Facility (WRF) – in the forefront are fine bubble diffuse aeration basins constructed during the plant expansion to 27 mgd which are off-line in this picture.



Secondary Clarifiers with lime handling buildings in background at UOSA WRF

Removed solids processing at UOSA WRF:

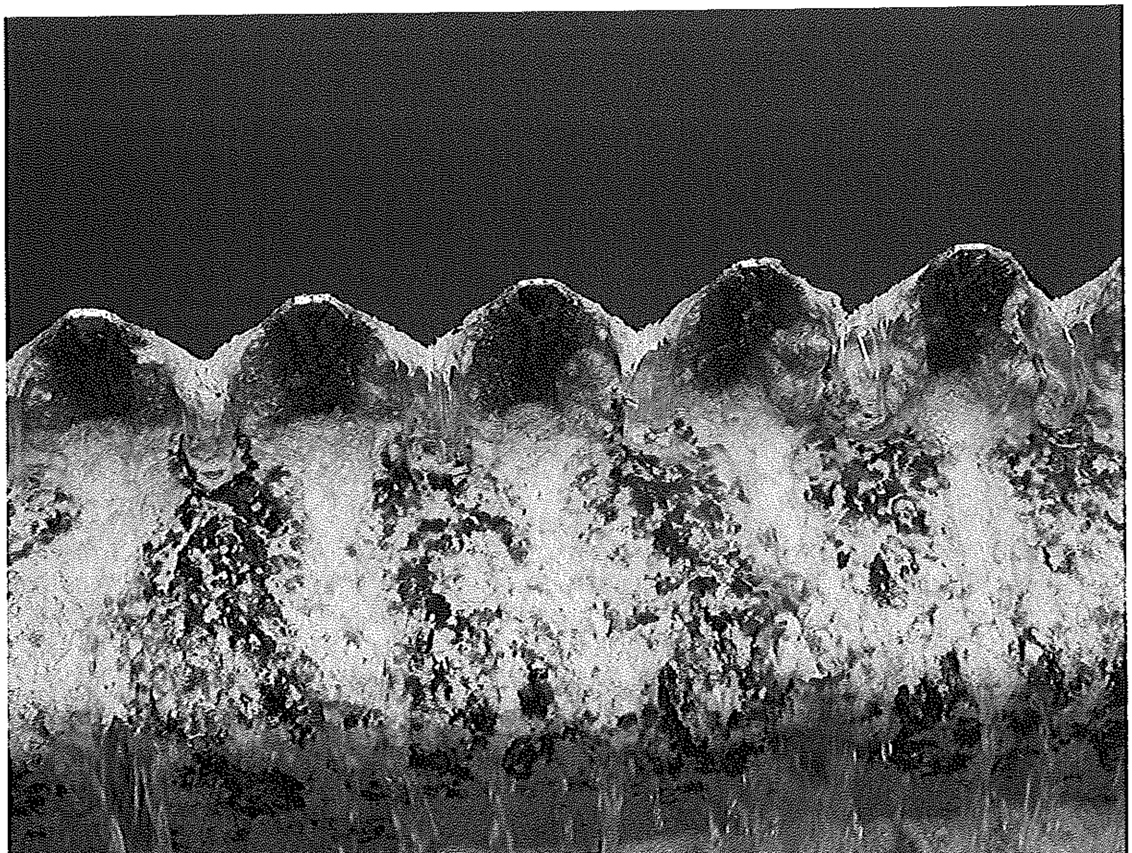
- Primary sludge and waste activated sludge are screened, digested, blended, dewatered by centrifuge and ultimately dried to produce fertilizer pellets.
- Chemical and recarbonation sludge are concentrated by gravity thickeners, filter press and then transported to a UOSA owned captive landfill.



Lime slurry being mixed into wastewater at UOSA WRF

Operational Considerations:

- The UOSA WRF experiences significant increased influent flows as the result of inflow and infiltration into the collection system. Although the annual average design flow into the plant is approximately 42 mgd, peak hourly influent flows of 120 mgd have been experienced during extreme storm conditions.
- Handling and mixing (slaking) lime is "messy". Scaling in the treatment system after lime addition also presents a maintenance problem.
- Operators believe the existing treatment system could achieve even lower levels of phosphorus in the final effluent with additional chemical addition.
- The 2006 operating budget was $21,227,800 to operate and maintain this facility. Over half of this cost is for UOSA staff wages. Electrical power and chemical costs are approximately $2,691,000 and $1,562,000, respectively.



Lime scaling on chemical clarifier weirs at the UOSA WRF

Fairfax County Wastewater Management, Noman M. Cole Jr. Pollution Control Plant

Contact Information:
Wastewater Treatment Division
Noman M. Cole Jr. Pollution Control Plant
9399 Richmond Highway
Lorton, VA 22079
Phone No. 703.550.9740

NPDES Permit: No. VA0025364, expiration date APR-13-2008

Design capacity: 67 mgd

Receiving water: Pohick Creek, tributary of Potomac River and Chesapeake Bay

Noman Cole WWTP Performance Information:

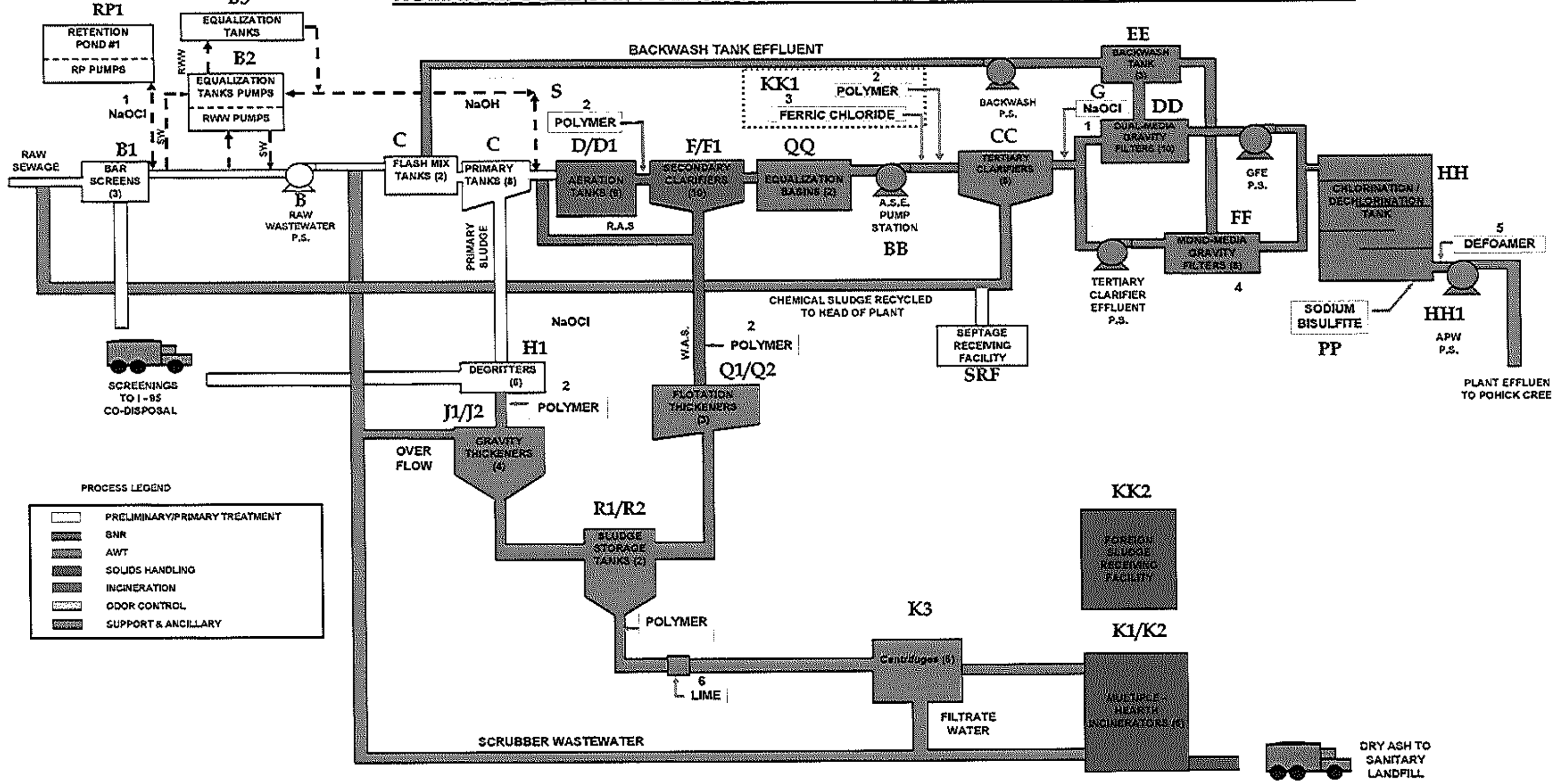
Parameter	NPDES Limitation	Average of monthly averages	Range of monthly averages	Maximum individual measurement	Reporting period
Total Phosphorus	0.18 mg/l	*<0.061 mg/l	<0.02 to <0.13 mg/l	0.20 mg/l (10/05)	4/03 to 6/06
Ortho-phosphorus	none	*<0.057 mg/l	<0.05 to <0.11 mg/l	0.20 mg/l (10/05)	4/03 to 6/06
NH3 - N	**1 mg/l	*<0.040 mg/l	0 to 0.20 mg/l	0.64 mg/l (10/05)	4/03 to 6/06
BOD	5 mg/l	below detection limit	Non detectable to <2 mg/l	2 mg/l (4/03)	4/03 to 6/06
TSS	6 mg/l	*<1.21 mg/l	0 to 3.5 mg/l	4.1 mg/l (12/04)	4/03 to 6/06

* Many measurements were reported as less than (<) values or below detection limit
** Seasonal limitation : from April to October (2.2 mg/l from November to March)

Monthly sewer use fee: $ 3.28/1000 gallons used. The average monthly residential fee is $21.

PROCESS FLOW DIAGRAM

NOMAN M. COLE,JR., POLLUTION CONTROL PLANT, COUNTY OF FAIRFAX, VIRGINIA

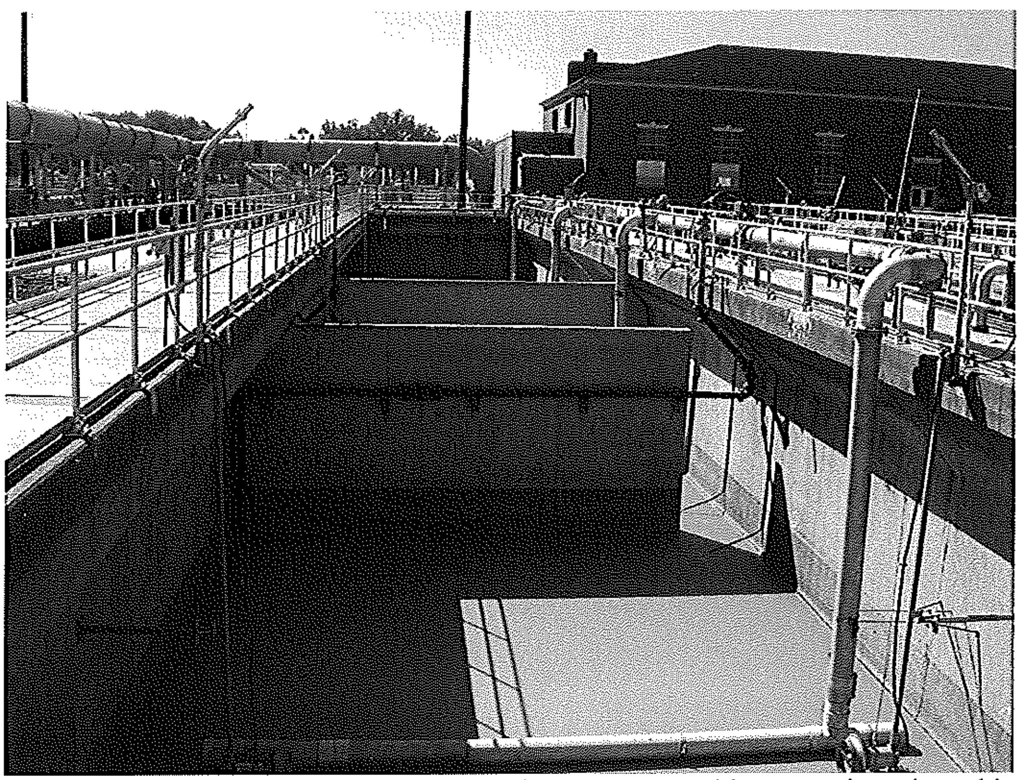


(Diagram provided by Fairfax County WWTP staff)

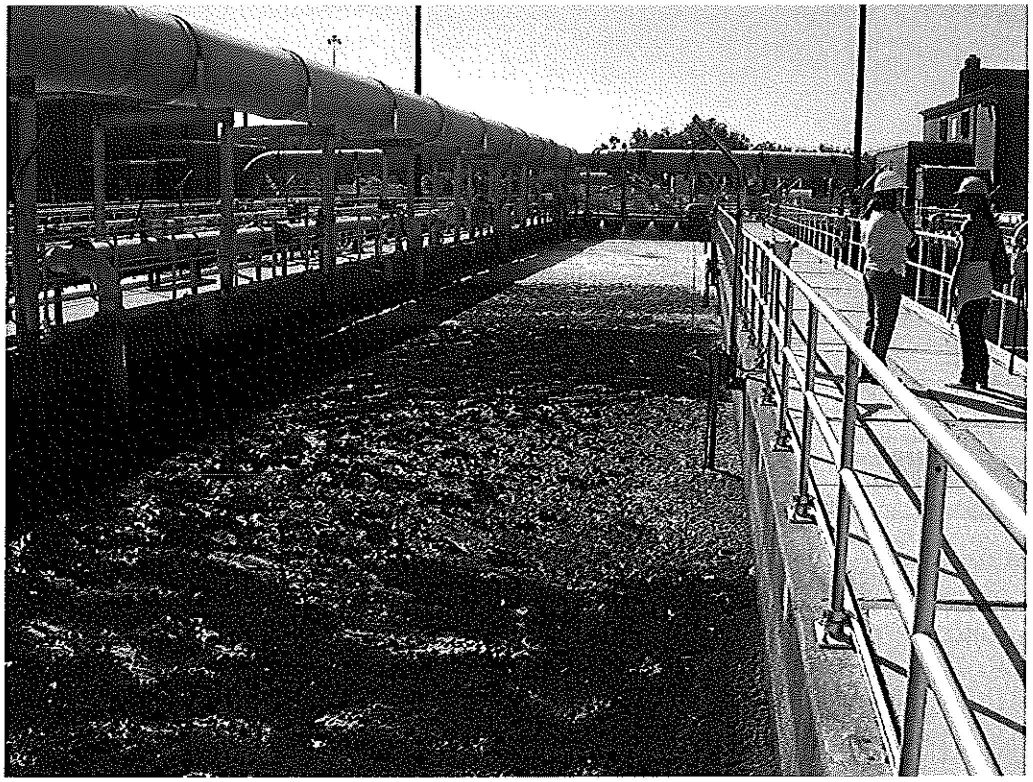
Facility Description:

Fairfax County is one of 15 counties and cities in Virginia and Maryland that comprise the Washington D.C. Metropolitan Statistical Area. Fairfax County owns and operates the Noman M. Cole Jr. Pollution Control Plant. This facility receives mostly domestic wastewater from over 3,200 miles of sewer lines in the service area and currently treats an average influent flow of 45 mgd. This and other municipal dischargers to the Potomac River and Chesapeake Bay are required to achieve monthly and weekly average permit limitations for total phosphorus of 0.18 and 0.27 mg/l, respectively. A monthly average limitation of 3 mg/l for total nitrogen will become effective in the year 2010.

Treatment at the Noman Cole Plant consists of screening; primary clarification (covered for odor control); biological treatment with enhanced biological nutrient removal (BNR); polymer addition as needed; secondary clarification; equalization and storage in retention ponds; tertiary clarification with ferric chloride addition to remove phosphorus; disinfection with sodium hypochlorite; filtration through dual/mono media gravity bed filters. Tertiary sludge is routed to a gravity thickener to create volatile fatty acids (VFAs) which are added to aid the biological phosphorus removal process. Removed solids from the primary and secondary clarifiers are dewatered by lime addition, filter presses and centrifuge, and then incinerated in multiple hearth incinerators. The inert ash is hauled by truck to a landfill.



Baffles installed in wastewater contact basin (empty) to achieve anoxic and aerobic conditions for enhanced biological nutrient removal at Noman Cole PCP.



Wastewater contact basin in operation at Noman Cole PCP

Operational considerations:

- The combination of biological nutrient removal, chemical addition with tertiary clarification and filtration effectively reduces total phosphorus concentrations to well below the 0.18 mg/l permit limitation. Other pollutants such as BOD, TSS and fecal coliform are also reduced to very low levels through these treatment processes.

- The amount of ferric chloride added in the tertiary clarifier to remove phosphorus has been reduced since biological phosphorus removal was implemented. The ferric chloride dosage before installation of biological nutrient removal was 18 to 20 mg/l. The concentration used now is down to 9 to 10 mg/l.

- The treatment processes are continuously being evaluated and optimized by staff with the goal of consistently meeting permit limitations in the most cost effective manner.

- Treatment upgrades necessary to meet the new nitrogen limitation are currently being considered. It is likely that methanol addition and other changes to the biological treatment train will be made to enhance nitrogen removal from wastewater.

- Opportunities to reuse the high quality final effluent for irrigation or as cooling water are being considered.

- The Noman Cole annual operating budget is reported to be approximately $18 to $20 million.

- Ferric chloride costs in 2005 were about $180,000.

Empty tertiary clarifier at Noman Cole PCP

Blue Water Technologies, Inc– Full scale pilot facility installed at the Hayden Area Regional Wastewater Treatment Plant

Contact Information:
Hayden Area Regional Wastewater Treatment Plant
10108 North Atlas Road
Hayden, ID 83835

Blue Water Technologies, Inc:
10108 10450 North Atlas Airport Road
Hayden, ID 83835
Phone No 208-209-0391
Website: www.blueh2o.net

NPDES Permit: No. ID0026590, expiration date 02-NOV-2004

Design capacity of Hayden WWTP: 1.65 mgd

Receiving water: Spokane River

Monthly sewer use fee: Company representatives estimate that were the Blue PRO phosphorus removal system added to the existing Hayden WWTP as tertiary treatment, the residential sewer use fee would increase by only $1.20 / month to cover all costs of construction and operation. Company representatives estimate the capital cost for the Blue PRO phosphorus removal system as tertiary treatment is $178,000 for a 1-mgd treatment plant and $494,000 for a 3-mgd treatment plant.

Facility Description:

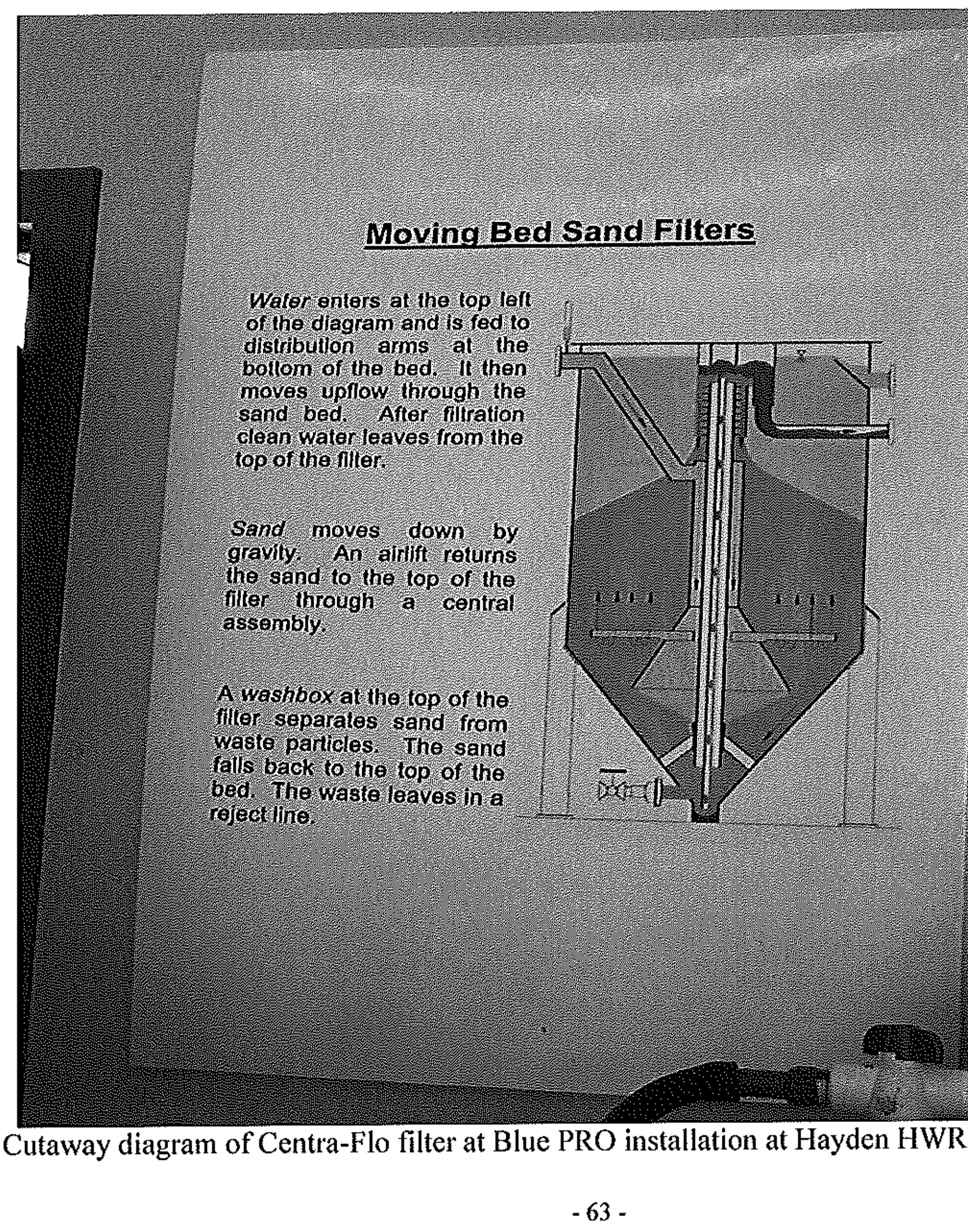
The Hayden WWTP is operated by the Hayden Area Regional Sewer Board, serving the greater Hayden, Idaho, area. The permitted plant flow is 1.65 mgd. All of the treated wastewater is utilized for silvacultural irrigation during the warm, dry summer period. During the other times of the year, WWTP effluent is discharged into the Spokane River. The quality of the Spokane River and Long Lake are documented as being impaired by excessive loading of nutrients during the summer period. An intensive water quality evaluation effort by the State of Washington determined that phosphorus loading from the point source dischargers must be significantly reduced to restore water quality. A TMDL is currently being developed by the state which will specify very low wasteload allocations for discharges into the river.

Treatment at the Hayden WWTP consists of screening and grit removal; oxidation ditches (2) with mechanical mixers; secondary clarification (3); and chlorine disinfection. Removed solids are aerobically stabilized and dewatered by a belt filter press. Although the Hayden WWTP is capable of providing treatment to nitrify ammonia, it is typically not operated in a nitrification mode during the summer months when the effluent is land applied.

Blue Pro filtration at the Hayden Wastewater Research Facility:

In 2004, Blue Water Technologies, Inc and the University of Idaho, in conjunction with the Hayden Area Regional Sewer Board constructed a full scale wastewater research facility to develop and test their treatment system. This installation is called the Hayden Wastewater Research Facility (HWRF). HWRF uses secondary effluent from the WWTP prior to chlorine addition and has the capacity to treat about one fourth of the total plant discharge.

Concentrations of phosphorus in the Hayden WWTP influent are typically about 7 to 9 mg/l. After secondary treatment the concentration of total phosphorus in the Hayden secondary effluent (without Blue PRO in operation) is typically about 4 mg/l. Since one purpose for testing this technology was to demonstrate how well it would perform as an add-on tertiary treatment to a secondary WWTP, the Hayden facility represented a good choice to test this technology.



Cutaway diagram of Centra-Flo filter at Blue PRO installation at Hayden HWRF

The Blue PRO technology combines co-precipitation and sorption to remove both particulate and soluble phosphorus. Through these processes, some phosphorus is precipitated and removed from water as it moves upward though the sand media. At the same time, some phosphorus is adsorbed onto the hydrous ferric oxide coated sand. This adsorption mechanism allows the process to achieve very low concentrations of phosphorus in the effluent. The phosphorus is then removed from the sand through abrasion and separated in the sand washer at the top of the filter. The treatment process installed at the HWRF is composed of:

- a pre-reactor where coagulant (ferric sulfate) is added and mixed with the secondary effluent;
- two continuous backwashing, upflow sand bed filters. The size of each filter is 14 feet deep, with a surface area of 50 square feet. The filters can be operated as single-pass or sequentially as a two-stage filtration system. The reject stream (around 7-8% of the flow to the filters) is recycled to the headworks of the Hayden WWTP.

A long-term, steady-state study was conducted from December 2005 through February 2006 using 0.25 mgd of the Hayden secondary effluent. Blue PRO was operated as a two-single-pass stage filtration system in December and as a two-stage filtration system in January and February during the study, although the second stage was not optimized until halfway through December. The reject stream (containing phosphorus and solids removed in the filters) returned to the WWTP headworks were observed to cause the phosphorus removal efficiency through the secondary process to improve significantly. This is likely the result of dosing the WWTP influent with the ferric compound used in the Blue PRO process. Concentrations of total phosphorus in the secondary effluent were observed to drop from 4 mg/l to about 1 mg/l during the steady state study. The monthly averages of total phosphorus in the Blue PRO effluent obtained during this steady-state study are:

- 0.036 mg/l in December (second stage filtration not optimized)
- 0.009 mg/l in January
- 0.016 mg/l in February
-

The average effluent TSS concentration using two-stage filtration during the study was about 1 mg/l. Considering all data from 2005 through 2007, the average phosphorus result was 0.014 mg/L TP, with a standard deviation of 0.006 mg/L. Based on the results of long term testing, Blue Water representatives state their phosphorus removal system can consistently achieve an effluent quality of less than 0.030 mg/l total phosphorus. This performance may vary when applied to the effluent of a different WWTP. Mobile pilot treatment facilities have been constructed and deployed to test the Blue PRO treatment process at other WWTPs. Results similar to those demonstrated at the HWRF have been achieved in these pilot studies.

A next-generation technology termed "Blue CAT" is currently in operation at HWRF. This patent-pending process adds an advanced oxidation component to the base Blue PRO process, achieving oxidation potentials up to 875 mV. In addition to improving phosphorus and solids removal over Blue PRO, this new technology adds disinfection to <2 cfu/100 mL and destructive removal of emerging micropollutants, such as endocrine disruptors, pharmaceuticals, and pathogens. The Blue PRO long-term, steady-state study report and other information about the Blue PRO phosphorus removal system are available from the Blue Water Technologies, Inc. website: www.blueh2o.net. Attributes claimed by this treatment system include:

- high efficiency, removing 99%+ of TP from municipal wastewater,
- low chemical dose, typically 6-10 mg/L Fe
- continuously flowing filtrate – no interruption for backwashing,
- low capital, operating, and maintenance costs (total for 1 MGD and 1 pass : less than $34.7300/lb of P removed),
- minimal sludge production, may improve sludge quality and reduce handling costs,
- works effectively without pH adjustment,
- highly tolerant of interfering water chemistry – wide usage
- significantly lowers turbidity and BOD (40% BOD removal and 80% TSS removal during the steady-state study),
- does not affect transmissivity for UV disinfection,
- mobile treatment units available,
- arsenic, selenium, and heavy metals such as zinc may also be removed.
- the Blue PRO tertiary treatment may also be adapted to denitrify through the filter(s).); installations achieve <3 mg/L total nitrogen.

CoMag™ Technology – Concord Wastewater Treatment Plant

Contact Information:
Concord Public Works Water/Sewer Division
135 Keyes Road
Concord, MA 01742

CoMag Process
Ray Pepin, Senior Engineer
Cambridge Water Technology (CWT)
Suite 100
41 Hutchins Drive
Portland, Maine 04102
207-774-2112 x3349

NPDES Permit: No. MA0100668, expiration date 28-FEB-2011

Design capacity: 1.2 MGD as average daily flow and 4.0 maximum daily flow

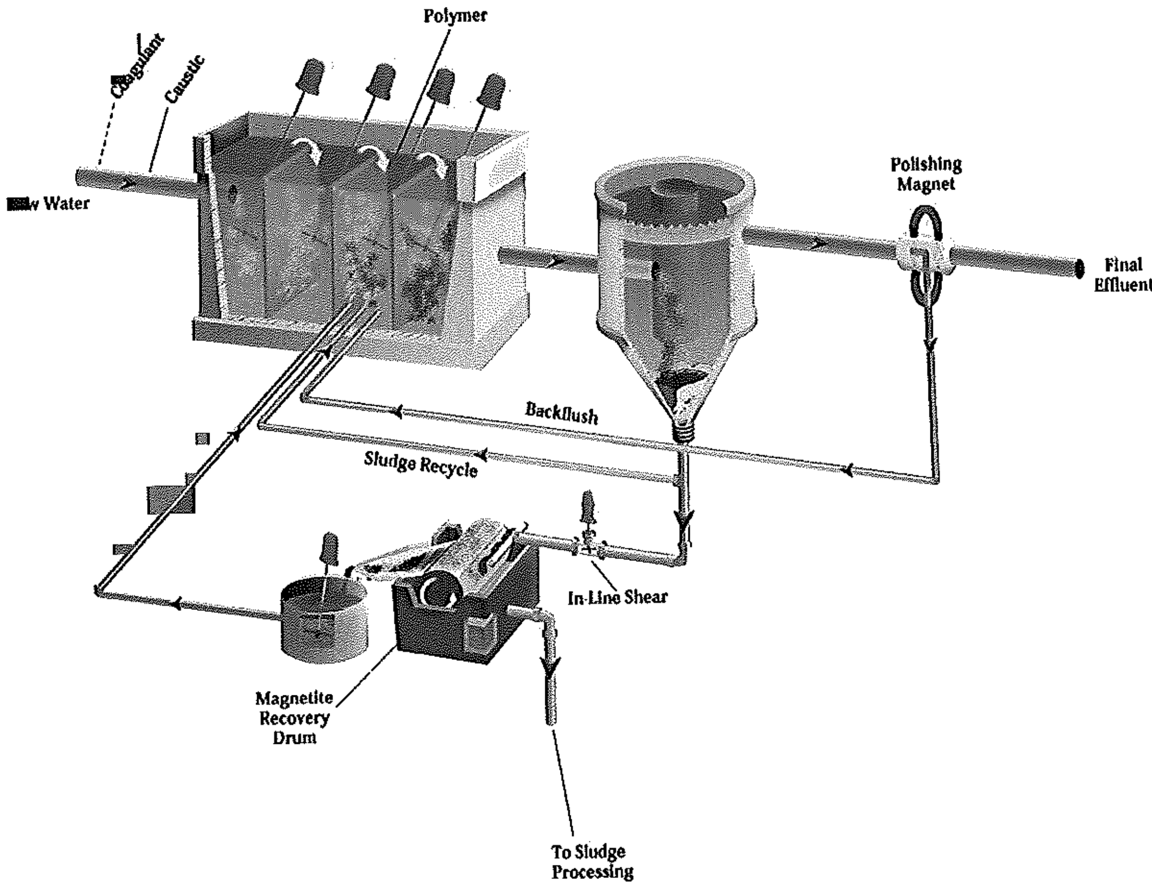
Receiving water: Concord River

Facility Description:

The existing Concord WWTP was built in 1986 and has a 1.2 mgd monthly average annual permitted discharge flow and discharges to the Concord River. Treatment through this WWTP currently consists of headworks, primary settling; trickling filters; secondary clarification; sand filters; and chlorine disinfection. Water quality of the Concord River is impaired, partially because of excessive amounts of nutrients entering the river. The seasonal total phosphorus effluent limitation which applies from April to October was lowered from 0.75 to 0.2 mg/l. The existing facility could only produce an effluent with a TP concentration of 0.6 to 0.7 mg/l by adding alum in advance of the secondary clarifiers. Therefore, a plant upgrade was needed to meet the proposed phosphorus limit and restore the quality of the receiving water.

The Concord WWTP is currently undergoing upgrade construction which, in addition to installing tertiary treatment for phosphorus removal (CoMag™), will improve the headworks, provide a new sludge dewatering process and switch from chlorine to UV disinfection. The tertiary process specification also required that the process be capable of meeting permit limits with one CoMag™ clarifier off line at maximum daily flow. The budget cost for the entire upgrade is $9.7 million, of which the CoMag™ process itself is less than 1/3 of the installed cost. The CoMag™ process supplier has certified that its treatment process will be capable of consistently achieving an effluent total phosphorus concentration of <0.05 mg/l.

CoMag™ Treatment Process:



CoMag is a "magneto-chemical" wastewater treatment process that incorporates the use of finely divided magnetic ballast to bind precipitated phosphorus and other fine particulates. The technology evolved from the minerals processing industry and all unit operations have been utilized for many years. Magnetite provides a "magnetic ballast seed" that when mixed with alum and polymer increases both flocculation and settling rates. These properties reduce the tank sizes necessary to remove the floc from wastewater. Since the floc particles are attracted to a magnet, High Gradient Magnetic Separation (HGMS) is used for final effluent "polishing filtration" rather than traditional sand filtration or membrane systems. The unit area flow rates that can be treated through the HGMS are claimed to be 50 times greater than those of traditional filters. The ballast seed is recovered from removed solids and from the effluent.

The CoMag™ process was selected for installation at the City of Concord because long-term pilot testing demonstrated its ability to achieve high phosphorus removal efficiencies at comparatively low costs. Other factors that prompted the Concord WWTP decision to install CoMag™ included:

- Reduced chemical doses are required to achieve low effluent total phosphorus concentrations, resulting in lower operational costs.
- CoMag™ utilizes simple clarifiers that are one-tenth the size of conventional clarifiers and does not require lamella style tubes which can plug or foul, thereby reducing capital costs and footprint requirements.
- The magnetic separator has a footprint 2 to 5 percent of the size required for conventional filtration processes.
- Ballasted sludge is very dense and cohesive, with little carry over of pin floc from the clarifier, even at high overflow rates, thereby allowing CoMag to handle wide variations in flows and loads.
- Ballasted sludge settleability is dependable and predictable.
- Ballast recycling and recovery is highly efficient and minimize ballast usage.
- The CoMag™ process has proven to be effective in removing TSS, metals, color, turbidity, pathogens and other pollutants.
- The process is simple and robust. All maintenance items are easily accessible and readily available. No specialized tools or training are required to operate or maintain the process.

* Information about CoMag™ was provided by company representatives at the Concord WWTP or extracted from the article "CoMag™ Process Achieves Low Effluent Total Phosphorus Levels While Reducing Footprint and Cost" by Steve Woodard.

LOTT Budd Inlet Wastewater Treatment Plant

Contact Information:
LOTT Budd Inlet Treatment Plant
500 Adams Street N.E.
Olympia Washington 98501-6911

NPDES Permit No. WA0037061, expiration date SEP-30-2010

Design capacity: 28 mgd

Receiving water: Budd Inlet (South Puget Sound)

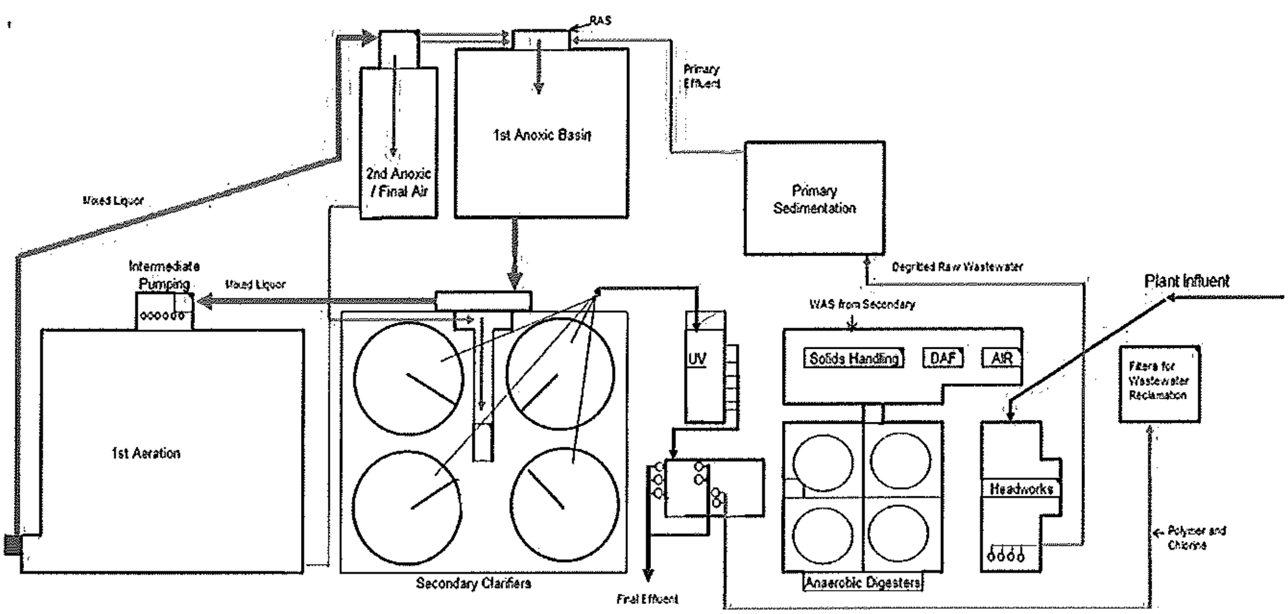
LOTT Budd Inlet Treatment Performance Summary:

Parameter	NPDES Limitation	Average of monthly averages	Range of monthly averages**	Maximum reported measurement (date)**	Reporting period
Total Inorganic Nitrogen	* 3 mg/l	2.2 mg/l	1.23 to 2.81 mg/l	2.81 mg/l (4/04)	4/03 to 9/06
BOD	* 9 mg/l	4.17 mg/l	2.14 to 8.66 mg/l	16.5 mg/l (5/06)	4/03 to 9/06
TSS	30 mg/l	7.15 mg/l	2.75 to 12.3 mg/l	21.3 mg/l (3/06)	1/03 to 9/06

* Seasonal limitation
** Data from period when seasonal limitations apply

Monthly residential sewer fee: $25.50

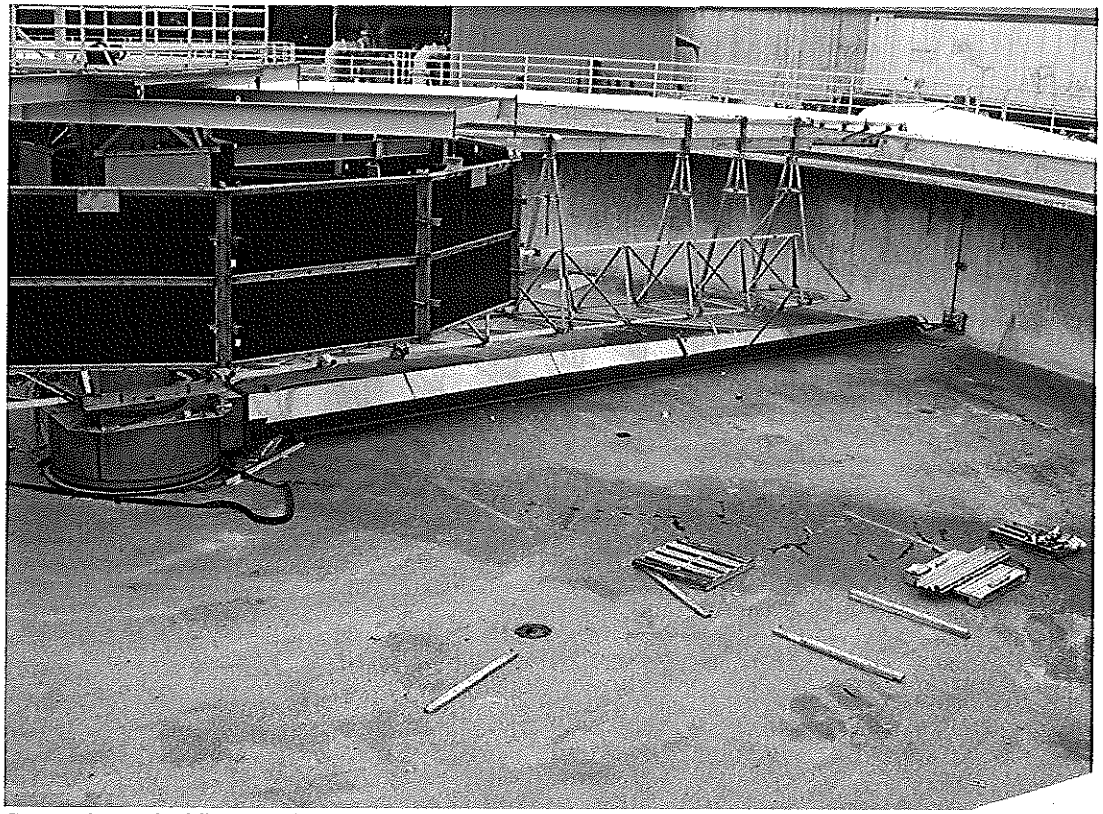
LOTT Budd Inlet WWTP Treatment Schematic:



Facility Description:

The LOTT Budd Inlet Treatment Plant provides advanced treatment of wastewater collected from a service area that includes the cities of Lacey, Olympia and Tumwater plus portions of Thurston County. These entities form the LOTT Alliance which operates the regional WWTP. Treated effluent is discharged into the marine waters of Budd Inlet which is located at the southern end of Puget Sound. This part of Puget Sound is poorly flushed and is very sensitive to nutrient loading, especially during the late spring through fall period. Excessive nutrient loading is blamed for low dissolved oxygen and excessive aquatic plant and algae growth in these waters. A TMDL is currently under development by Washington State for this water body which is expected to establish wasteload allocations (WLAs) for the Budd Inlet Treatment Plant as well as for other sources of nutrient loading. Although these WLAs have not yet been determined, it is a fact that Budd Inlet does not have any capacity for additional nutrient loading during the critical warm weather season.

The LOTT facility has undergone many changes since it was upgraded to provide secondary treatment in 1982. During this time most of the storm water collection systems have been separated from the sewage collection system, although a small portion in the downtown Olympia sewer is still a combined system. The original UNOX wastewater treatment basins were converted and additional tankage built to provide anoxic, aerobic; second anoxic and final aerobic wastewater contact areas necessary to accomplish enhanced biological nutrient removal (EBNR) of nitrogen. A high internal recycle rate of about 4:1 is maintained to provide adequate contact time for wastewater treatment through EBNR. This recycle rate means that for every 10 mgd of wastewater influent treated about 50 mgd is routed through the treatment system. The mixed liquor suspended solids concentration is maintained at about 1800 mg/l in the contact basins. This represents a solids retention time of about 20 days. Many other improvements to improve treatment efficiency at the LOTT plant are currently under construction or are being planned.



Secondary clarifiers undergoing upgrade construction at LOTT's Budd Inlet Treatment Plant (2006)

In addition to primarily domestic wastewater, LOTT received high strength wastewater from the Olympia brewery until that facility closed about three years ago. The resulting changes to the character of the influent wastewater required significant adjustment in operation of the WWTP. One associated change was that LOTT began adding methanol to provide food for the bacteria necessary to accomplish denitrification of the wastewater. Additional adjustments to wastewater recycling within the treatment system and to operation of the aeration basins have maintained excellent nitrogen removal efficiency. With the operation experience gained over time, these adjustments have significantly reduced the need to add methanol. At the time of the EPA visit to the LOTT WWTP, continuous monitors indicated that the total inorganic nitrogen level of the final effluent was less than 1 mg/l (0.1 mg/l NH3-N + 0.59 mg/l NO3-N + 0.1 mg/l NO2-N = 0.79 mg/l TIN).

Treatment at LOTT consists of: flow into an influent equalization basin (2.25 mgd); screening; grit removal; primary clarification; EBNR (methanol is added to the second anoxic basin); secondary clarification and ultraviolet disinfection. Removed solids are routed to dissolved air flotation thickeners, stabilized in anaerobic digesters, and dewatered by centrifuge before being disposed by land application. Centrate from the centrifuge is metered back into the primary effluent.

A portion of the LOTT effluent is reclaimed and utilized for irrigation of public lands. The final effluent destined for reuse is provided filtration through single-stage, continuous back-washing Parkson sand filters. These filters are each 14 feet deep and configured in three banks of two filters. Polyaluminum chloride (PACl) is added to aid filtration effectiveness. Additional disinfection is provided by chlorination.

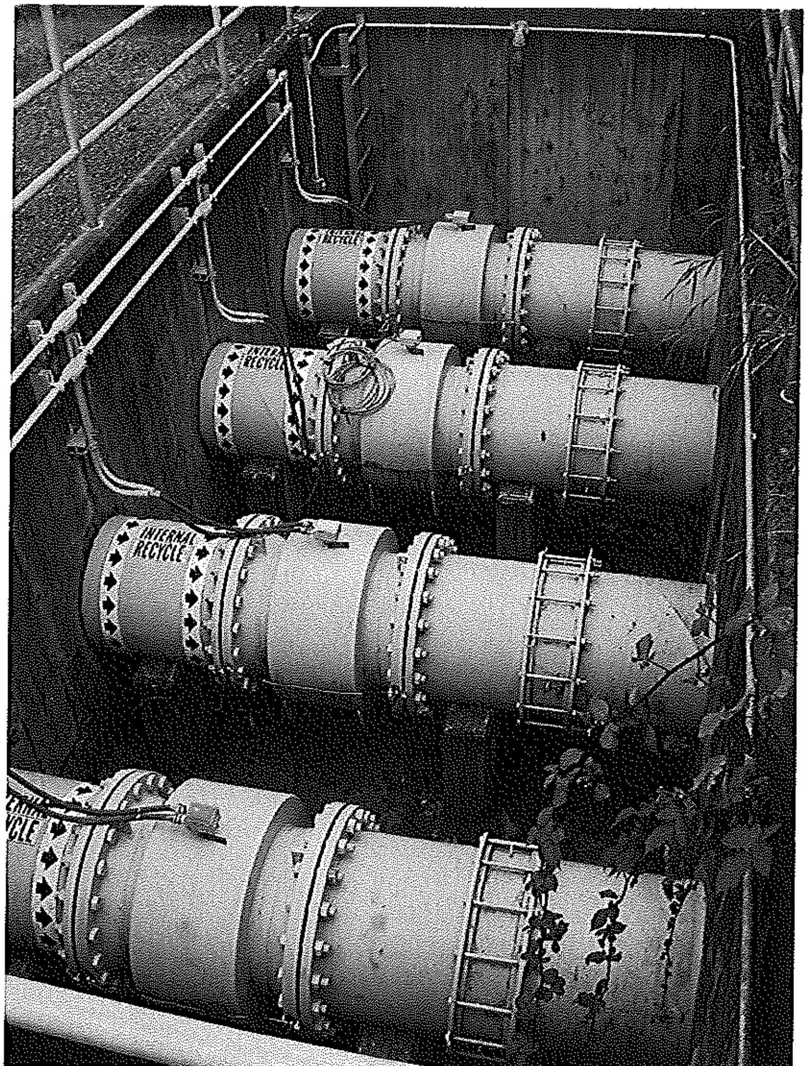
Planning for the Future:

The rapid development and population growth in the South Puget Sound service area required the LOTT partners to carefully plan to meet future wastewater treatment needs. The marine waters of Budd Inlet are already impaired by excessive loading of nutrients and this situation precludes the option of simply increasing treatment capacity and discharge at the main plant. Although the existing LOTT plant already achieves about the best nitrogen removal that current biological treatment technology can accomplish, there is simply no assimilative capacity in South Puget Sound for additional nutrient loading during the critical period.

LOTT implemented numerous water conservation programs in the service area and began promoting use of reclaimed wastewater for irrigation and groundwater recharge. LOTT also decided to meet the need for additional wastewater treatment capacity by constructing 'satellite' facilities. These satellite wastewater treatment plants are located in areas needing sewer service where land is still available to accommodate reuse of the effluent. Advanced treatment is provided at the satellite WWTPs to meet state requirements for reclaimed wastewater such that it may be utilized for groundwater recharge and/or irrigation during the dry summer months. The first of the planned satellite treatment plants is a two mgd membrane bioreactor treatment plant that was placed in operation in 2006. The membranes are hollow fiber filaments produced by U.S. Filter Corporation. Treated effluent from this satellite WWTP is reclaimed and used for groundwater recharge. Solids removed during treatment at the satellite plant are returned to the sewer main for handling at the Budd Inlet WWTP. Land was recently purchased by LOTT for construction of a second satellite plant.

Operational Considerations:

- The five trains of aeration basins have excess capacity and only two of the five basins are typically needed to treat wastewater flows during normal dry weather. The aeration delivery system installed in these basins is somewhat limiting to operational control.
- Adjusting aeration (DO setpoints) has significantly reduced the need to add methanol as supplemental feed for bacteria necessary for nitrogen removal. Methanol is only fed during nighttime hours. Methanol currently costs about $1.60 per gallon (delivered to the plant).
- Nitrate concentration measured in the aeration basin effluent is used for process control for determining how much food additive (methanol) to use.
- Oxidation/reduction meters are installed and connect to the SCADA system to assist with operational control.
- A high internal recycle rate (4 gallons recycled: 1 gallon treated) is necessary to achieve the desired effluent quality. The electricity and maintenance costs associated with internal recycle pumping are quite expensive.



24 inch internal recycle piping at LOTT's Budd Inlet WWTP

- There have been some problems with filamentous bacteria (Microthrix parvicella). Operators are experimenting with polyaluminumchloride (PAX) to control this organism.
- Sludge collectors in the secondary clarifiers are being upgraded.
- An operational goal is to keep total inorganic nitrogen levels in the final effluent under 2 mg/l to insure that the 3 mg/l permit limitation is met consistently.

Footnote 7

Setting Phosphorus Targets in the Spokane TMDL
to meet Dissolved Oxygen Criteria
4/1/09

Background

Following the request from EPA for Ecology to postpone submittal of the 2008 draft TMDL, an interagency workgroup comprised of IDEQ, Ecology, EPA, and the Spokane Tribe of Indians collaborated through the latter part of 2008 into 2009 to develop a revised list of modeling scenarios for the TMDL. A key change in the TMDL direction was an agreement between agencies and stakeholders that Avista be considered in the TMDL for their contributions to dissolved oxygen levels in Lake Spokane. Therefore, the goals of this modeling effort are to develop a scenario or set of scenarios that will allow the TMDL to:

- Distinguish the dissolved oxygen impacts caused by Long Lake Dam from impacts caused by excess nutrients from the upstream Dischargers and
- Determine the cumulative impact on dissolved oxygen in Lake Spokane by upstream Dischargers.

In order to meet these goals, it became clear that a different modeling approach and new set of scenarios are necessary to assign a quantitative value for a dissolved oxygen impact caused by Long Lake Dam. The new TMDL scenarios will rely on a two step process to determine allocations, involving two assessment points in Lake Spokane:

1. The first step involves setting an assessment point in the riverine portion of Lake Spokane. A modeling scenario will then use pre-determined total phosphorus wasteload allocations for upstream Dischargers and tributary nonpoint load allocations designed to meet this riverine assessment point.
2. Modeled results from the first step will then be used to analyze dissolved oxygen in the lake, using a second assessment point that is based on an average of the lake conditions.

This will provide the framework for a "dual assessment point" concept: riverine nutrient allocations and dissolved oxygen targets in the lake. The dual assessment point concept is a significant change from past modeling, which did not try to differentiate the effects on dissolved oxygen caused by point source dischargers from the effects caused by Long Lake Dam. Modeling results using the dual assessment point concept will allow the TMDL to determine discharger wasteload allocations, tributary load allocations, and Avista's dissolved oxygen requirement.

What Steps and Assumptions make up this dual assessment concept?

1. Set a target total phosphorus concentration for the riverine portion.

   After technical analysis and review of data, a total phosphorus concentration of 10 µg/L was chosen for the riverine model assessment target. This target represents an approximate 60% reduction from the current water quality standard concentration of 25 µg/L in Lake Spokane, which was shown not to be protective of water quality

(Cusimano, 2004). The following section of the Washington State water quality standards apply when the existing phosphorus concentrations are not protective of water quality:

> WAC 173-201A-230
> 3 (b) Determine appropriate total phosphorus concentrations or other nutrient criteria to protect characteristic lake uses. If the existing total phosphorus concentration is protective of characteristic lake uses, then set criteria at existing total phosphorus concentration. If the existing total phosphorus concentration is not protective of the existing characteristic lake uses, then set criteria at a protective concentration.

In the WAC, 10 µg/L is the phosphorus concentration that delineates between oligotrophic and lower mesotrophic.

Using Carlson's (1996) trophic state index, the existing standard of 25 µg/L TP was on the mesotrophic / eutrophic line, while our new target of 10 µg/L gives an index of 37, which is on the oligotrophic / mesotrophic line. The goal of the TMDL is to push Lake Spokane toward an Oligotrophic state as opposed to a continuation of the eutrophication that existed with the 25 µg/L TP standard.

Further, this target is recommended in EPA's *Ambient Water Quality Criteria Recommendations* for rivers and streams in ecoregion II. Therefore, Ecology believes this is a reasonable target to base the modeling on.

This target concentration provides the foundation from which the load allocations can be validated for the riverine portion of the Spokane TMDL. The target will be used as part of the basis for the model in order to determine whether the wasteload allocations chosen in subsequent modeling steps meet the defined riverine phosphorus target. The overall focus on meeting dissolved oxygen criteria by reducing point and nonpoint sources of phosphorus remains unchanged from previous drafts of the TMDL.

2. Set tributary total phosphorus nonpoint source load allocations for Hangman, Little Spokane, and Coulee Creeks. The allocations will be expressed as percentage reductions based on 2001 concentrations.

3. Set the Discharger phosphorus wasteload allocations based on two TMDL scenarios:

    - Scenario #1: 50 µg/L for all sources except Kaiser (35 µg/L)
    - Scenario #2: 35 µg/L for all Washington sources except Inland Empire and Idaho sources (all remain at 50 µg/L)

4. Set the Discharger CBOD and Ammonia allocations based on previously modeled values.

5. Run CE-QUAL-W2 model and output total phosphorus, dissolved oxygen, and ammonia at riverine assessment point. Determine if 10 µg/L phosphorus target is met.

6. If target is met at riverine assessment point from March through September, analyze the reservoir dissolved oxygen output. If target is not met, the interagency modeling team will consider lowering the wasteload allocation inputs to the model.

7. Determine Avista dissolved oxygen requirement by taking the difference in reservoir dissolved oxygen between TMDL scenario #1 and the No Source scenario minus 0.2 mg/L (this requirement will be expressed as a bi-weekly average dissolved oxygen improvement).

EPA Support for the Dual Assessment Methodology

Ecology has consulted with EPA to ensure that this methodology is supported by EPA and will lead to TMDL approval. EPA agrees that this is a reasonable method for quantifying Avista's contrition to the dissolved oxygen in Lake Spokane, in relation to contributions of nutrients from the Dischargers. EPA notes that setting up assessment points to be used for modeling purposes is different from a compliance point designed to determine compliance with the water quality standards. Therefore, riverine and lake targets set as assessment points in the TMDL are not necessarily representative of water quality standards.

References

Carlson, R.E. and J. Simpson. 1996. *A Coordinator's Guide to Volunteer Lake Monitoring Methods*. North American Lake Management Society. 96 pp.

Cusimano, B. 2004. *Spokane River and Lake Spokane (Long Lake) Pollutant Loading Asssessment for Protecting Dissolved Oxygen.* Publication no. 04-03-006. Washington State Department of Ecology, Environmental Assessment Program. Olympia, Washington.

Footnote 8

-----Original Message-----
From: Doug Krapas
Sent: Wednesday, May 27, 2009 9:31 AM
To: Wayne Andresen; Kevin Rasler
Cc: Chris Averyt
Subject: FW: FW: Modeling Scenarios

FYI - confirmation from EPA as well.

-----Original Message-----
From: Moore, David (ECY) [mailto:DMOO461@ECY.WA.GOV]
Sent: Wednesday, May 27, 2009 9:19 AM
To: Doug Krapas
Subject: FW: FW: Modeling Scenarios

Doug, see Ben's email below. IEP will be at 50 for all the scenarios.
Dave

-----Original Message-----
From: Cope.Ben@epamail.epa.gov [mailto:Cope.Ben@epamail.epa.gov]
Sent: Wednesday, May 27, 2009 8:53 AM
To: Moore, David (ECY)
Cc: Ross, James D. (ECY)
Subject: Re: FW: Modeling Scenarios

Dave, we did ask more questions about Kaiser, not IEP. This kind of confusion is a natural result of the complexity of this thing and as you said, lots of info flying around. That's why we are having this round of review! FYI, I looked a back at the info sent out on March 25th, and it turns out IEP was not consistent for Alt 2 and 3 in those documents- the scenario table said all at 35, the tech spec spreadsheet had IEP at 50.

So I think it's fair to tell Doug that it was an oversight, and we'll change it to 50 for Alt 2 and 3 (in both documents this time...). I'm sure he'll be relieved.

-BC

Ben Cope, Environmental Engineer
Office of Environmental Assessment
EPA Region 10
Seattle, Washington
206-553-1442

"Moore, David (ECY)" <DMOO461@ECY.WA.GOV>

05/27/2009 07:40 AM

To
Ben Cope/R10/USEPA/US@EPA, "Ross, James D. (ECY)" <JROS461@ECY.WA.GOV>

cc

Subject

FW: Modeling Scenarios

Was there some discussion on this last week? I only remember talking about Kaiser. Can we please change IEP back to 50 for Alternatives 2 and 3? They are in a different category as far as effluent quality and abilities to make nonpoint source reductions. My apologies for not weighing in if I had the email. There were lots of emails flying around.

Thanks,
Dave

From: Doug Krapas [mailto:dougkrapas@iepco.com]
Sent:: Tuesday, May 26, 2009 4:39 PM
To: Moore, David (ECY)
Cc: Wayne Andresen; Kevin Rasler; James Tupper; Cope.Ben@epamail.epa.gov
Subject: Modeling Scenarios

Dave:

We received documents submitted by Ben Cope last Friday for presentation at the May 27th technical meeting. IEP has reviewed the attachments and are concerned with changes that were made to the modeling scenarios.
The Total P waste load allocations (WLA) for IEP have been reduced from 50 to 35 ppb in TMDL Alternatives #2 and #3. Is this a mistake, and if not, what is the justification for this change?

Ecology is well aware that IEP will have significant difficulties attempting to achieve a 50 ppb Total P waste load allocation. This was confirmed through extensive pilot testing of a wide cross section of state-of-the-art phosphorus treatment technologies. The report supporting this assertion was submitted to Ecology and EPA as recently requested. Testing and optimization of IEP's full-scale Trident HS system has further substantiated the difficulties in attaining phosphorus reduction of IEP's effluent to 50 ppb.

There was recognition and agreement amongst the stakeholders and the Agencies that IEP's effluent differs significantly from municipal wastewater treatment facilities and that there were limitations to our phosphorus treatment capabilities. This understanding was considered in the previous version of the scenarios that included IEP's Total P WLA at 50 ppb. To our knowledge, there was no concern expressed by any party to this consideration in the scenarios. You personally expressed this understanding by the Agencies in the development of the scenarios during a recent conversation.

We would greatly appreciate your response to the above Dave, and trust that this may be a simple oversight.

Regards,

Doug

Douglas P. Krapas
Environmental Manager

Inland Empire Paper Company
3320 N. Argonne
Spokane, WA 99212

Phone: 509/924-1911, ext. 363

Fax: 509/927-8461
E-Mail: dougkrapas@iepco.com

Footnote 9

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Spokane River and Lake Spokane (Long Lake) Pollutant Loading Assessment for Protecting Dissolved Oxygen

February 2004

Publication No. 04-03-006
printed on recycled paper

Lake Spokane is usually completely mixed or unstratified until the beginning to the middle of June because of the large amount of inflow and outflow water due to spring snowmelt conditions that significantly increase flows in the Spokane River. Figures 16 and 17 present an example of June and August temperature and conductivity profiles for Lake Spokane that represent the stratification and high conductivity interflow in the lake. (Station LL1 is located about 5.3 miles upstream of the dam.) The graphs illustrate the onset of temperature stratification in June and the fully developed stratification and interflow that occurs by the middle of July and extends to mid-September. Starting in September, temperatures in the river decrease because of cooler air temperatures. The river still has high salinities such that the inflowing water to the reservoir follows along the bottom of the reservoir (i.e., interflow turns into bottom flow). The bottom flow through the reservoir accelerates the beginning of fall turnover that begins in October (Soltero, 1992).

Nuisance algae populations and hypolimnetic oxygen depletions within Lake Spokane have been reported to occur during the summer growing season between June and October when inflows and corresponding flushing rates are low (Patmont, 1987; Soltero, 1992 and 1993). In addition to the reduced flow-through characteristic of Lake Spokane during this time, lake stratification during the growing season creates a complex mixing regime in which inflows are partially separated from the lake surface and bottom waters. This is due to the interflow of incoming waters through the metalimnion to the penstock tube openings in the Lake Spokane Dam. The compartmentalization due to these complex hydrodynamics results in non-steady-state relationships between nutrient loading and in-lake water quality conditions (Patmont, 1987).

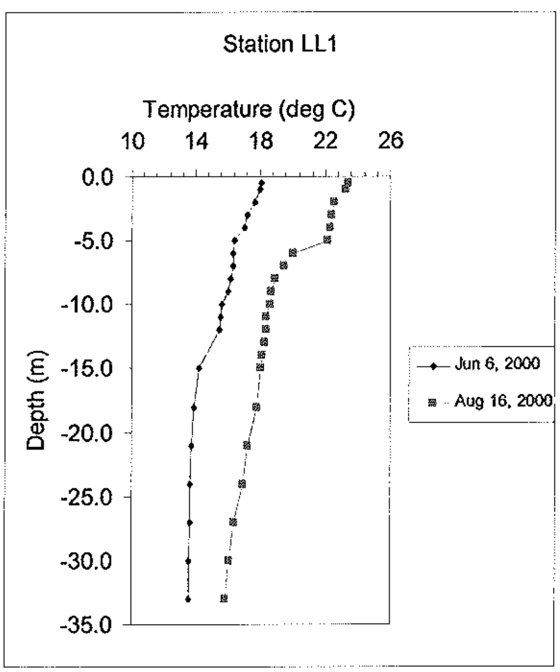


Figure 16. Lake Spokane temperature profiles for June 6 and August 16, 2000.

Application of Water Quality Criteria

The dissolved oxygen criterion for Lake Spokane is "no measurable change from natural conditions." The criterion for the river is "dissolved oxygen shall exceed 8.0 mg/L," which is to apply at all times; therefore, the minimum dissolved oxygen concentrations shall exceed 8.0 mg/L. However, in other TMDLs for oxygen-consuming substances, Ecology has allowed a 0.2 mg/L degradation in dissolved oxygen concentration due to human impacts when the dissolved oxygen concentration is below (or near) the criteria. We are proposing to apply this allowable change in dissolved oxygen for the Spokane River and Lake Spokane TMDL study as discussed in the following paragraphs. Any additional decrease in dissolved oxygen would require formally changing the water quality criteria for the river and lake (i.e., developing site-specific criteria) or conducting a Use Attainability Analysis (UAA) to reduce the level of beneficial use protection. No discussion about developing site-specific dissolved oxygen criteria or conducting a UAA is presented in this document.

In general, it is not possible to precisely define natural conditions that existed before human impacts. Any analysis can only approximate natural conditions given the physical changes that may have altered the waterbody and its watershed (including groundwater). For example, Lake Spokane is a man-made reservoir that is formed by a hydroelectric dam and is classified as a lake in the state standards. Physical, chemical, and biological processes in the reservoir, even without additional human impacts due to pollution, are different than what they would be if the river were free flowing, and any attempt to compare the two states directly would be inappropriate unless there is likelihood that the dam will be removed. In general, impoundments have less assimilative capacity for oxygen-consuming substances than free-lowing rivers, because organic substances can accumulate and degrade in the bottom waters and cause large oxygen deficits unlike a well-aerated, free-flowing river. At this time, Ecology does not foresee the dams being removed on the Spokane River and we will not attempt to define water quality conditions with and without the dams. However, because there may be some benefit to water quality by examining the effects of changing their operation or water withdrawal points, modeling scenarios could be conducted to examine management options for the dams that might provide more assimilative capacity for the river system.

Even if "natural" conditions cannot be fully determined, Ecology believes that water quality in Lake Spokane (and the Spokane River) does have a reference water quality condition that would exist if there were little or no pollutant effects. Once defined, this reference condition can be used to compare against current and possible future water quality conditions. We are proposing to apply the Lake Class dissolved oxygen criteria to Lake Spokane as follows:

> Under critical year conditions, allow no more than a 0.2 mg/L deficit in dissolved oxygen from "natural conditions" (i.e., reference conditions) at any point in the water column due to identified point and nonpoint pollutants. Reference conditions for Lake Spokane will be defined as the water quality conditions estimated by the calibrated CE-QUAL-W2 model that would occur with no point source discharges and tributary pollutant (nonpoint source) concentrations set to estimated background conditions. Critical year conditions will be a

A History of The Washington Water Power Company

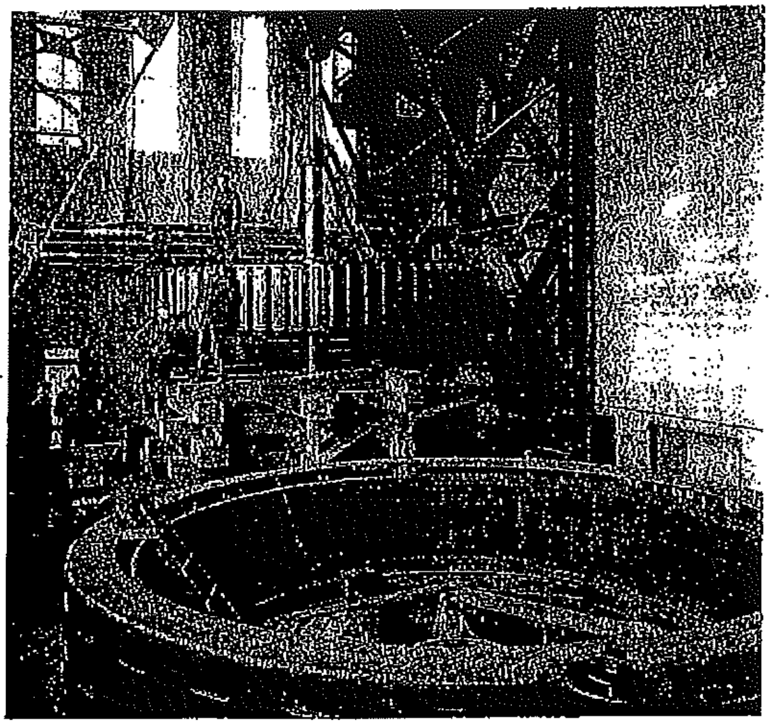
1889 to 1989

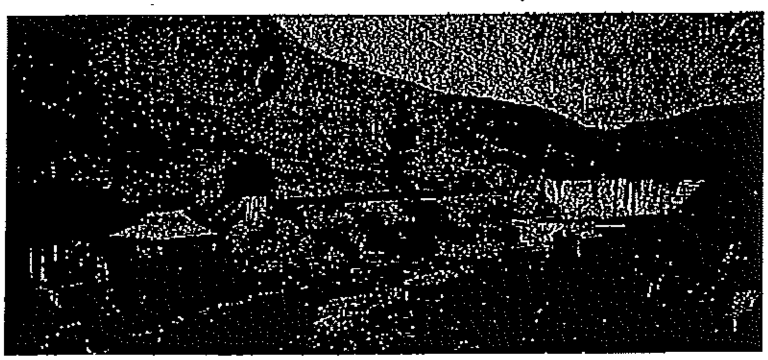
Building On A Century of Service

by

Steve Blewett, ABC

Published
by
The Washington Water Power Company
March 8, 1989
Spokane, Washington

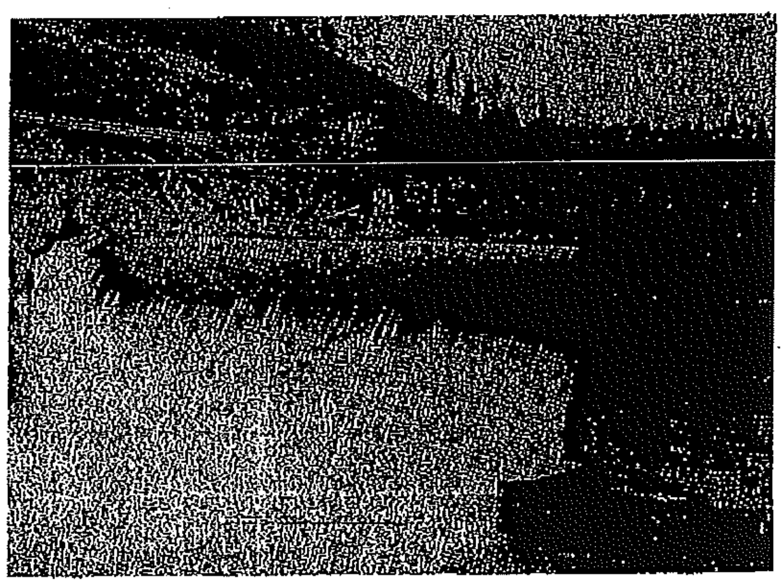




The construction site itself was equipped with the "usual necessary machine shop, blacksmith shop, engines, derricks, cableways, mixers, compressors, motors, steam shovel (and) sawmill." The concrete mixing plant, 400 feet above the river on the north bank, had a capacity of 2,000 yards a day and received its gravel over an electrified railway from a pit 2-1/2 miles away. Electrical and mechanical equipment was hauled from the railroad terminal by steam tractors. Due to the size of the project, special attention was given to providing adequate ventilation to the generator deck and a drainage system and watertight doors to cope with high water during spring runoff. The control gates—which were not installed until the dam was raised several years later—were rolling gates of European design and relatively new to the U.S. When the project was completed in 1915, the original installed capacity of 25,000 kw again increased WWP's generating capacity by half, bringing total system capacity to almost 80,000 kw.

The addition of Long Lake made it possible for WWP to take Ross Park out of service in 1916, ending WWP's involvement with steam generated power until 1971. A leveling out of business, then inflation and a decrease in business towards the end of WWI, caused WWP to forego further generation development until 1919, when 27,500 kw were added at Long Lake. But in 1922, another 10,000 kw were added in Spokane with the construction of the Upper Falls, the first vertical-design unit on WWP's system and one of the first installed in the West. At about the same time, in May 1921, WWP acquired the rights to the Kettle Falls on the Columbia River near Colville and applied to the recently created Federal Power Commission for a license to build on the site, which later would be

WWP hydro plants, built or acquired at various times, counter-clockwise from above to the next page: Upper Falls, Oroville, Meyers Falls, Nine Mile, Grangeville, Asotin, Lewiston and Chelan.



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SPOKANE RIVER HYDROELECTRIC PROJECT

FERC No. 2545

Final Application for New License
Major Project—Existing Dam

VOLUME I
Exhibits A, B, C, D, F, G, and H

Avista Corporation
Spokane, Washington

July 2005

333871

EXHIBIT A—DESCRIPTION OF THE PROJECT

A.1 General Description and Location of the Spokane River Project

The Spokane River Hydroelectric Project (Project) is owned and operated by Avista Corporation (Avista) and operates under a license issued by the Federal Energy Regulatory Commission (Commission or FERC) as Project No. 2545. The Project as currently licensed consists of five hydroelectric developments (HED) located on the Spokane River in northern Idaho (Kootenai and Benewah counties) and eastern Washington (Spokane, Stevens, and Lincoln counties). Through the relicensing process, Avista is seeking to obtain a separate license for the eastern-most HED, Post Falls, which is the only Project HED located in Idaho. This license application describes the four HEDs located in Washington State and the operations of all four HEDs. The information about Post Falls HED is contained in a separate license application filed concurrently with this license application and the accompanying preliminary draft environmental assessment (PDEA).

The Spokane River originates at the outlet of Coeur d'Alene Lake in Idaho and flows westerly approximately 111 miles to the confluence with the Columbia River in eastern Washington (which is now within Lake Roosevelt, the impoundment created by Grand Coulee Dam). The four developments (upstream to downstream) proposed as the new Spokane River Project are Upper Falls (river mile 74.2), Monroe Street (river mile 74), Nine Mile (river mile 58), and Long Lake (river mile 34). The Project has a combined installed capacity of 122.92 megawatts (MW). Post Falls HED, which is located at river mile 102, has an installed capacity of 14.75 MW and brings the entire system capacity up to 137.67 MW.

Upper Falls HED is a run-of-river[3] facility consisting of a 366-foot-long, 35.5-foot-high dam across the north channel of the Spokane River; a 70-foot-long, 30-foot-high intake structure across the south channel; an 800-acre-foot reservoir; a 350-foot-long, 18-foot-diameter penstock; and a single-unit powerhouse with a generator nameplate capacity of 10 MW.

Monroe Street HED is a run-of-river facility consisting of a 240-foot-long, 24-foot-high dam; a 30-acre-foot reservoir; a 332-foot-long, 14-foot-diameter penstock; and an underground single-unit powerhouse with a generator nameplate capacity of 14.82 MW.

Nine Mile HED is a run-of-river facility consisting of a 466-foot-long, 58-foot-high dam; a 4,600 acre-foot reservoir; a 120-foot-long, 5-foot-diameter diversion tunnel; and a 4-unit powerhouse with a nameplate capacity of 26.4 MW.

Long Lake HED is a storage-type facility consisting of a 593-foot-long, 213-foot-high main dam; a 247-foot-long, 108-foot-high cutoff dam; a 148,500-acre-foot reservoir (gross storage); four 236-foot-long, 16-foot-diameter penstocks; and a 4-unit powerhouse with a nameplate capacity of 71.7 MW.

The four hydroelectric developments are further described in the sections that follow.

[3] Run-of-river, as used here, means that water flow into the hydroelectric development reservoir is essentially equal to downstream outflow, and the reservoir water levels change little unless under flood conditions, operations and maintenance activities, or other unusual circumstance.

A.4.6 Proposed New Structures and Facilities

Periodic maintenance of the entire facility and assessment of upgrade potential will continue through the term of a new license. Avista will evaluate replacing the flashboards with a more permanent feature such as a rubber dam. Assuming the flashboards are eventually replaced by a rubber dam, the pool level would not change, nor would operations change at Nine Mile HED other than that the flashboards would no longer be released downstream, and Avista would have the ability to restore the pool elevation somewhat more quickly after spill events.

A.5 Long Lake HED

A.5.1 Physical Composition, Dimension, and Configuration of Existing Structures

Long Lake HED is located 24 river miles downstream of Nine Mile HED. Long Lake HED includes an L-shaped, concrete gravity dam ("main dam") and adjacent intake structure; a concrete arch cutoff dam ("crescent dam") located along the western shoreline approximately 700 to 800 feet upstream of the main dam; a gated spillway along the top of the main dam; and a four-unit powerhouse.

A.5.1.1 Dam

The main dam is a 593-foot-long, 213-foot-high concrete gravity dam. The top of the dam is at elevation 1,537 feet. The main dam includes a 353-foot-long, gated ogee spillway with a crest elevation of 1,508 feet. The spillway has eight 25-foot-wide, 29-foot-high vertical lift gates and a capacity of 115,000 cfs at a water surface elevation of 1,536 feet.

The cutoff, or crescent, dam is a 247-foot-long, 108-foot-high concrete arch dam with a crest elevation of 1,537 feet.

A.5.1.2 Power Intakes and Water Conduits

There are four intake structures integral to the main dam connecting to four 236-foot-long, 16-foot-diameter riveted steel penstocks that traverse the downstream face of the dam.

A.5.1.3 Powerhouse

Located at the base of the dam, the T-shaped powerhouse consists of a 161-foot-long, 75-foot-wide generator section and a 207-foot-long, 56-foot-wide switchroom section. The powerhouse contains four turbine-generator units with a total generating capacity of 71.7 MW and a combined hydraulic capacity of 6,300 cfs.

A.5.2 Reservoir

The reservoir (commonly known as Lake Spokane) extends approximately 23.5 miles upstream of the main dam. It has a maximum depth of 180 feet and a 5,060-acre surface area at normal full pool elevation of 1,536 feet. The usable storage, at a maximum drawdown of 24 feet, is 105,080 acre-feet.

EXHIBIT C—PROJECT HISTORY AND PROPOSED CONSTRUCTION SCHEDULE

C.1 Project History

Before Washington Water Power Company was formed in the late 1800s and began constructing hydroelectric developments on the Spokane River, water power facilities for the purposes of electrical generation already existed. Most of these early facilities were located within the downtown portions of the city of Spokane, then known as "Spokan Falls." These facilities were mostly limited to small installations fed by flumes or built where a water wheel could be dropped directly into the river current. Most of these were Edison electric lighting plants, with the Edison Electric Light Company (headquartered in the eastern United States) typically retaining 30 percent of the profits from the plants.

In 1889, a group of local Spokane businessmen formed Washington Water Power Company and began negotiating for the power rights to the lower falls of the Spokane River, an area later referred to as "Monroe Street." While the local founders of the Washington Water Power Company strongly believed in the value of the river's water power, there were eastern investors in the company that held equally strong beliefs that steam was a superior power source. These investors saw little value in the use of water power for the purpose of electrical power production. Nonetheless, the local company founders persisted and eventually pressed forward with the acquisition and development of the lower falls of the Spokane River.

Monroe Street HED became Spokane's first "modern" hydroelectric plant upon completion in 1890. Monroe Street HED was considered modern because it used penstocks to deliver water to the generating equipment rather than open ditches and flumes. The initial installed capacity of 350 kilowatts (kW) of direct current (DC) electricity on November 12, 1890, more than doubled the generating capacity of all power plants then operating on the Spokane River. Given the size and efficiency of the new power plant and the electricity demands of the time, the Edison systems soon became obsolete. Washington Water Power Company began acquiring those properties and had acquired all of the Edison plants by the end of 1891, paving the way for the company to further develop the Spokane River's water power potential.

Washington Water Power Company then began a systematic approach for development of a broader electrical generation and transmission system in 1903 with the addition of two alternating current (AC) turbine-generator units at Monroe Street HED. This was followed by a period of substantial expansion in Washington Water Power Company's generating capacity along the Spokane River, extending up through 1930. Substantial transmission line facilities were also being constructed or acquired by Washington Water Power Company during this period, and it provided electricity to a wide area around Spokane and extending well into Idaho. It was during these years that Post Falls (1906), Little Falls (1910),[4] Long Lake (1915), and Upper Falls (1922) HEDs were completed by Washington Water Power Company. It was also during this time that The Spokane and Inland Empire Railway Company completed Nine Mile

[4] The Little Falls Project is owned and operated by Avista but is not part of the Spokane River Project or Post Falls HED.

C.1.3 Long Lake HED

Constructed over a 4-year period from 1911 to 1915, Long Lake HED is the largest hydroelectric development on the Spokane River. The original capacity, when completed in 1915, was 25 MW, produced by two Francis-style turbines. Additional units were installed in 1919 (Unit 3) and 1924 (Unit 4). The forebay water surface elevation was increased by 3 feet in 1930, and then again by 5 feet in 1949. In the 1990s, Avista upgraded the turbines and amended the license in 1996 to reflect the current installed capacity of 71.7 MW.

C.1.4 Upper Falls HED

Constructed between 1921 and 1922, Upper Falls HED was the last hydroelectric development constructed by Washington Water Power Company on the Spokane River, using the power potential of the falls located immediately upstream of Monroe Street HED. The Upper Falls powerhouse contains a single generator and vertical-shaft Francis turbine rated at 10 MW. No significant construction or capacity changes have occurred at the development, and the original unit is still in place.

C.1.5 Project Chronology

Table C-1 presents the chronology of construction, major maintenance, and upgrades of the Spokane River Project.

Table C-1. Spokane River Project chronology.

Activity	Date
Monroe Street HED construction	1889–1890
Monroe Street HED powerhouse expanded: two additional AC turbine generator units added	1903
Monroe Street HED DC units phased out	1904–1912
Nine Mile HED construction (The Spokane and Inland Empire Railway Company)	1906–1908
Long Lake HED construction	1911–1915
Long Lake HED Unit 3 added	1919
Upper Falls HED construction	1921–1922
Long Lake HED Unit 4 added	1924
Nine Mile HED purchased from The Spokane and Eastern Inland Railway & Power Company by Washington Water Power Company	1925
Long Lake HED forebay water surface elevation increased by 3 feet	1930
Added 2-foot flashboards to top of existing flashboards at Nine Mile HED	1947
Long Lake HED forebay water surface elevation increased by additional 5 feet	1949
Added 3-foot flashboards to top of existing flashboards at Nine Mile HED	1950
Long Lake HED Unit 1 rewound	1956
Long Lake HED Unit 3 rewound	1957

SPOKANE RIVER HYDROELECTRIC PROJECT
FERC No. 2545

Application for New License
Major Project—Existing Dam

VOLUME II

Applicant-Prepared
Preliminary Draft Environmental Assessment

18 CFR, Part 4, Subpart F, Section 4.51

SPOKANE RIVER

Avista Corporation
Spokane, Washington

February 2005
(Draft provided for public review)

002443

Nine Mile HED

Nine Mile HED is located on the Spokane River at river mile 58. Nine Mile HED lies 16 miles downstream of Monroe Street HED and 24 miles upstream of Long Lake HED. A single dam and associated powerhouse comprise this development. Some unique features associated with Nine Mile HED include a sediment bypass tunnel (or diversion tunnel) that was installed at the dam in 1996, and the Nine Mile cottages, originally built for facility operators at the dam and now leased to Washington State Parks (Figure 3-7, Appendix A). Some of the features, structures, and specifications associated with Nine Mile HED include:

- an approximately 6-mile-long reservoir (Nine Mile Reservoir) with normal full-pool elevation of 1,606.6 feet, an impounded surface area of 440 acres at full pool and usable storage of 3,130 acre-feet under a 16.6-foot maximum drawdown;
- a 364-foot-long, 58-foot-tall dam;
- a 225-foot-long concrete overflow spillway, with a spillway crest elevation of 1,596.6 feet, plus two rows of 5-foot-high flashboards;
- four intakes integral to the face of the dam where water is fed to the turbines via steel and concrete bulkhead chambers called a "wet pit"; and
- a powerhouse integral to the dam containing four horizontal Francis turbines (including an indoor substation) with a total nameplate capacity of 26.4 MW and a total hydraulic capacity of 6,500 cfs.

Long Lake HED

Long Lake HED is located on the Spokane River (river mile 34), approximately 25–30 miles northwest of Spokane, Washington, and 24 miles downstream of Nine Mile HED. Long Lake HED includes an L-shaped, concrete gravity main dam and adjacent intake structure, a concrete arch cutoff dam located along the western shoreline approximately 700 to 800 feet upstream of the main dam, a gated spillway along the top of the main dam, and a powerhouse (Figure 3-8, Appendix A). Some of the features, structures, and specifications associated with Long Lake HED include:

- a 23.5-mile-long reservoir (Lake Spokane) with a maximum width of about 0.7 mile, a maximum depth of 180 feet, and approximately 5,060 acres of impounded surface area and 105,080 acre-feet of usable storage at normal full-pool elevation of 1,536 feet;
- a 213-foot-tall, 593-foot-long main channel dam, with a top-of-dam elevation of 1,537 feet;
- a 108-foot-tall, 247-foot-long cutoff dam;

Footnote 10 –

See Footnote 9

Footnote 11 –

See Footnote 9

Footnote 12

POST FALLS HYDROELECTRIC PROJECT
FERC No. 2545

Application for New License
Major Project—Existing Dam

VOLUME II

Applicant-Prepared
Preliminary Draft Environmental Assessment

18 CFR, Part 4, Subpart F, Section 4.51

SPOKANE RIVER

Avista Corporation
Spokane, Washington

July 2005

Lake Spokane thermally stratifies from June through September, and stagnation of deep water results in low DO concentrations near the bottom of the lower portion of the reservoir in the summer and early fall. The primary effects of current Project operations on DO concentrations are that concentrations are increased in the upper end of the lake during most of the spring and summer and decreased in the hypolimnion of the lower portion of the lake in comparison to free-flowing conditions. The model indicates that 8.0-mg/l concentrations would be met under unimpounded conditions, whereas the current impoundment of water behind Long Lake Dam and current Project operations, collectively, contribute to not satisfying the 8.0-mg/l criterion between 3 to 5 months per year in the interflow and hypolimnion of the lower portion of the lake under current conditions (HDR, 2005). Monitoring data indicate that pH levels are generally within the acceptable limits of 6.5 to 8.5 units, although pH exceeds the 8.5-unit criterion on occasion (HDR, 2005). The model predicted that, during August through October, pH levels exceed the upper limit of 8.5 units near the surface for both current Project operations and free-flowing conditions; however, higher pH values were predicted for current Project operations (HDR, 2005).

Monitored powerplant discharges from Long Lake HED have DO concentrations of less than the 8.0-mg/l criterion established for the Spokane River by Washington State and the Spokane Tribe of Indians for a period of about 120 to 130 days during the summer and fall (HDR, 2005). The model predicted that DO concentrations under unimpounded conditions would not drop below the 8.0-mg/l criterion, whereas current conditions result in DO concentrations of less than 8.0 mg/l for more than 108 days (HDR, 2005). HDR (2005) did not evaluate the relationship between pH values for current operations and unregulated conditions at this location.

Effects Analysis

The effects of the Proposed Action to increase the minimum discharge at Post Falls were evaluated through the use of the CE-QUAL-W2 model. Results indicate that increasing the Post Falls HED flow release to 700 cfs (used here to evaluate the approximate effects of the 600-cfs minimum flow proposed under the Proposed Action) would have little, if any, effect on upstream water quality conditions in Coeur d'Alene Lake, its tributaries and the upper Spokane River. Similarly, modeling results indicate that there would be little effect on DO and algae concentrations in the Spokane River and Lake Spokane (Koreny, 2004). Figure 5-19 displays the average daily minimum DO concentrations along with the average difference in daily minimum DO concentrations between current Project operations and a 700-cfs minimum discharge for August 2001. In the Spokane River, the average difference in daily minimum DO concentrations was within ± 0.5 mg/l at all sites other than Barker Road (river mile 90.4), where an increase of 0.9 mg/l was predicted (Figure 5-19). The change in DO concentrations at Barker Road is partially due to a corresponding cooling effect in the river in that reach which increases the water's capacity to retain oxygen. DO concentrations predicted for the surface of Lake Spokane are virtually the same for the 700-cfs release as for current Project operations. Modeled values for deeper layers generally indicated only negligible differences in DO concentrations, although minor differences of less than 1 mg/l were indicated for some water column profiles (Koreny, 2004). The effects of more than doubling the minimum flow releases from Post Falls HED (from 300 cfs or less to 700 cfs) resulted in only small differences in modeled daily minimum DO concentrations from the outflow of Lake Spokane, on average, approximately 0.1 mg/l.

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Footnote 13

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Water Quality Certifications for Existing Hydropower Dams

Guidance Manual

March 2005
Publication No. 04-10-022

standard is the 110 percent total dissolved gas criteria. The common numeric criteria associated with hydropower facilities are grouped together in the first half of this section.

- Narrative criteria rely on the analysis of impacts to uses such as fishing, aquatic organisms, boating, swimming, and aesthetics. Narrative criteria are implemented on a case-by-case basis to protect water quality and beneficial uses from the effects of water pollution. Narrative criteria are used where numeric standards are not sufficient to protect a sensitive beneficial use.

- Use protection is the bottom line of the standards. Even if numeric criteria are attained, if studies show the uses in the water body are being harmed by the activities to be permitted, the narrative criteria may be invoked to further restrict the activities.

  Uses designated in the water quality standards must be protected unless a formal process called a use attainability analysis (UAA) is conducted on the water body in question to show the uses do not exist or are not attainable.

- The anti-degradation policy in the water quality standards protects beneficial uses by providing a three-tiered system of protection:
  - Tier I, protection and maintenance of existing and designated uses. *The Tier I criterion will apply to existing dams.*
  - Tier II, protection of waters of higher quality than the standards. *Tier II generally will not apply to relicensing except for expansion projects that alter the characteristics of the water body. Tier II criteria would apply to new dams.*
  - Tier III, protection of outstanding resource waters. *These are pristine waters where no pollution is allowed. A public process is used to assign waters to Tier III. No water bodies in Washington presently exist in this category as of 2005.*

- Natural conditions are defined as "surface water quality that was present before any human caused pollution." Pollution is broadly defined to include most kinds of activities that harm beneficial uses. If natural conditions in a water body exceed the criteria found in the water quality standards, natural conditions are used as the water quality criteria for that water body. For some water quality criteria, the water quality standards allow and additional small change from natural conditions for human effects.

- Reservoirs with a mean detention time of greater than 15 days are treated as lakes under the water quality standards. The water quality standards for lakes are often based on maintaining natural conditions, but the fact is the dam and the "lake" behind it are not natural. This means that Ecology cannot treat dam effects to water quality as natural.

Footnote 14 –

See Footnote 13

Footnote 15

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Water Quality Certifications for Existing Hydropower Dams

Guidance Manual

Comments and Responses

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Watershed Management Section
Water Quality Program

Washington State Department of Ecology

February 2005

192314

Response:
The way that federal and state water quality standards regulations are designed, Ecology will ensure that all existing uses, and all attainable uses designated for the water body in the state standards, will be protected under the conditions of the certification.

CRITFC
26. Comment:
Pg. 24. Ecology indicates that dams and the reservoirs created are not natural systems, so it cannot assume that any impact that this system creates either above or downstream is natural. The highest attainable water quality in the reservoir would then be the criterion. Ecology claims that the discharge from the reservoir would not be considered a natural condition or contribute to deviations from water quality standards. However, it is also claimed that *"the certification should focus on meeting the water quality criteria downstream of the dam"* although this is contradicted by the statement that downstream conditions caused by the reservoir cannot be considered to contribute to the problem.

The highest attainable water quality condition, given the presence of an unnatural source of water quality degradation, is generally considered to be a technology-based consideration. What is the highest attainable water quality now is a matter of available technology and costs that the public is willing to bear (either the cost of implementing the technological remedies or the public health or fish and wildlife damage costs). The attainable water quality condition now is likely to be different from what is possible in the next 10 years. This is one reason why revision of standards and the required procedures to achieve the standards is needed.

The biological requirements for water quality parameters to meet the needs of fish, wildlife, and public health may be understood more clearly through time, but the biological responses to various specific water quality conditions would remain relatively unchanged. If certain beneficial uses (*e.g.*, coldwater fisheries) are to be maintained at all or at a high level of functioning, it is simply a fact that this imposes a requirement for achieving at least a minimal level of water quality. Many types of developments in our watersheds and along our streams would be considered an unnatural addition to the environment.

Hydropower systems and reservoirs are not the only facilities contributing to water quality degradation; irrigation systems, sewage treatment plants, chemical plants, and many other kinds of facilities considered important to modem life are not considered exempt from regulation simply because they can impair natural conditions. For this reason, Ecology needs to realize that alternatives to these facilities may be considered when the damage to fish, wildlife, and public health are too great and the deviation from natural is too great. Also, what is considered to be the highest attainable water quality is dependent on changing technology and desire to address the issues. Deliberately setting lower criteria so as to exempt a polluting facility or to essentially make it part of the pollution background level unfairly short-circuits this feedback loop by burying the information on the cumulative level of deviation of water quality from natural. This process of obscuring what the natural background actually is also makes it less likely that the public would ever have to consider the tradeoffs between exempting a facility and allowing excessive mortality to fish populations.

Response:
Dams are held accountable for the water quality of the downstream waters and the requirement is to meet the assigned water quality standards for the river downstream of the impoundment. It is only within the impoundment itself that a different approach is being taken. Within a reservoir the water quality and physical habitat conditions will take on the characteristics of a lake. The requirement to achieve the highest attainable water quality within these reservoirs reflects the requirements in the water quality standards for lakes and reservoirs - where human effects are generally not allowed to cause any substantial changes from natural conditions. And this requirement is written the way it is because of the recognition that the reservoir itself is not a natural condition. Achieving the highest water quality in a reservoir parallels the need to maintain conditions at near natural levels in natural lakes. Ecology will also require a ten-year compliance schedule to systematically pursue all available technology to improve water quality in the reservoir, as well ensure that all feasible steps are taken to meet downstream water quality criteria and standards. If the standards cannot be met using all feasible controls, then a UAA may need to be developed to identify and formally adjust the standards so that they reflect the highest attainable water quality conditions both within the reservoir as well as downstream. Since the bottom line requirement is that all uses existing since 1975 must continue to be protected at the highest level that they have existed since 1975, there is a threshold beyond which further impact will not be tolerated. But the focus for the certification process is on protecting both the existing uses as well as all uses that have been designated for the water body that are found through careful analysis to also be attainable.

CRITFC
27. Comment:
Pg. 25. We wonder why Ecology chooses the 7Q-10 as the flood flow metric for this guidance document and the TMDLs. A more appropriate metric would be the 7Q-20- this would ensure greater protection to the aquatic resource beneficial use from total dissolved gas impacts.

The total dissolved gas variance of 110% TDG at all times should be the ultimate goal to be achieved at the end of a 10 year adaptive management-compliance process for the 401 Certification. Fish passage protection through spill or surface bypass technologies should not be compromised in attaining this goal. The temporary fish spill variance should be limited to: 1) end of the 10 year compliance period at most and, 2) the active migration of all anadromous fish, including adults. There needs to be year-to-year flexibility in providing the fish spill variance timing as different physical, chemical and biological conditions combine to change fish migrations on an annual basis.

It is the responsibility of the dam owner to meet total dissolved gas standards by any means necessary, not limited to generation of power when markets are favorable. For example, Ecology should require applicants to consider running turbines during off peak

Footnote 16

Part 1. Dams, diversions, and hydrologic modifications and UAAs

Dams, reservoirs, and other hydrologic modifications can directly preclude uses by blocking the path upstream or creating lethal conditions. They may also indirectly preclude uses by limiting the ability of the waterbody to sustain the quality of uses that are identified in the water quality standards. The federal regulations provide six conditions under which a designated use, that is not an existing use, may be removed from a state's water quality standards regulation. These six conditions allow numerous environmental and economic factors to be used solely or in combination to support removing non-existing designated uses. Each of these conditions is designed to assess whether or not the use is attainable if human activities were modified sufficiently.

The federal regulations [40 CFR 131.10(g)] provide that designated uses may be removed, or new less stringent subcategories of a use established, when:

(1) Naturally occurring pollution concentrations prevent the attainment of the use; or

(2) Natural, ephemeral, intermittent, or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or

(3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or

(4) Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or

(5) Physical conditions related to the natural features of the water body, such as lack of proper substrate, cover, flow; depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses; or

(6) Controls more stringent than those required by § 301 (b) and 306 of the Clean Water Act would result in substantial and widespread economic and social hardship.

While any of the six UAA conditions may apply to a specific waterbody, conditions (4) and (6) above would create the primary basis for conducting a UAA for a dammed system. Ecology is currently working with the EPA to develop guidance on how these two economic factors will be defined and used for dams in Washington. While there may be other UAA rationale that also apply, and can be used to further define and support the conclusions in a UAA, they typically relate to the natural conditions of the waterbody and are not as relevant for evaluating hydrologically modified systems.

Types of Dams and their Regulatory Linkages to UAAs:

How a UAA would be applied to a dam would in part be based on the ownership status of the dam. Federal dams, dams needing federal licenses, and non-federal dams not required to obtain federal licenses all occur in Washington. Each has unique features of review that effect how they comply with the state water quality standards.

Federal Dams. Ecology does not have direct review authority over federal dams. Federal dams are also not required to obtain federal permits. Federal dams, however, must consult with the state and must meet the state water quality standards (CWA Sec. 313). The state may seek to compel compliance with such standards through a citizen suit under the Clean Water Act. Ecology can also issue orders that would need to be enforced through the federal courts - either as enforcement of a mandatory duty under the CWA or citizen suit pursuant to the Clean Water Act. One unique consideration in conducting a UAA for waters impacted by federal dams is that the dams were authorized by congress. As such the UAA regulations should generally not be read as requiring an analysis that their removal (restoration of the natural system) be required to meet the state water quality standards. Thus the UAA issues should be focused on feasible structural and operational changes that can be made to bring them into compliance with the standards.

Federally Licensed Dams. Non-federal dams that are used to generate electrical power must obtain a license from the Federal Energy Regulatory Commission (FERC). In issuing or reissuing such a federal license, FERC must provide the state an opportunity to review the license and certify or not certify that the dam will meet the state's water quality standards. This Clean Water Act Section 401 Certification is the primary vehicle that the state uses to ensure that federally licensed facilities will take whatever steps are necessary to meet the state's water quality regulations. Non-federal dams, if using 40CFR131(10)(g)(4) should fully evaluate both restoration of the system and modifications to thwe dam and/or its operations (as required in the regulation).

Non-Licensed Non-Federal Dams. Where a dam serves purposes other than the generation of energy, no FERC license is required; although, authorization from the Corps of Engineers or other federal agency may be necessary, in which case a section 401 permit would be required. The enforcement sections in Chapter 90.48 RCW are used if the dam does not comply with WQS. Non-federal dams, if using 40CFR131(10)(g)(4) should fully evaluate both restoration of the system and modifications to thwe dam and/or its operations (as required in the regulation).

The Compliance Schedule Provision for Dams:

Ecology adopted regulatory provisions into its water quality standards guiding the development of UAAs for dams [WAC 173-201A-510(5)]. These provisions establish that dams must be brought into compliance with the water quality standards. They also establish that this should be done as part of a long-term compliance schedule that sets up a reasonable plan for evaluating structural and operational changes that can be feasibly implemented to bring the dam into compliance with the standards. The underlying goal is to ensure that sufficient alternatives have been tested to know with a high degree of confidence whether or not it is truly feasible to restore or protect the designated uses of the waterbody prior to initiating a rule change pursuant to a UAA. What this means for dammed systems is that it may be up to ten years before Ecology will be in a position to recommend that a dam owner conduct a UAA or to support a proposal that the standards be changed for an impacted waterbody.

Key Definitions:

There are several terms that are integral to interpreting the federal regulations on UAAs:

Existing uses are those uses actually attained in the waterbody on or after November 28, 1975, whether or not they are included in the water quality standards. This represents the date the federal regulations on water quality standards were first adopted.

Designated uses are those uses specified in the water quality standards for each waterbody or segment, whether or not they are being attained.

Use Subcategories refer to more refined definitions of otherwise broad use types. For example, "warm water aquatic life" would be a subcategory of a broader "aquatic life" use category. The state of Washington has already established subcategories for the aquatic life and recreation use types. Where appropriate, however, further refinement of these subcategories is possible.

Feasible – This definition is currently being developed.

Steps to Conducting a UAA for Hydrologically Modified Systems:

There are four primary steps to conducting a UAA for a hydrologically modified system:

Step 1: Determine if the designated uses have been attained. If a designated use has been attained at any time since November 28, 1975, then it would constitute an existing use. A UAA cannot be used to remove a designated use that is also an existing use.

- If the named uses are present in the waterbody and the criteria associated with the designated uses have been met at any time since November 28, 1975, then the uses are considered to have been attained (existing uses).

Step 2: Determine if the designated uses are attainable. Regardless of whether a designated use currently exists, or has ever existed in a waterbody, if it is feasible (definition of feasible currently being developed) to attain the designated use then it must be retained in the state standards and provided full protection. The process for identifying attainable uses can be summarized as:

a) Identify all technically feasible alternatives that may individually or jointly result in attainment of the designated use(s). At this point in the evaluation, economic and social implications are not used in the selection of alternatives.

b) Evaluate the costs and social implications of each technically feasible alternative.

c) Identify those technically feasible alternatives whose implementation meets the criteria for feasibility in 40CFR131.10(g). This definition is currently being developed. This step is used to create the list of alternatives that will be tested in the compliance schedule process (WAC 173-201A-510) and evaluated during any subsequent UAA process.

d) Implement those alternatives identified above as being feasible. Using an adaptive process for queuing up feasible alternatives for testing, Ecology will establish a compliance schedule having sufficient milestones and directives to determine by the end of a maximum ten year compliance period what combination of alternatives results in the highest attainable uses and water quality conditions [WAC 173-201A-510].

- While in some cases this step will be completed by the conclusion of the initial compliance schedule, in cases where new alternatives are recognized that were not tested, a second compliance period may be established by Ecology with the explicit purpose of testing those new alternatives.

Step 3. If the designated use is not attainable (as discussed and verified through Step 2), then a UAA (or site specific criteria) development process can be initiated. This UAA process will use the knowledge gained in Step 2 above to document the designated use is not attainable, and to take the necessary follow-up step of defining the highest quality of use that is attainable.

a) The UAA must describe the quality of uses that would exist if all human sources were controlled consistent with the six federal UAA conditions [40 CFR 131.10(g)].

- To change the designated use in the state standards it would not be sufficient to examine only those facilities or activities under the control of the UAA proponent. Where mutiple sources contribute to non-attainment of a use, the examination of the effects of just a single entity can only be used to establish a temporary but renewable variance [WAC 173-201A-420] in the water quality standards for specific water quality constituents (e.g., temperature, oxygen, total dissovled gas, etc).

b) Where a designated use is not attainable, then the next most sensitive use of that category (i.e., aquatic life, wildlife, recreation, etc.) which is attainable will need to be identified and protected. This may result in selecting a use-type that already exists in the state standards, or developing a unique subcategory of a use that better reflects the highest attainable use for that waterbody. All feasible alternatives are required to both attain a designated use, and to establish the highest attainable use subcategory.

- Where the named use-type (e.g., salmonid spawning, rearing, and migration; primary contact recreation, etc) occurs in the waterbody, protecting the highest attainable level of the use will often be the same as maintaining the highest attainable water quality condition. This will be true as long as there is not a clear match with another use-type (e.g., warm water fish habitat, secondary contact recreation, etc.). This is because in the first case the waterbody is already not meeting the criteria established in the standards to fully protect those key uses, and any further deterioration of water quality will translate into some degree of further degradation to the use as well. In this case, Ecology would need to adopt a new designated use-type into the standards that reflects this highest attainable use. This may be something like a "limited spawning and seasonal core rearing" use, or a "seasonal salmonid rearing-only use". Thus the highest attainable use would be defined by the estimate of the highest attainable water quality condition.

c) As part of this step, the UAA would need to identify all the existing uses (those uses attained in the waterbody on or after November 28, 1975, whether or not they are included in the water quality regulations) for the waterbody. The UAA will need to demonstrate the criteria and uses in the final UAA proposal will fully protect all of the existing uses, as well as the designated uses that were not a subject of the UAA evaluation.

- Existing uses go beyond those directly mentioned in the state water quality standards, which lists only the most sensitive key uses for the general category (i.e., aquatic life, recreation, water supply, etc.). It is possible that in some cases, none of the use types listed in the water quality standards for a general category of use exist in a waterbody. In this situation, it is still necessary to identify the existing uses so the most sensitive existing uses (in addition to any attainable designated uses) will be protected by setting appropriate water quality criteria.

<u>Step 4</u>: Evaluate how changes in uses and criteria proposed in the UAA would effect uses and criteria both upstream and downstream of the UAA study area. Standards established through the UAA process must provide for the attainment and maintenance of the existing and designated uses and water quality criteria outside of the area of interest for the UAA.

- It may sometimes be appropriate to set a less sensitive use in an upstream region, but to retain a more restrictive (less pollution would be allowed) criteria in order to protect other downstream uses. Typically, if the same criteria for the designated use would be needed to protect downstream uses, Ecology would not support investing the resources needed to change the named use in the standards. An exception may be where the state wants to discourge or not show support for public uses such as swimming or fishing in waters where legal prohibitions or hazardous conditions exist. In such a situation, the use may be changed (e.g., eliminating the use of swimming) but the criteria to protect that use would be retained to protect any members of the public that use the water in spite of any objective hazards or legal prohibitions.

Part II. General Guidance

What does it mean to meet Water Quality Standards in a Reservoir behind a dam?

The lake criteria in the state water quality standards were established with the intention that they be applied to both natural lakes, as well as human reservoirs with impoundments having a mean annual detention time of greater than 15 days. This is because such reservoirs behave much like a natural lake does in terms of warming, oxygen depletion, stratification, and use by aquatic communities and humans.

The criteria for lakes recognize that it is problematic to establish fixed statewide values (biological threshold criteria) for water quality expectations in lakes and reservoirs for certain water quality constituents. The criteria for temperature, dissolved oxygen, and pH were set, therefore, to match "natural" levels. While this approach is generally fine for natural lakes, it does not account for the fact that reservoirs are not natural and are subject to human manipulation that may significantly alter water quality conditions.

If Ecology were to treat a reservoir as if it was a natural feature, then it would also need to treat the water passing through the dam and affecting downstream rivers as if it were natural as well. This approach would not meet federal and state water quality laws and regulations, or be technically appropriate. Through structural and operational changes in the dam and reservoir, a dam operation can influence the water quality both in the reservoir as well as in the downstream river.

To address this situation, a UAA needs to be done for the reservoir that determines the highest water quality that is feasible to attain in that waterbody. **The UAA needs to focus on meeting the water quality criteria (or the highest attainable uses if the designated uses associated with those criteria are not attainable) downstream of the dam, <u>and</u> achieving the highest attainable water quality condition within the reservoir.** This goal is most consistent with the water quality standards and the state's water pollution control laws. Achieving the highest attainable water quality in a reservoir is essentially the same as maintaining a natural lake in its highest natural state. It is important to recognize, however, that since the reservoir is not natural the discharge from the reservoir will not be considered a natural condition and thus cannot be allowed to cause or contribute to an excursion from the downstream water quality standards.

In conducting a UAA for a damned system, it is also necessary to consider water quality problems that are made worse by the dam's operation. Ecology will need to understand how the design and operation of the dam and reservoir will interact with upstream sources of pollution and other human modifications. The goal of this analysis would be to identify how the dam would need to be designed and operated to support the highest level of attainable uses (if meeting the designated uses is found to be an unattainable goal).

What is meant by achieving the highest attainable water quality condition in the reservoir?

Changes in reservoir management can cause complex changes in water quality. It is expected to be rare to identify structural or operational changes that will exert a positive influence on all water quality parameters throughout all portions of a reservoir. Typically, achieving the highest attainable water quality condition will mean identifying the structural and managerial actions that result in the greatest net improvements. This can be done through a numeric analysis. However, since the goal of the water quality standards is to protect instream uses such as aquatic life and wildlife habitat, there is also a need be able to consider the net biological benefits. Thus if the largest net improvement in water quality was obtained by focusing on creating improvements in a deep hypoxic layer of a reservoir, but most of the species of concern rely on the epilimnion and metalimnion (upper layers), then maximizing the *water quality* improvement in the hypolimnion may not really represent the highest attainable condition. So, while Ecology will need to assess the numerical changes in the various water quality parameters, the department will also need to consider what changes result in the highest level of protection for the existing and attainable uses of the reservoir.

One way to demonstrate numerical improvements in water quality in a reservoir is to evaluate possible changes in operations using a frequency distribution for each of the key water quality parameters (e.g., temperature, dissolved oxygen, turbidity, pH). If a reservoir is divided into sufficient model segments (e.g., 1 km long) and the model run at a high resolution (e.g., 1 meter depths) then the results could be used to construct a frequency distribution for the entire reservoir showing where improvements in water quality, as measured against the most applicable criteria for each parameter, would occur (e.g., the numeric criteria for the use type as shown for rivers, such as 16°C and 8 mg/l dissolved oxygen for salmonid rearing, would be an effective target for comparison for this exercise in reservoirs). This approach would graphically illustrate which alternative results in the greatest net improvement in each numeric water quality parameter, and would illustrate where these improvements would occur. In doing so, it will provide support for both numeric and qualitative examinations aimed at determining which alternative results in the greatest improvement in water quality and protection for existing and attainable uses.

Waterbodies that cross Multiple Political Jurisdictions

It will always be a more challenging and tenuous process to develop a UAA for a waterbody that crosses national, state, and tribal boundaries. No political jurisdiction can change the water quality standards of another jurisdiction. Thus even if a state or tribe adopts a UAA for its waters, the activities of that upstream state or tribal jurisdiction and the quality of the water crossing their downstream boundary must meet the standards of the downstream jurisdiction. This means that any benefits to reducing the stringency of the uses and criteria from conducting a UAA in the waters of an upstream jurisdiction may be negated by the continued need to meet the standards at the boundary with the downstream jurisdiction.

Anytime a UAA involves a river that flows through multiple jurisdictions, it will be important to try and create a working partnership among the effected parties. This partnership is important to increase the chance the downstream jurisdiction will support the results of the UAA and, ideally, be willing to change their standards to accommodate the results.

The federal Clean Water Act [Section 401(a)(2)] details the requirement for certifications issued in one state to be conditioned so as to comply with the applicable water quality requirements of any effected downstream state. Where there are disputes as to whether conditions will provide for attainment of the downstream state's water quality requirements, EPA serves as the authority for determining if the evidence supports a conclusion that those downstream standards will be met. If the imposition of conditions in the certification cannot insure such compliance, then the license or permit is not to be issued.

When the downstream jurisdiction is a tribe, and upstream use changes would create a situation where the downstream tribe's standards might not be met, the EPA is less likely to approve changes in an upstream state's standards in an effort to uphold their trust responsibilities to the tribe. The federal regulations do, however, provide a dispute resolution process that allows EPA to intervene and modify the downstream state or tribes' standards [40 CFR 131.7] to prevent "unreasonable consequences" (Note: Ecology is unaware of any examples where EPA has used this provision or further defined what could constitute an unreasonable consequence).

Where a UAA is conducted for a waterbody that originates in Canada, such as the Columbia River, the existing condition of the inflow at the border can be used as a baseline condition in the UAA analysis. Before making changes to the standards, however, the state, through EPA, should attempt to enter into negotiations with Canada to determine if they would be willing to help identify and protect the highest attainable uses and conditions of the water as it flows into Washington.

Ownership of the Dam

Dams may be owned and controlled by private or public entities, and may additionally be owned by public entities at the federal or local level. The process for Ecology review and the ability to influence the operations of any dam depends to a large extent on its ownership pattern. For those dams needing to be relicensed by the Federal Energy Regulatory Commission, it also depends on where they are in their licensing cycle.

This creates a complex pattern for the state to ensure that the operation of these facilities is in compliance with the water quality standards in general, and it creates some particular challenges when it comes to conducting a UAA for the effected waters. All of these facilities, however, are required by state and federal laws and regulations to comply with the state water quality standards. It is this requirement that provides a mechanism to bring dams into a UAA process.

Compelling Participation in a UAA Study:

If needed, Ecology, or some other UAA proponent, should work with each dam operation to encourage their voluntary participation in conducting a UAA. Proponents other than Ecology may find it difficult to obtain participation. Where Ecology is conducting a UAA, if voluntary participation is not occurring then the agency might compel participation from all eligible facilities. Ecology may compel participation in a UAA only from dam operations that are causing or contributing to a violation of the state surface water quality standards. Participation can be invoked through a compliance order, or can be made a condition to a 401 certification.

Ecology will issue a notice of violation, followed by a compliance order, as a first step in compelling participation in the UAA process. The recipient dam would be directed towards entering into a joint UAA study for the entire system. However, they should not be compelled to participate jointly if they wish to develop their own UAA or individually bring about compliance (perhaps through demonstrating they have no detrimental impact to water or habitat) with the criteria established to protect the designated uses. This is a less efficient and more expensive option for the dam operation, but the study can be designed to provide the necessary information to support a system wide UAA.

Relicensing Individual Dams

Under only a few conditions is it possible to grant a water quality certification for relicensing an individual dam that exists in a river with multiple dams:

1) Studies show the water quality standards are being met in the reservoir and in the downstream waters.

3) Studies show the dam and its reservoir do not degrade the quality of the incoming water, and would meet the criteria and support the designated uses if the upstream water met the criteria (Note: This concept needs to be considered in combination with the need to also mitigate upstream sources of pollution as discussed below).
4) The dam is placed on a compliance schedule consistent with the requirements of Chapter 173-201A-510(5) to meet the state water quality standards, or eventually demonstrate through a UAA (or other mechanism) those standards can be appropriately changed for the waterbody or a variance established for that facility.

Accounting for Upstream Sources of Pollution and Use Degradation

As noted previously, a UAA will need to describe the quality of uses that would be attained if all human sources were controlled consistent with the six federal UAA conditions [40 CFR 131.10(g)] listed above. The UAA will need to take into consideration the effects of upstream sources of water quality degradation (i.e., point sources, nonpoint sources, dams, etc.). and consider whether or not water quality problems are made worse by the dam operations. For instance, if upstream sources add nutrients to the water and the dam impoundment facilitates creation of critical conditions that contribute to a problem with dissolved oxygen, both the upstream sources and the dam must be evaluated as part of the waterbody UAA.

While a UAA must consider the attainable condition that would result if all sources are being controlled to their maximum feasible extent, Ecology will not assume that all upstream sources have or will be controlled to that extent when setting the discharge allocations for downstream dams and dischargers. Doing otherwise would result in authorizations for individual sources to violate the water quality standards, unless the allocations were formally made in an enforceable regulatory context to all contributing sources, such as is done through a TMDL.

Ecology will need to understand how alternative structural and operations changes for the dams and reservoirs will interact with upstream sources of pollution and other human modifications. The goal of this analysis would be to identify how the dam(s) would need to be designed and operated to result in the support of the highest level of attainable uses (if meeting the designated use is found to be an unattainable goal).

Reservoirs, particularly storage reservoirs, often create conditions that worsen the impact of upstream pollutants (more stagnant flows, warmer temperatures in surface layers, and stratification at depth restricting mixing). How reservoirs are operated (depth of pool at different seasons, flushing rates, outlet depth and release patterns), however, can influence the extent to which the incoming pollution exerts an influence on the overall water quality in and below the reservoir. For this reason it is necessary that structural and operational controls for the dam and reservoir be examined with the intent of considering how they may be managed to help mitigate the impacts of incoming pollution. This does not mean that the dams are responsible for cleaning up incoming water, but rather for the effects they cause which would otherwise not exist if the dam created conditions were not present. It also recognizes the goal of obtaining the highest attainable uses within and downstream of the reservoir.

Where information is not available to document the specific levels of feasible improvement for all these upstream sources (and in some cases downstream as well), it may in some situations be possible to substitute general but optimistic estimates on the levels of improvement possible. Any form of estimation increases the risk the UAA will not be ultimately approved, so using estimates that lean towards erring on the site of expecting greater environmental improvement will increase the chance that the final result will be viewed as defensible.

Scale of the Assessment

Typically the entire waterbody (watershed) will need to be modeled and evaluated to determine: 1) if the designated uses can be attained, or if not, 2) what the highest attainable uses would be if all human sources of degradation were appropriately controlled [see 40 CFR 131.10(g)(1)-(6)].

Any UAA effort that falls short of this goal, would be unlikely to result in a change in the designated uses. The only change that would likely be approved through a partial (non-system wide) UAA would be to grant a temporary but renewable variance (WAC 173-201A-420). There remains the possibility, however, that a site specific criteria (WAC 173-201A-430) could be developed by a single entity and used to change the water quality criteria used in the state standards. If any human activities were involved in establishing or limiting the aquatic community or other uses being evaluated for a site specific criteria, very cautious and environmentally protective assumptions would be needed. For example, if migratory species are not present because of a dam that does not allow migrants to pass, site specific criteria could not be based only on the requirements of non-migratory species.

Where a UAA is based on applying the economic hardship provision [40 CFR 131.10(g)] of the federal UAA regulations for an individual facility, Ecology is also unlikely to remove any uses from the waterbody. Rather, the department is more likely to limit approval to adopting a formal variance for the facility from meeting certain criteria.

Hypothetical Case Study: (*A single Dam Operator Proposes a UAA*):

A mid-Columbia River dam is having trouble meeting the water quality criteria established to protect "salmon and trout spawning, noncore rearing, and migration". They have already determined they cannot feasibly operate their dam and reservoir in a manner that does not lower the quality of the incoming water. And they believe that the uses are not set appropriately for the mid-Columbia River and want to conduct a UAA.

Dams, reservoirs, withdrawals, and pollution discharges in Canada, Idaho, Oregon, and Washington combine to influence the attainable uses in the Columbia River. This situation is made more complex by the fact that the dams and reservoirs are operated by a mixture of private, local public, and federal entities; and licenses are either not required or have already been issued for many of these facilities. This situation further adds to the complication of determining a UAA for this enormous and complex waterbody system.

There are two pathways this UAA analysis could take: 1) a facility level analysis, or 2) a system wide analysis. The second approach would be relatively difficult for a single entity to pursue as estimates on the ability for all human sources of degradation to be remedied would be needed for the watershed. However, this second approach would have the greatest chance of resulting in a permanent change in a designated use in the water quality standards.

In both cases, the proponent would need to determine the existing uses of the waterbody. This entails identifying the highest uses that have been attained in the waterbody at anytime since November 28, 1975. This represents the existing uses. It is not acceptable to limit this analysis only to the categories or uses established in the water quality standards regulation. It is also not acceptable to use the criteria associated with those categories to define whether or not a use has occurred. In this exercise it is important to describe in careful detail the highest level of the use that has occurred (high densities versus low densities, common versus infrequent, early versus late spawning, etc), and note the associated highest water quality condition that occurred in association with these uses. If the designated use or uses in question occurred at anytime since 1975, then they are existing uses and a UAA cannot be used to remove them from the state standards. If uses are identified that require more stringent water quality criteria then the designated use(s) in question, then an alternative use and criteria must be proposed in the UAA that will protect those more sensitive existing uses. For example, if bull trout spawning was an existing use, but salmon spawning is the designated use in question, the salmon spawning use could only be removed if an alternative use were established with criteria that would protect the existing use of bull trout spawning.

In a facility level UAA analysis, the operator of the dam would need to evaluate the impact to water quality from the existence of the facility (for nonfederal projects only). They would also need to evaluate all technically feasible structural and operational alternatives that they could use to improve water quality in the reservoir and downstream of the dam (while upstream impacts are uncharacteristic they would need to be considered as well).

Any technically feasible alternative that would result in the waterbody attaining the designated use would be required so long as its implementation would not cause substantial and widespread economic and social impact. If, even with the use of such technically feasible alternatives the designated use cannot be attained, then a UAA can be pursued to change the state standards. The selection of a replacement use and the criteria for protecting that use, will be based on a couple considerations:

1) If the attainable use is well described by one of the uses established within the state water quality standards, then that described use may serve as a replacement for the non-attainable designated use.

2) If the attainable use appears to be a level of use that falls between the designated use and the next lower category of use described in the state standards, then a unique use type would be established based on providing the highest attainable level of use support.

If the proponent can show the designated use is not an existing use, then a UAA might be an appropriate pathway to develop alternative water quality standards for the river and their reservoir. To do this:

- First they need to demonstrate that the designated use has not been attained in the waterbody at anytime on or after November 28, 1975. This can be done in part by showing the criteria established to protect the use has substantially not been met at anytime since 1975. If the use has not been attained (not an existing use) then a UAA can be pursued. If it has been attained, then a UAA cannot be used to change the water quality standards and the criteria must be achieved through some means or another.

- Once it is determined that the designated use is not an existing use, the proponent needs to provide an analysis showing why it is not feasible to restore the waterbody to its original condition (for non-federal projects only) or to incorporate structural and operational changes that will result in compliance with the standards (i.e., attainment of the designated use).

- At this juncture there are really two pathways the UAA could take:

  1) Show that restoring the system and implementing structural and operational changes necessary to attain the use will result in substantial and widespread economic and social impact, <u>or</u>
  2) Conduct a system wide UAA that will estimate the improvements in water quality that may be expected if:
     a) All technically feasible structural and operational changes are being used to regulate dams diversion, and other hydrologic modifications;

b) The highest technology-based controls are being provided to all point sources of pollution, short of those that would cause substantial and widespread economic and social impact; and

c) All cost effective and reasonable best management practices are being provided to all non-point sources in the watershed.

This first pathway is facility specific and would be the easiest course for a individual dam to take. *Without* a system wide analysis, however, Ecology could likely only grant a temporary but renewable variance for the specific dam. This is because the economic pathway does not account for the potential improvements in use protection from other sources, and so does not allow identification of the highest attainable use – which would be the use that would need to be adopted in the place of the current designated use.

- The second pathway (conduct a system wide UAA) is significantly more complicated. In this case the proponent would have the greatest chance of success if they secure the cooperation of all of the other dam operations on the river in developing the UAA.

Footnote 17

From:	Braley, Susan (ECY)
Sent:	Wednesday, November 28, 2007 4:50 PM
To:	Pickett, Paul (ECY) <PPic461@ECY.WA.GOV>
Cc:	Maynard, Chris (ECY) <cmay461@ECY.WA.GOV>; Kannadaguli, Monika (ECY) <MKAN461@ECY.WA.GOV>; Drabek, John (ECY) <JDRA461@ECY.WA.GOV>
Subject:	RE: Jackson Project--Questions from Ivy Anderson

Paul—Regarding your confusion with past modeling of reservoirs, Chris and I have done some homework and here is what we find...

The question to model or not to model a reservoir behind a dam is based on a number of logical, rational decisions and assumptions about the specific dam and the value that modeling would have on the outcome. At least that is my read of the past decisions Ecology has made on whether to model or not.

The precedence for modeling reservoirs behind dams for temperature depends on whether the reservoir is treated as a lake (greater than 15 day retention time) or a river.

The precedence has been NOT to model the reservoir for temperature natural background above the dam when it is treated as a lake. We did not model reservoir temperatures for Baker Lake, the Lewis River dams, Rife Lake (on Cowlitz) and Cushman. According to Chris' Reservoir Table, Packwood Lake is the only reservoir that we are requiring modeling for natural pre-dam temperature (my understanding is that the Spokane River modeling is for D.O., not temperature). I do not know the reasoning behind why Packwood Lake requires modeling. Chris wasn't sure as it doesn't impact downstream temperatures and is a high mountain lake (in fact it may cause cooler waters downstream), and has no significant upstream sources (I will follow up with Deborah Cornet to find out why it is different).

For reservoirs that act as a river, on the other hand, the precedence HAS been to model the reservoir (as you note below). I assume the assumptions and similarities of these types of reservoirs makes the modeling more meaningful in answering how much the dam impacts temperatures, especially downstream.

The main questions that should be asked in order to determine the need to model are as follows:

1. What do you gain by modeling? Will the results influence how the dam operates to control temperature, especially downstream? How would modeling natural conditions of the pre-dam reservoir get you to cooler water?

Response: If the modeling will provide information that will influence how the dam operates or provide meaningful information to base decisions on for getting to cooler water, it is worthwhile to do. If the model will only provide a pre-dam temperature, especially for a lake, it is not useful in establishing how to measure the 0.3 allowance from the post-dam background. This is similar to how we are now starting to require NPDES permit monitoring for temperature (permitters must monitor to establish background temperatures from which to apply the temperature standards).

1. Short of modeling, what should be used as a baseline for establishing the 0.3 allowance above the reservoir temperature background?

Response: Use vertical profiling. The reservoirs/lakes that were not modeled were all required to do a characterization of the lake, including vertical profiles and lateral transects, for D.O. and temperature. Part of the characterization includes looking at habitat, recreation and aesthetics. This information will provide enough information to establish a background condition of the reservoir in which to measure the 0.3 allowance.

I believe there are probably some logical tiered questions we can come up with that will help determine whether a reservoir above a dam needs to be modeled. Some that come to mind are:

1. Is the temperature upstream or downstream not meeting standards?

1. Is the reservoir contributing or impacting down stream temperatures?

1. Is the reservoir a run of the river? If yes, modeling likely needed.

1. Is the reservoir a lake? If yes, only model if the reservoir impacts downstream temperatures.

1. Is the reservoir impacted by upstream sources of temperature increase? If yes, determine if modeling would help answer the question of how to get the water cooler.

I guess my conclusion is that Jackson project would not need a model, but certainly needs the full characterization (vertical profiling, etc) of the lake. Unless there are compelling reasons that I have missed. If there are PLEASE LET ME KNOW!! If this needs a meeting let me know. I do want to get back with Ivy at some point.

Thanks--Susan

From: Pickett, Paul (ECY)
Sent: Monday, November 26, 2007 4:49 PM
To: Braley, Susan (ECY)
Cc: Maynard, Chris (ECY); Kannadaguli, Monika (ECY); Drabek, John (ECY)
Subject: RE: Jackson Project--Questions from Ivy Anderson

I'm a little confused because we have required pre-dam modeling to determine natural conditions for Avista's Spokane River project, Rocky Reach, Priest Rapids, Boundary Dam, and Packwood Lake. The first is a lake created from a river, the next three are run of the river, while Packwood Lake is a pre-existing lake. So if Chris meant that we haven't asked for pre-existing modeling for a reservoir that was a river before but is a lake now, Spokane is the one example. Baker Lake was not required to do modeling, but it was a lake before it was dammed.

We went over several ideas for assessing "natural" for Jackson, but I haven't looked at that for a while, so I'll need to review the project and get back on that when I've caught up a bit more.

Paul

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From: Braley, Susan (ECY)
Sent: Monday, November 26, 2007 4:41 PM
To: Kannadaguli, Monika (ECY); Drabek, John (ECY); Pickett, Paul (ECY)
Cc: Maynard, Chris (ECY)
Subject: Jackson Project--Questions from Ivy Anderson

Hey Guys—I had a follow up call with Ivy Anderson and think I understand her questions regarding the Jackson project. This will probably not be news to you but I wanted to reiterate the conversation and my thoughts. She explained that they are now in the process of developing the monitoring plans for work that will occur in order to be ready for the re-licensing and 401 certification of the Jackson Project. They have been exploring what modeling, if any, would be needed for the reservoir (defined as a lake with 100 day retention time) behind the dam, in order to determine monitoring needs if modeling were to be required. She said that data needs of the river downstream are not a problem (they have been figured out).

The question raised has to do with the temperature standards for lakes, which says (from WAC):

(v) For lakes, human actions considered cumulatively may not increase the 7-DADMax temperature more than 0.3°C (0.54°F) above natural conditions.

They are concerned about how you determine natural conditions, given that it is a dam that created the reservoir. And if modeling is the answer, does it really make sense to model the reservoir to determine what baseline to apply the 0.3 allowance from? So bottom line, what do they use as a baseline for the reservoir?

Chris and I discussed what we have done in the past with dam re-licensing, and he said he was not aware of any dams where we have required modeling of reservoirs (lakes) to determine natural conditions. Given the location of the dam (higher elevation lake) and the fact that it appears to meet temperature downstream, leads me to conclude that there is not a reason to require something different of the Jackson project in terms of requiring modeling of the reservoir. Ivy did say that they planned 2-3 years of data collection (including presence of aquatic life), and it seems like that would be sufficient to establish a temperature baseline from which to measure the 0.3 degrees from. Chirrs suggested that Monika talk to Alison about how they treated the Baker project, as it sounded similar.

So, that is my take on the Jackson project and Ivy's questions. Did I miss something significant that would change the decision to treat Jackson similar to how we have other dams with regard to upstream reservoirs?

Thanks—Susan

Susan Braley
Unit Supervisor
Watershed Management Section
(360) 407-6414

Footnote 18

From:	Robert Steed
To:	John Tindall; "bryce.sandy@epa.gov";
cc:	Robert Steed;
Subject:	FW: Spokane River: Northern Rockies or Columbia Plateau? 2nd Opinion
Date:	Monday, April 13, 2009 4:56:42 PM
Attachments:	spokaneriver.jpg image002.png

John,

The information I have sent you (see email below) may need to be further discussed. I have been in contact with Ms. Sandy Bryce, and have learned much. Sandy works for Dynamac Corporation for the Western Ecology Division of U.S. EPA in Corvallis. Sandy is an author of many of the country's ecoregion maps, and a developer of the ecoregion maps for our area. Sandy told me several things that bolster DEQ's challenge to the appropriateness of 10 ug/L TP target for an assessment point somewhere between Nine Mile dam and Long Lake Reservoir (the inundated portion of the Spokane River). EPA's total phosphorus criteria recommendations are based on Aggregate Nutrient Ecoregion III. Sandy's ecoregion delineations have been aggregated to form Nutrient Ecoregions.

Below I reference the ecoregion "type" areas. The concept of ecoregion "type" areas is not applicable to the current ecoregion maps. Making comparison with what is in the center of an ecoregion may not necessarily be a correct method for determining which ecoregion an area belongs to. I keyed in on the over-story pines, assuming that pines were a characteristic for the Northern Rockies ecoregion. The Columbia plateau has other examples of areas with pines, especially where ground water is available.

Sandy stated that, "It is a toss up whether the nine mile area shown below is in ecoregion 10 (Columbia plateau) or 15 (northern Rockies)". Columbia plateau is part of Xeric West aggregate nutrient ecoregion and northern Rockies is part of Western Forested Mountains aggregate nutrient ecoregion. When delineating ecoregions, developers avoid contacts that run along waters, like the contact does along the east half of Long Lake Reservoir. If I understood her correctly, it appears that our assessment point (nine mile area) is part of the Four Mound Prairie, which is within the Columbia plateau ecoregion.

Clearly the basis for 10 ug/L TP in this section of river isn't as simple as it has been portrayed. The presence of a map line itself is not appropriate justification for the application of numeric criteria for protection of beneficial uses. DEQ should stick with our position that the assessment point is on the contact between ecoregions and the assessment concentration should also be between the suggested values for each aggregate nutrient ecoregion.

On another element of this issue; I am still questioning that appropriateness of the Western Mountains aggregate nutrient ecoregion results because:

1. It is my understanding that most (99%+) nutrients in the data base were analyzed following EPA method 365.4. EPA method 365.4 has and applicable range (MDL) between 0.01 and 20 mg/L TP. Labs do provide low level TP analysis, but the quality of these low level analyses is less than can be ascertained following the method. When I send samples to the lab sometimes the results to not meet data quality objectives. The best I can get our lab to perform at for low level nutrient analysis is precision DQO of 20% and accuracy DQO of ± 25% recovery. That means there is a 95% chance when I look at a lab report that says TP = 9.9 the value is somewhere between 7.4 and 12.4. How can criteria be developed from data that are likely to be inaccurate? It's not a sliding scale because the method is actually changed (different stuff is used) when running low level TP.
2. The criteria are said to be based on 25th percentiles of Aggregate Nutrient Ecoregion II Reference Conditions, but I believe they are actually the 75th percentile of the Aggregate Nutrient II Conditions. I can not find the documentation that "Reference" waters were identified for the Western Mountains.
3. The table from executive summary shows the Range of Level III Subecoregions Reference Conditions, especially the lower limit are greater than the individual ecoregions. How can an aggregate have a range smaller than a subset of the ecoregion?
4. Table 3h. Reference conditions for level III ecoregion 15, which is the Northern Rockies, shows TP (along with other parameters) ranging from 0 to 760. How can TP = 0 with the analysis methods available to us. The method detection limit is 10 ug/L. How were BDL handled? Zero's in a data base make me wonder. Do you suppose zeros are used for BDL? Or do zeros represent "no data". Was the 25th or 75th percentile calculated with zeros in the data base?

I have contacted the folks that developed these guidance documents, but have not gotten what I need yet.

I have included Sandy on this e-mail. Sandy, any correction, or clarification would greatly be appreciated.

Bob-

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From: Robert Steed
Sent: Monday, March 30, 2009 4:34 PM
To: John Tindall
Cc: Robert Steed
Subject: FW: Spokane River: Northern Rockies or Columbia Plateau?

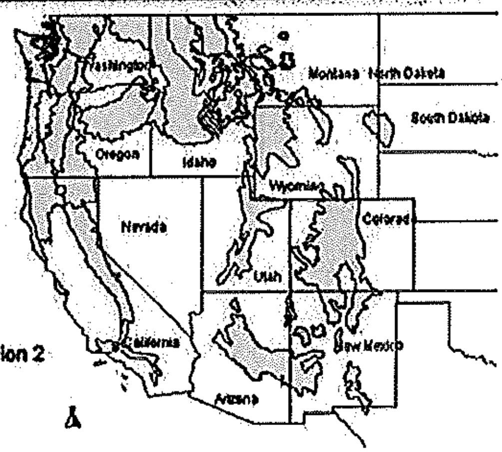
It is not always that simple. Boundaries between two ecoregions (contacts) are not always that clear and for that reason it is important to be familiar with the area. I suggest, from my memory of Long Lake Reservoir area, satellite imagery, and photos; that the Long Lake Reservoir area is more like Northern Rockies type areas, and less like Columbia Plateau type areas. Classification using Northern Rockies Ecoregion is probably correct, but poorly justified. In my opinion, on border contacts, it isn't appropriate just to default to the map. Application of EPA Ambient Water Quality Criteria Recommendations to contacts between ecoregions may not make sense. It is likely that WQ targets should be somewhere between Northern Rockies and Columbia Plateau.

Let's run an analogy between your front yard and back yard. When you are standing in the front yard, "which yard you are in" is obvious. From your front yard you can see the front of your house, you can see the driveway to the garage, and you can see the street and the front of the neighbor's house across the street. On the other hand, when you are in the back yard you can see the back of your house, the back of your neighbor's house, and dog toys. These descriptive "yard" characteristics are similar to the characteristics used to describe ecoregions. Ecoregion descriptions usually characterize a typical (type) location representing the rest of the Ecoregion. Areas along the contact between ecoregions commonly display characteristics of both adjoining ecoregions. Back to the yard, as you walk from the front of the house to the back, you'll get to an area where you can see both the front of the neighbor's house across the street and the back of the neighbor's house out back. Further toward the back you get to a location where you can no longer see the driveway, even further you may get into the dog poop zone. The contact between the front yard and back yard may be at different locations depending on what criteria you use to define each. You know there is a line (contact) between the front yard and the back yard, but the actual location becomes subjective.

Back to the Spokane River. The lake is bisected by the contact between the "Columbia Plateau" and the "Northern Rockies" Aggregate Nutrient Ecoregions 3.

Aggregate Nutrient Ecoregion III	Streams – 25%tile of Reference Conditions	Streams – Range of Reference Conditions
Columbia Plateau	21.88 ug/L	10-55 ug/L
Northern Rockies	10.0 ug/L	3.0-32.5 ug/L

EPA's Technical Guidance Manual for Developing Nutrient Criteria for Rivers and Streams describes two ways of establishing a reference condition. One method is to choose the upper 25th percentile (75th percentile) of a reference population of streams. This is the preferred method to establish a reference condition. The 75th percentile was chosen by EPA since it is likely associated with minimally impacted conditions, will be protective of designated uses, and provides management flexibility. When reference streams are not identified, the second method is to determine the lower 25th percentile of the population of all streams within a region. The 25th percentile of the entire population was chosen by EPA to represent a surrogate for an actual reference population. Data analyses to date indicate that the lower 25th percentile from an entire population roughly approximates the 75th percentile for a reference population (see case studies for Minnesota lakes in the Lakes and Reservoirs

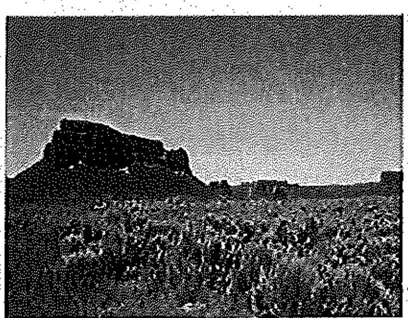


Aggregate Nutrient Ecoregion 2

Aggregate Nutrient Ecoregion 3

Descriptive Characteristics of Columbia Plateau

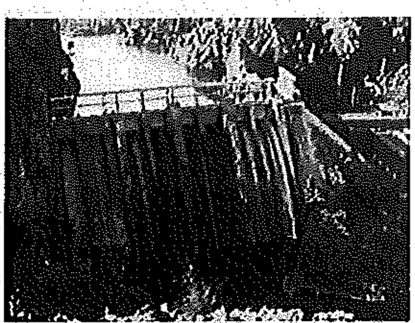
The Columbia Plateau is an arid sagebrush steppe and grassland surrounded on all sides by moisture, predominantly forested, mountainous ecological regions. This region is underlain by lava rock up to two miles thick and is covered in some places by loess soils that have been extensively cultivated for wheat, particularly in the eastern portions of the region where precipitation amounts are greater.



Descriptive Characteristics of Northern Rockies

The Northern Rockies is an ecoregion of high, rugged mountains. Although alpine characteristics, including numerous glacial lakes, are found in the higher elevations, the region is not as high nor as snow and ice covered as the Canadian Rockies. The mosaic of vegetation that presently and originally covered the region is different than that of the Middle Rockies. Although Douglas fir, subalpine fir, Englemann spruce, and ponderosa pine are characteristic of both regions, western white pine, western red cedar, and grand fir were and are common in the Northern Rockies, but not the Middle Rockies. Mining activities have caused stream water quality problems in portions of the region.

Lake Spokane Reservoir
The following pictures are from Lake Spokane Reservoir.



Caveat from EPA's Ambient Water Quality Criteria Recommendations: The values presented in this document generally represent nutrient levels that protect against the adverse effects of nutrient over enrichment and are based on information available to the Agency at the time of this publication. However, States and Tribes should critically evaluate this information in light of the specific designated uses that need to be protected. For example, more sensitive uses may require more stringent values as criteria to ensure adequate protection. On the other hand, overly stringent levels of protection against the adverse effects of cultural eutrophication may actually fall below levels that represent the natural load of nutrients for certain waterbodies. In cases such as these, the level of nutrients specified may not be sufficient to support a productive fishery. In the criteria derivation process, it is important to distinguish between the natural load associated with a specific waterbody and current reference conditions, using historical data and expert judgment. These elements of the nutrient criteria derivation process are best addressed by States and Tribes with access to information and local expertise. Therefore, EPA strongly encourages States and Tribes to use the information contained in this document and to develop more refined criteria according to the methods described in EPA's technical guidance manuals for specific waterbody types.

Bob-

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From: Nickel.Brian@epamail.epa.gov [mailto:Nickel.Brian@epamail.epa.gov]
Sent: Friday, March 27, 2009 12:24 PM
To: JROS461@ECY.WA.GOV
Cc: DMOO461@ECY.WA.GOV; Cope.Ben@epamail.epa.gov; Mann.Laurie@epamail.epa.gov; John Tindall; Robert Steed
Subject: Spokane River: Northern Rockies or Columbia Plateau?

Hi Jim,

At the meeting, some of the stakeholders were suggesting that the Spokane River is actually in the Columbia Plateau nutrient ecoregion. During the first go-around on this project, I asked our nutrient coordinator (at the time, it was Ralph Vaga) which ecoregion the Spokane River was in. He sent me the attached map. According to that map, the Spokane River is in the Northern Rockies ecoregion, which is part of the larger Western Forested Mountains ecoregion, except for the lower part of Lake Spokane, which is apparently in the Columbia Plateau ecoregion.

The recommended phosphorus value for the Western Forested Mountains aggregate ecoregion is 10 ppb (EPA 822-B-00-015, Page 19).
http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/rivers_2.pdf

Thanks,

Brian Nickel, E.I.T.

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Please conserve natural resources by not printing this message.

Footnote 19

Guidelines for Reviewing TMDLs under Existing Regulations issued in 1992

Section 303(d) of the Clean Water Act (CWA) and EPA's implementing regulations at 40 C.F.R. Part 130 describe the statutory and regulatory requirements for approvable TMDLs. Additional information is generally necessary for EPA to determine if a submitted TMDL fulfills the legal requirements for approval under Section 303(d) and EPA regulations, and should be included in the submittal package. Use of the verb "must" below denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable. These TMDL review guidelines are not themselves regulations. They are an attempt to summarize and provide guidance regarding currently effective statutory and regulatory requirements relating to TMDLs. Any differences between these guidelines and EPA's TMDL regulations should be resolved in favor of the regulations themselves. *A one-page checklist of the review elements may be found on the last page of this document.*

1. Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking

The TMDL submittal should identify the waterbody as it appears on the State's/Tribe's 303(d) list. The waterbody should be identified/georeferenced using the National Hydrography Dataset (NHD), and the TMDL should clearly identify the pollutant for which the TMDL is being established. In addition, the TMDL should identify the priority ranking of the waterbody and specify the link between the pollutant of concern and the water quality standard (see section 2 below).

The TMDL submittal should include an identification of the point and nonpoint sources of the pollutant of concern, including location of the source(s) and the quantity of the loading, e.g., lbs/per day. The TMDL should provide the identification numbers of the NPDES permits within the waterbody. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of the natural background. This information is necessary for EPA's review of the load and wasteload allocations, which are required by regulation.

The TMDL submittal should also contain a description of any important assumptions made in developing the TMDL, such as:

(1) the spatial extent of the watershed in which the impaired waterbody is located;

(2) the assumed distribution of land use in the watershed (e.g., urban, forested, agriculture);
(3) population characteristics, wildlife resources, and other relevant information affecting the characterization of the pollutant of concern and its allocation to sources;
(4) present and future growth trends, if taken into consideration in preparing the TMDL (e.g., the TMDL could include the design capacity of a wastewater treatment facility); and
(5) an explanation and analytical basis for expressing the TMDL through *surrogate measures*, if applicable. *Surrogate measures* are parameters such as percent fines and turbidity for sediment impairments; chlorophyl *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

2. Description of the Applicable Water Quality Standards and Numeric Water Quality Target

The TMDL submittal must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the antidegradation policy. (40 C.F.R. §130.7(c)(1)). EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation.

The TMDL submittal must identify a numeric water quality target(s) – a quantitative value used to measure whether or not the applicable water quality standard is attained. Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. The TMDL expresses the relationship between any necessary reduction of the pollutant of concern and the attainment of the numeric water quality target. Occasionally, the pollutant of concern is different from the pollutant that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as Dissolved Oxygen (DO) criteria). In such cases, the TMDL submittal should explain the linkage between the pollutant of concern and the chosen numeric water quality target.

3. Loading Capacity - Linking Water Quality and Pollutant Sources

A TMDL must identify the loading capacity of a waterbody for the applicable pollutant. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

The pollutant loadings may be expressed as either mass-per-time, toxicity or other appropriate measure (40 C.F.R. §130.2(i)). If the TMDL is expressed in terms other than a daily load, e.g., an annual load, the submittal should explain why it is appropriate to express the TMDL in the unit of measurement chosen. The TMDL submittal should describe the method used to establish the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

The TMDL submittal should contain documentation supporting the TMDL analysis, including the basis for any assumptions; a discussion of strengths and weaknesses in the analytical process; and results from any water quality modeling. EPA needs this information to review the loading capacity determination, and load and wasteload allocations, which are required by regulation.

TMDLs must take into account *critical conditions* for steam flow, loading, and water quality parameters as part of the analysis of loading capacity. (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable *critical conditions* and describe their approach to estimating both point and nonpoint source loadings under such *critical conditions.* In particular, the TMDL should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

4. Load Allocations (LAs)

EPA regulations require that a TMDL include LAs, which identify the portion of the loading capacity attributed to existing and future nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Where possible, load allocations should be described separately for natural background and nonpoint sources.

5. Wasteload Allocations (WLAs)

EPA regulations require that a TMDL include WLAs, which identify the portion of the loading capacity allocated to individual existing and future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit.

The individual WLAs may take the form of uniform percentage reductions or individual mass based limitations for dischargers where it can be shown that this solution meets WQSs and does not result in localized impairments. These individual WLAs may be adjusted during the NPDES permitting process. If the WLAs are adjusted, the individual effluent limits for each permit issued to a discharger on the impaired water must be consistent with the assumptions and requirements of the adjusted WLAs in the TMDL. If the WLAs are not adjusted, effluent limits contained in the permit must be consistent with the individual WLAs specified in the TMDL. If a draft permit provides for a higher load for a discharger than the corresponding individual WLA in the TMDL, the State/Tribe must demonstrate that the total WLA in the TMDL will be achieved through reductions in the remaining individual WLAs and that localized impairments will not result. All permitees should be notified of any deviations from the initial individual WLAs contained in the TMDL. EPA does not require the establishment of a new TMDL to reflect these revised allocations as long as the total WLA, as expressed in the TMDL, remains the same or decreases, and there is no reallocation between the total WLA and the total LA.

6. Margin of Safety (MOS)

The statute and regulations require that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set aside for the MOS must be identified.

7. Seasonal Variation

The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variations. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).

8. Reasonable Assurances

When a TMDL is developed for waters impaired by point sources only, the issuance of a National Pollutant Discharge Elimination System (NPDES) permit(s) provides the reasonable assurance that the wasteload allocations contained in the TMDL will be achieved. This is because 40 C.F.R. 122.44(d)(1)(vii)(B) requires that effluent limits in permits be consistent with "the assumptions and requirements of any available wasteload allocation" in an approved TMDL.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. This information is necessary for EPA to determine that the TMDL, including the load and wasteload allocations, has been established at a level necessary to implement water quality standards.

EPA's August 1997 TMDL Guidance also directs Regions to work with States to achieve TMDL load allocations in waters impaired only by nonpoint sources. However, EPA cannot disapprove a TMDL for nonpoint source-only impaired waters, which do not have a demonstration of reasonable assurance that LAs will be achieved, because such a showing is not required by current regulations.

9. Monitoring Plan to Track TMDL Effectiveness

EPA's 1991 document, *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA 440/4-91-001), recommends a monitoring plan to track the effectiveness of a TMDL, particularly when a TMDL involves both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur. Such a TMDL should provide assurances that nonpoint source controls will achieve expected load reductions and, such TMDL should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring and leading to attainment of water quality standards.

10. Implementation

EPA policy encourages Regions to work in partnership with States/Tribes to achieve nonpoint source load allocations established for 303(d)-listed waters impaired by nonpoint sources. Regions may assist States/Tribes in developing implementation plans that include reasonable assurances that nonpoint source LAs established in TMDLs for waters impaired solely or primarily by nonpoint sources will in fact be achieved. In addition, EPA policy recognizes that other relevant watershed management processes may be used in the TMDL process. EPA is not required to and does not approve TMDL implementation plans.

11. Public Participation

EPA policy is that there should be full and meaningful public participation in the TMDL development process. The TMDL regulations require that each State/Tribe must subject calculations to establish TMDLs to public review consistent with its own continuing planning process (40 C.F.R. §130.7(c)(1)(ii)). In guidance, EPA has explained that final TMDLs submitted to EPA for review and approval should describe the State's/Tribe's public participation process, including a summary of significant comments and the State's/Tribe's responses to those comments. When EPA establishes a TMDL, EPA regulations require EPA to publish a notice seeking public comment (40 C.F.R. §130.7(d)(2)).

Provision of inadequate public participation may be a basis for disapproving a TMDL. If EPA determines that a State/Tribe has not provided adequate public participation, EPA may defer its approval action until adequate public participation has been provided for, either by the State/Tribe or by EPA.

12. Submittal Letter

A submittal letter should be included with the TMDL submittal, and should specify whether the TMDL is being submitted for a *technical review* or *final review and approval.* Each final TMDL submitted to EPA should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute. The submittal letter, whether for technical review or final review and approval, should contain such identifying information as the name and location of the waterbody, and the pollutant(s) of concern.

13. Administrative Record

While not a necessary part of the submittal to EPA, the State/Tribe should also prepare an administrative record containing documents that support the establishment of and calculations/allocations in the TMDL. Components of the record should include all materials relied upon by the State/Tribe to develop and support the calculations/allocations in the TMDL, including any data, analyses, or scientific/technical references that were used, records of correspondence with stakeholders and EPA, responses to public comments, and other supporting materials. This record is needed to facilitate public and/or EPA review of the TMDL.

TMDL Review Checklist

State/Tribe:

§303(d) Segment(s):

Pollutant(s):

Date of Submittal:

Date of EPA Action:

Date Entered into Tracking System:

EPA Reviewer:

Review Element	Adequate?	Recommendations/ Comments
Submittal Letter		
Identification of Waterbody, Pollutant of Concern, Pollutant Sources, & Priority Ranking		
Applicable Water Quality Standards & Numeric Targets		
Loading Capacity		
Load Allocations (LAs)		
Wasteload Allocations (WLAs)		
Margin of Safety (MOS)		
Seasonal Variation		
Reasonable Assurances: through NPDES permits or if WLAs depend on LAs		
Public Participation		
Technical Analysis/Supporting Documentation		
Information entered into TMDL Tracking System		
Other Comments		