UDWQ POTW Nutrient Removal Cost Impact Study: Analysis of Price River Water Improvement District

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COPIES: Price River Water Improvement District

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In partial fulfillment of the Utah Division of Water Quality *Publicly Owned Treatment Works (POTW) Nutrient Removal Cost Impacts Study,* this Technical Memorandum (TM) summarizes the process, financial and environmental evaluation of the Price River Water Improvement District (PRWID) to meet the four tiers of nutrient standards presented in Table 1.

The thirty mechanical POTWs in the State of Utah were categorized into five groups to simplify process alternatives development, evaluation, and cost estimation for a large number of facilities. Similar approaches to upgrading these facilities for nutrient removal were thus incorporated into the models developed for POTWs with related treatment processes. The five categories considered were as follows:

- Oxidation Ditch (OD)
- Activated Sludge (AS)
- Membrane Bioreactor (MBR)
- Trickling Filter (TF)
- Hybrid Process (Trickling Filter/Solids Contact (TF/SC) or Trickling Filter/Activated Sludge (TF/AS))

The PRWID fits in the Hybrid Process (TF/AS) Category.

TABLE 1
Nutrient Discharge Standards for Treated Effluent

Tier	Total Phosphorus, mg/L	Total Nitrogen, mg/L
1N	0.1	10
1	0.1	no limit
2N	1.0	20
2	1.0	no limit
3	Base condition (1)	Base condition (1)

Note: (1) Includes ammonia limits as per the current UPDES Permit

1. Facility Overview

This facility is designed for an average flow of 4 million gallons per day (mgd) and currently receives an average annual influent flow of 1.8 mgd. The facility operates a TF/AS process with primary treatment to achieve nitrification in order to meet its effluent ammonia limits. Residual primary and secondary solids are co-settled in the primary clarifiers and stabilized using conventional mesophilic anaerobic digestion. The stabilized biosolids are dried in facultative sludge basins, and the biosolids are land applied. A process flow diagram is presented in Figure 1 and an aerial photo of the POTW is shown in Figure 2. The major unit processes are summarized in Table 2.

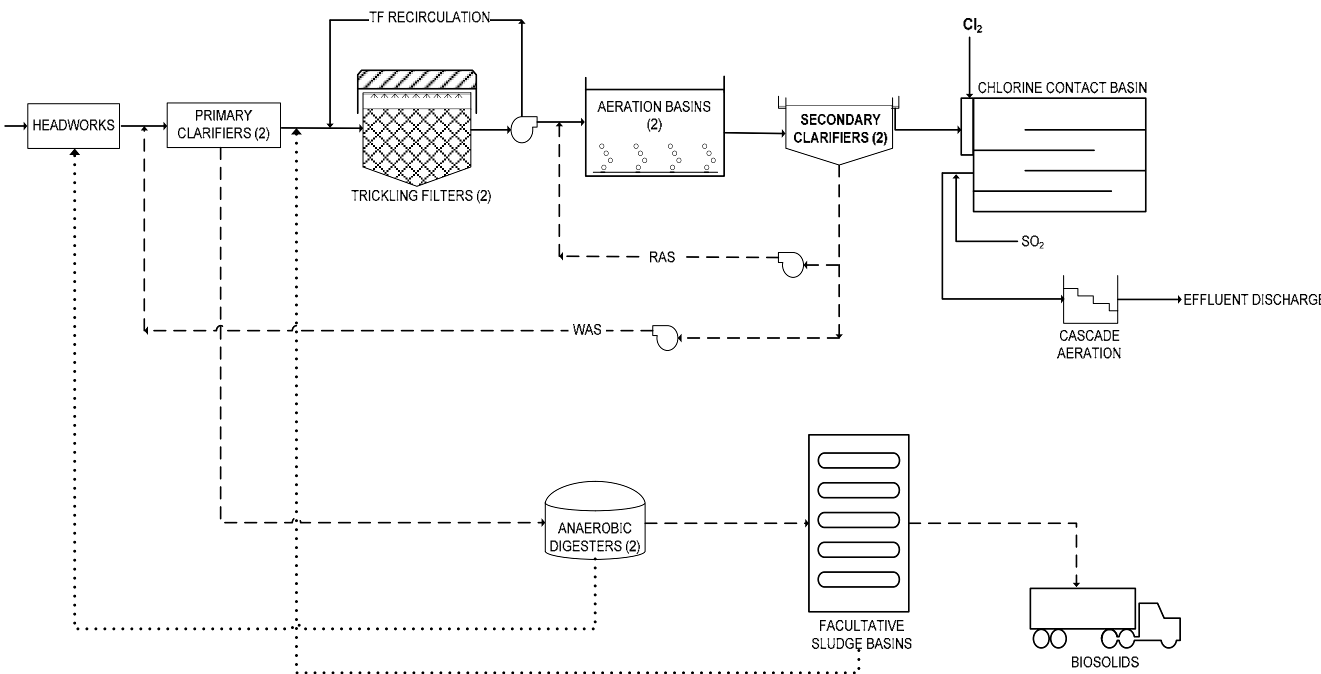

FIGURE 1
Process Flow Diagram

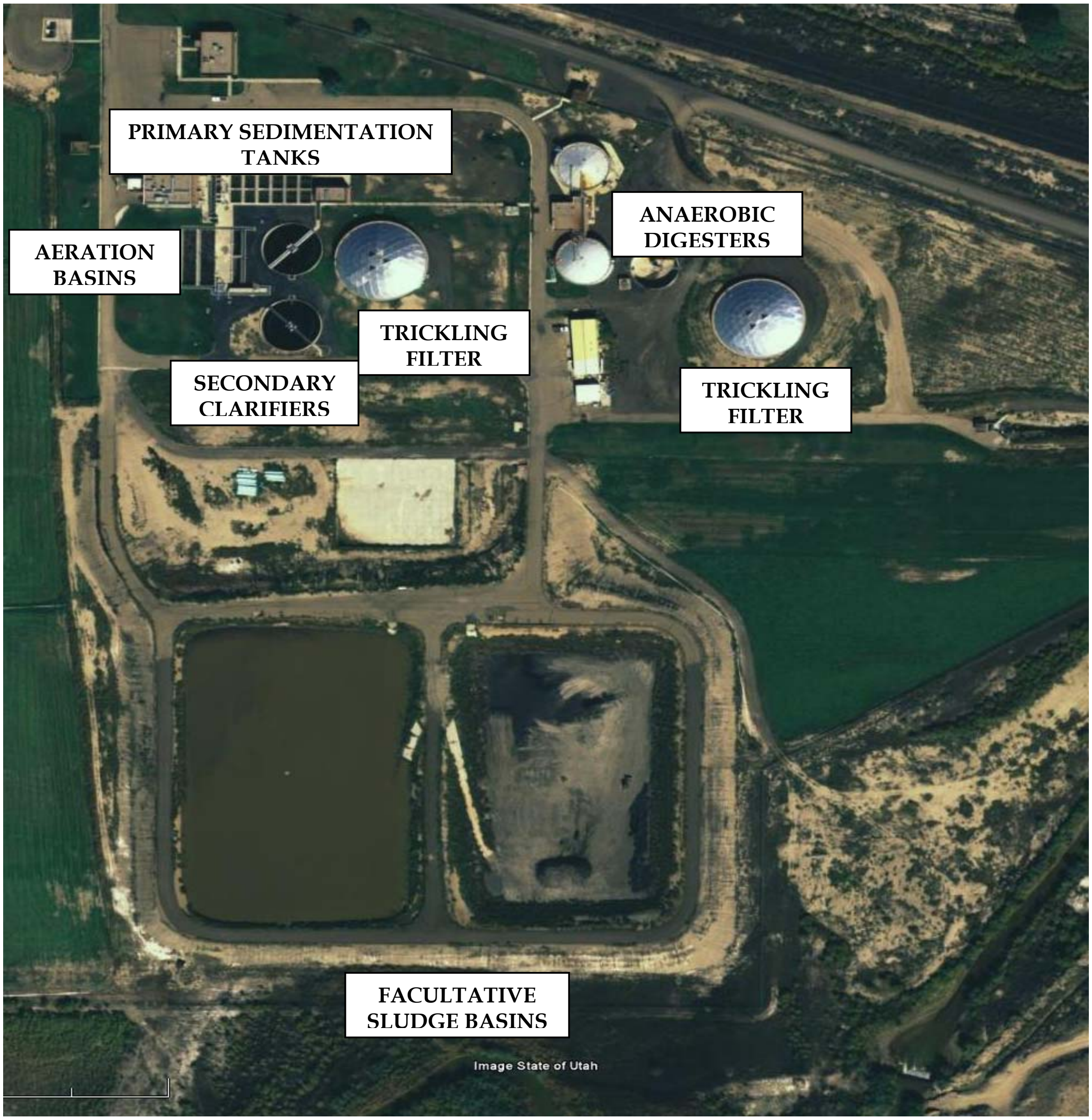

FIGURE 2
Aerial View of the Facility

TABLE 2
Summary of Major Unit Processes

Unit Process	Number of Units	Size, Each	Details
Primary clarifiers	2	120-ft x 21.5-ft, 10-ft depth	Rectangular tanks
Trickling filters	2	110-ft diameter, 10-ft media depth	Forced air, Rock media
Aeration basins	2	0.173 MG, 14-ft SWD	----
Secondary clarifiers	2	75-ft diameter, 13.75-ft SWD	Round clarifiers
Anaerobic digestion	2	0.6 MG	Anaerobic mesophilic
Solids Lagoons	2	300-ft x 500-ft x 18-ft	Facultative sludge basins

2. Nutrient Removal Alternatives Development, Screening and Selection

A nutrient removal alternatives matrix was prepared in order to capture an array of viable approaches for TF/SC and TF/AS facilities (See Attachment A). This matrix considers biological and chemical phosphorus removal approaches as well as different activated sludge configurations for nitrogen control. The alternatives matrix illustrates that there are several strategies for controlling nutrient limits. The processes that were modeled and described in subsequent sections are considered proven methods for meeting the nutrient limits. There may be other ways to further optimize to reduce capital and operation and maintenance (O&M) costs that are beyond the scope of this project. This TM can form the basis for an optimization study in the future should that be desired by the POTW.

The PRWID has two (2) rock media trickling filters and two (2) aeration basins. With this in mind, it was decided that a phased transition from the current process to an activated sludge treatment process only would be an appropriate treatment scheme to meet the increasingly stringent tiers of nutrient control. Figure 3 shows the selected upgrade approach used between each tier of nutrient control with the following bullet points A through D describing each upgrade step:

A. From Tier 3 (existing process) to Tier 2 phosphorus control, a metal-salt addition system was implemented ahead of the primary and the secondary clarifiers for chemical phosphorus removal.

B. To go from Tier 2 to Tier 2N, the existing aeration basins were expanded to a biological nutrient removal (BNR) process that operated in parallel with the existing rock media trickling filters, and treat roughly 50% of the primary effluent flow. The unsettled effluent from the trickling filters combined with the mixed liquor of the BNR process for further nitrification before settling. New secondary clarifiers were added to accommodate the modifications.

C. To go from Tier 2 to Tier 1 phosphorus control, granular media filters and an intermediate pump station were added to the facility with metal-salt feed facility upstream of the secondary clarifiers and the filters.

D. To add nitrogen removal to Tier 1, the BNR process added in B were expanded to treat 100% of the primary effluent and the trickling filters were decommissioned. Additional basin volume and new secondary clarifiers were added along with the granular media filters for chemical phosphorus polishing.

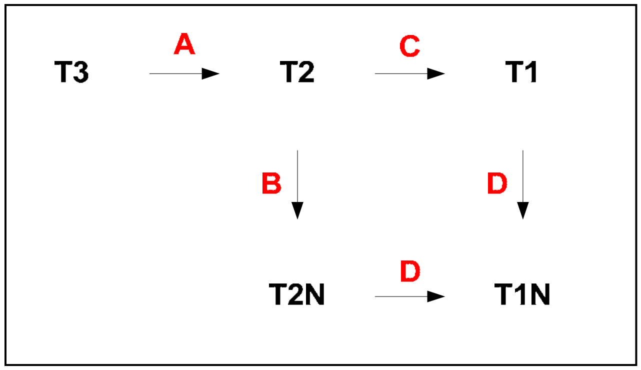

FIGURE 3
Upgrade Scheme for Meeting Increasingly More Stringent Nutrient Control

Data Evaluation and Modeling of Upgrades

The selected progression of upgrades conceived for meeting the different tiers of nutrient control for PRWID was analyzed using the following four steps:

- Step 1. Review, compile, and summarize the process performance data submitted by the POTW;
- Step 2. Develop and calibrate a base model of the existing POTW using the summarized performance data;
- Step 3. Build upon the base model by sequentially modifying it to incorporate unit process additions or upgrades for the different tiers of nutrient control and use model outputs to establish unit process sizing and operating requirements;
- Step 4. Develop capital and O&M costs for each upgrade developed in Step 3.

The facility information and data received from PRWID per the initial data request was evaluated to (a) develop, and validate the base process model, (b) size facilities to conserve the POTW's current rated capacity, and (c) project operating costs from 2009 through 2029. Table 3 provides a summary of the reported information used as the model input conditions. See Process Modeling Protocol (Attachment B) for additional information.

TABLE 3
Summary of Input Conditions

Input Parameter	2009(1)	2029(2)	Design(3)
Flow, mgd	1.80	1.90	4.0
BOD, lb/day	3,000 (200 mg/L)	3,169 (200 mg/L)	6,672 (200 mg/L)
TSS, lb/day	4,700 (313 mg/L)	4,991 (315 mg/L)	6,672 (200 mg/L)
TKN, lb/day	569 (38 mg/L)	602 (38 mg/L)	730 (38 mg/L)
TP, lb/day	68 (4.5 mg/L)	71 (4.5 mg/L)	94 (4.5 mg/L)

(1) Historic conditions 2007-2009

(2) Projected by the POTW

(3) Reported design average flow and loads of the POTW

The main sizing and operating design criteria that were important for capturing the costs associated with the system upgrade for PRWID are summarized in Table 4.

TABLE 4
Main Unit Process Sizing and Operating Design Parameters

Design Parameter (Nutrient Tier)	Value
Influent design temperature	14 deg C
Target metal:PO_4-P molar Ratio (All Tiers)	1:1, 2:1, 7:1 (1)
Metal salt storage (All Tiers)	14 days
Portion of primary effluent bypassed around TFs (T2N)	50%
Fraction of anaerobic volume in the BNR process (T2N and T1N)	15%
Fraction of anoxic volume in the BNR process (T2N and T1N)	30%
Mixed-Liquor return pumping ratio as a percent of influent flow (T2N)	100% to 150%
Nitrification Safety Factor (T2N)	1(3)
Nitrification Safety Factor (T1N)	2(4)
SVI (All Tiers)	120
Granular filter loading rate (T1)	5 gpm/ft^2 (2)

(1)Target dosing ratio at the primary clarifiers, secondary clarifiers and upstream of polishing filter, respectively. Filter doses were for Tier 1 and 1N only

(2)Hydraulic loading rate at peak hourly flow

(3) SRT in the BNR process adjusted to maintain a nitrification safety factor of 1 since the TFs will seed nitrifiers to the aeration basins.

(4) SRT in the BNR process adjusted to maintain a nitrification safety factor of 2

3. Nutrient Upgrade Approaches

The following paragraphs provide details of the upgrade approaches as presented previously in Figure 3.

Tier 2 Phosphorus (A)

The effluent limit for Tier 2 alternative is 1.0 mg/L total phosphorus. PRWID could achieve this goal by introducing a metal-salt addition system upstream of the primary and the secondary clarifiers. This provided the utility an option to add metal-salt at either of the two locations or at both locations for phosphorus control as required. The recycle stream from the facultative sludge basins was moved from ahead of the trickling filters to the primary clarifiers, before the metal-salt feed point. This allowed any additional phosphorus recycled back to the main process treatment train to be removed chemically at the primary clarifiers. A process flow diagram for this alternative is presented in Figure 4.

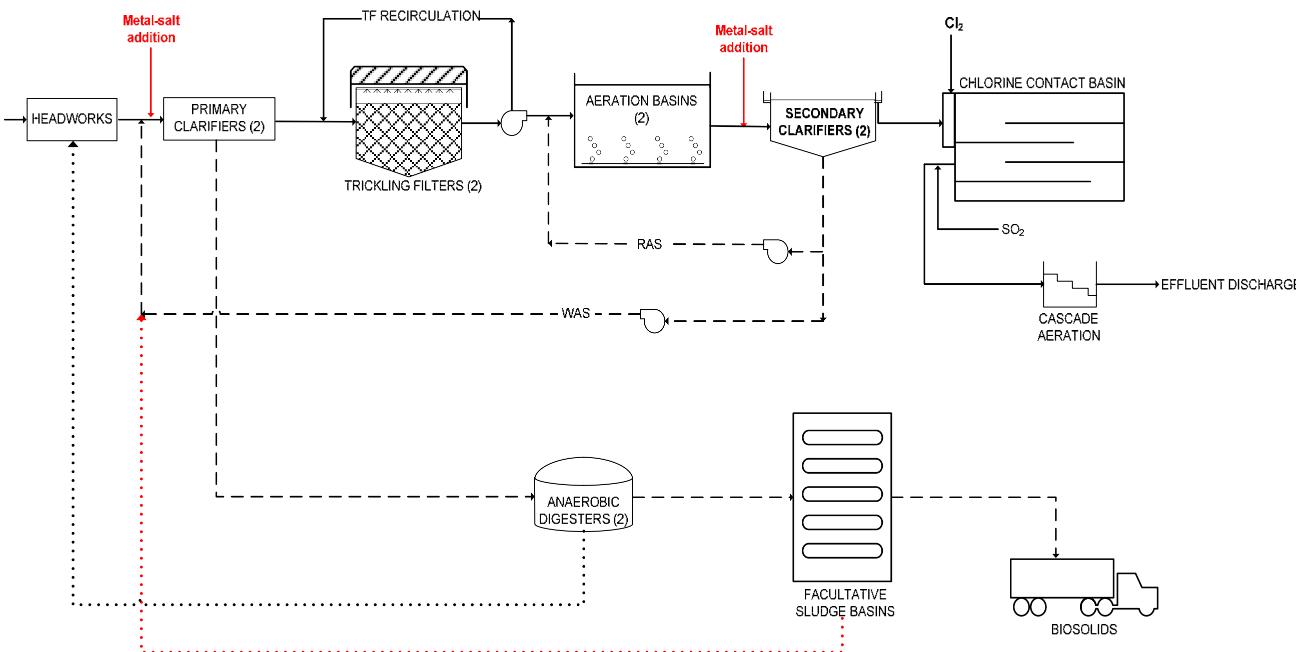

FIGURE 4
Modifications to POTW for Tier 2 Nutrient Control

Tier 2N – Phosphorus & Nitrogen (B)

The metal-salt feed point approach in Tier T2 was adjusted for this Tier to achieve moderate levels of nitrogen control along with phosphorus control. The existing aeration basins were expanded and modified to include separate anaerobic, anoxic and aerobic zone for BNR. This BNR process treated approximately 50% of the primary effluent while the remainder continued to be treated using the trickling filters. The unsettled trickling filter effluent recombined with the BNR process at its aerobic zone. Additional secondary clarifier capacity was added to accommodate the biological process and a new gravity belt thicker was installed for the WAS thickening. A process flow diagram for this alternative is presented in Figure 5.

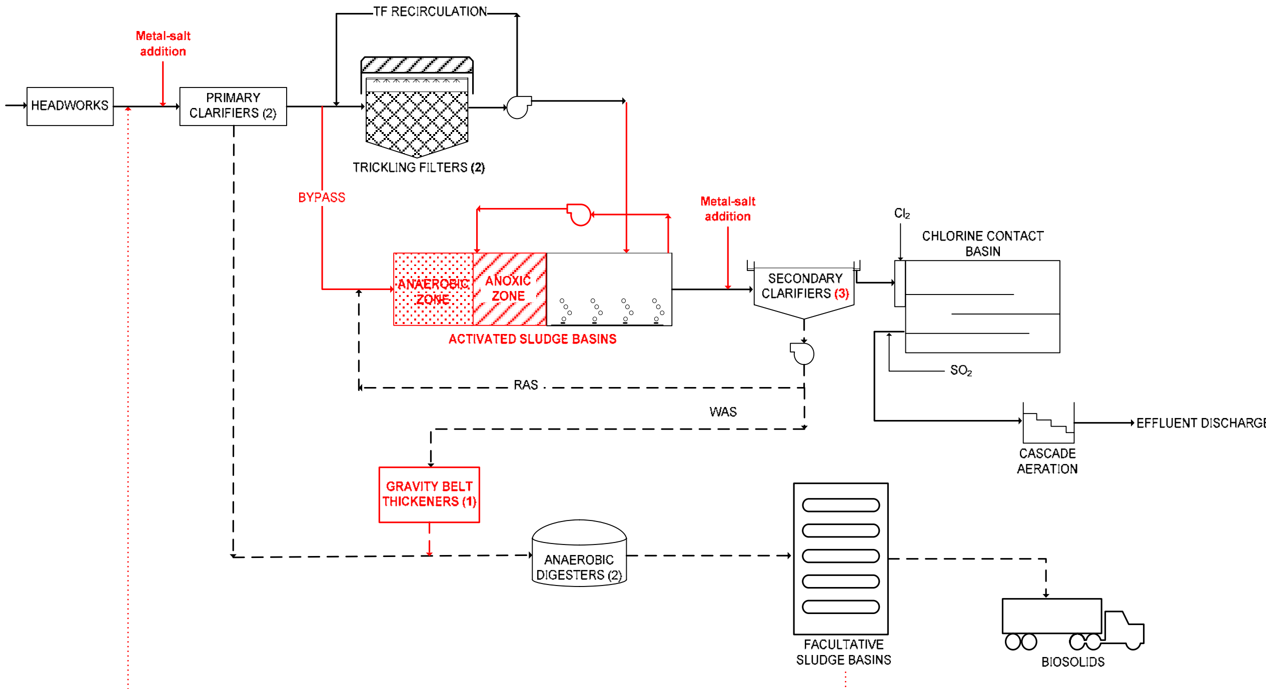

FIGURE 5
Modifications to POTW for Tier 2N Nutrient Control

Tier 1 Phosphorus (C)

This alternative builds upon the Tier 2 approach for phosphorus control. Deep bed granular media filters with a feed point for metal-salt addition upstream of it was installed after the existing secondary clarifiers. The effluent from the TF/AS process was pumped to the filters for chemical phosphorus polishing. A process flow diagram for this alternative is presented in Figure 6.

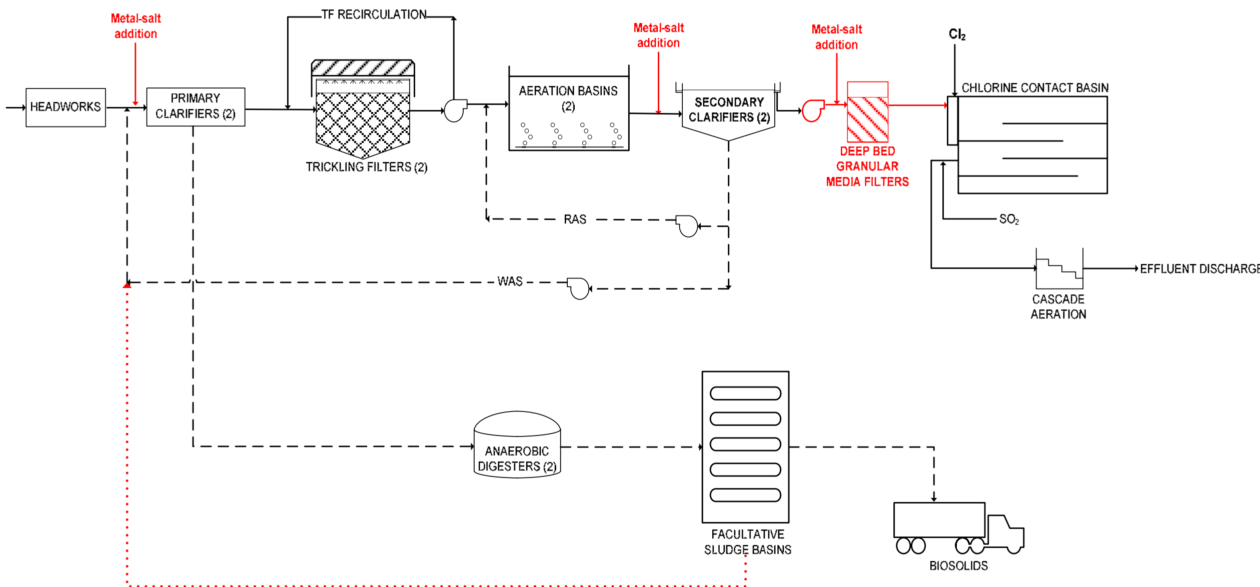

FIGURE 6
Modifications to POTW for Tier 1 Nutrient Control

Tier 1N Phosphorus & Nitrogen (D)

This approach builds on Tier 2N and Tier 1 by completely phasing out the trickling filters and replacing it with an expanded BNR process sized to treat 100% of the primary effluent flow. With a complete BNR process, metal-salt consumption at the primary and the secondary clarifiers was driven by either use as a backup to enhanced biological uptake of phosphorus or for other needs. Additional secondary clarifier capacity was added to accommodate the biological process and a new gravity belt thicker would be installed for the WAS thickening. A process flow diagram for this alternative is presented in Figure 7.

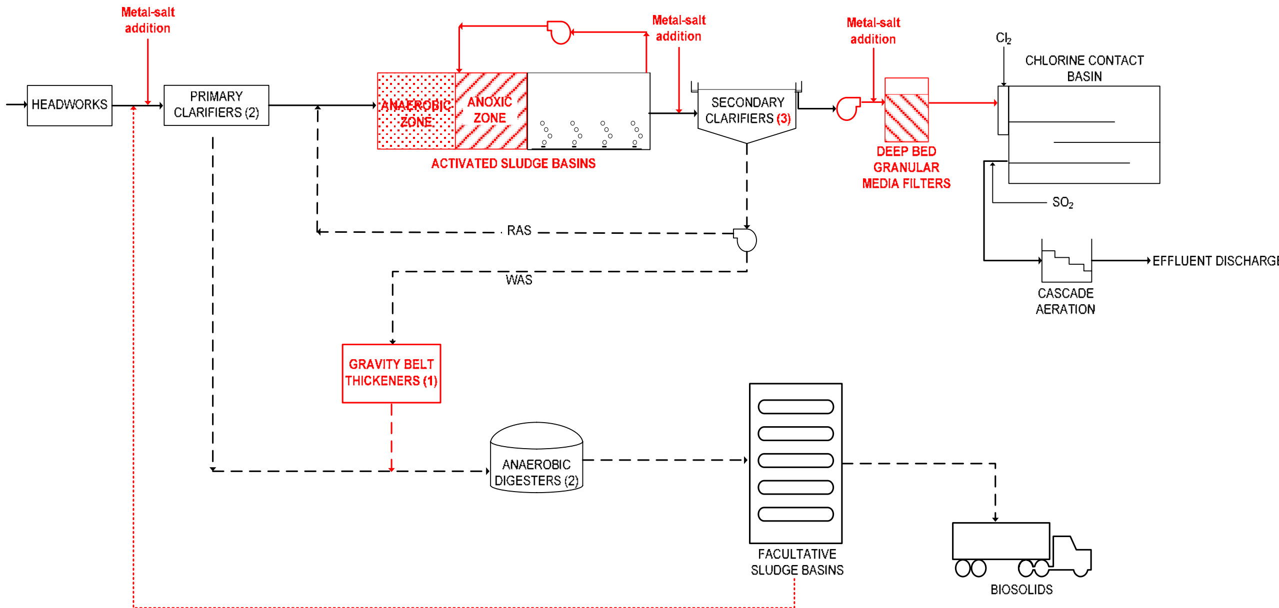

FIGURE 7
Modifications to POTW for Tier 1N Nutrient Control

4. Capital and O&M Cost Estimates for Nutrient Control

This section summarizes the cost-impact results from this nutrient control analysis. These outputs were used in the financial cost model and subsequent financial analyses.

Table 5 presents a summary of the major facility upgrade components identified for meeting each tier of nutrient control. For Tier 2, metal-salt storage facility and new metal-salt feed pumps were added to the existing infrastructure. To go to Tier 2N, a bypass structure was required to bring the flow around the TF to the new BNR process, and the existing aeration basins were modified and expanded to operate as a BNR process complete with mixed liquor recycling system and additional secondary clarifiers. A new gravity belt thickener was required for WAS thickening and additional secondary clarifiers were needed. In order to upgrade the POTW to meet nutrient limits of Tier 1, new a secondary effluent pump station, metal-salt feed pumps and new deep bed granular media filters were installed. For Tier 1N the BNR system was expanded to treat the entire flow with an additional secondary clarifier.

TABLE 5
Major Facility Upgrade Summary

Processes	Tier 2	Tier 2N	Tier 1	Tier 1N
Metal-salt feed and storage facility	X	X	X	X
Bypass piping, flow distribution structure modification		X		X
BNR tanks, secondary clarifiers, mixed liquor recycling system		X		X
Gravity belt thickener		X		X
Secondary clarifier				X
Secondary effluent pump station			X	X
Deep bed granular media filters			X	X

The capital cost estimates shown in Table 6 were generated for the facility upgrades summarized in Table 5. These estimates were prepared in accordance with the guidelines of the Association for the Advancement of Cost Engineering (AACE) International and defined as a Class 4 estimate. The expected accuracy range for the estimates shown in Table 6 is -30%/+50%.

TABLE 6
Capital Cost Estimates ($ Million)

Unit Process Facility	Tier 2	Tier 2N	Tier 1	Tier 1N
Metal-salt feed and storage facility	$0.65	$0.65	$0.77	$0.77
Modification to TF effluent piping and flow distribution structure	$0.00	$0.48	$0.00	$0.60
Anaerobic basin with mixers	$0.00	$0.82	$0.00	$1.02
Anoxic basin with mixers	$0.00	$1.06	$0.00	$2.01
Mixed liquor recycle system	$0.00	$0.17	$0.00	$0.27
Gravity belt thickener	$0.00	$0.22	$0.00	$0.29
Secondary clarifier	$0.00	$1.74	$0.00	$1.74
Secondary effluent pump station	$0.00	$0.00	$2.42	$2.42
Deep bed granular media filters	$0.00	$0.00	$9.63	$9.63
TOTAL TIER COST	**$0.65**	**$5.15**	**$12.82**	**$18.74**

December 2009 US Dollar

Incremental O&M costs associated with meeting each tier of nutrient standard were generated for the years 2009 and 2029. The unit costs were either provided by the POTW or assumed based on the average costs in the State of Utah, and are presented in Table 7. A straight line interpolation was used to estimate the differential cost for the two years. O&M costs for each upgrade included the following components:

- Biosolids management: hauling , use, and disposal
- Chemical consumption costs: metal-salt, and, polymer
- Power costs for the major mechanized process equipment: aeration, secondary effluent pumps, backwash pumps and dewatering units

TABLE 7
Operating and Maintenance Unit Costs

Parameter	Value
Biosolids hauling	$0/wet ton
Biosolids tipping fee	$0/wet ton
Roundtrip biosolids hauling distance [(1)]	10 miles
Ferric chloride	$1000/ton
Polymer	$1/lb
Power	$0.06/kwh

(1) Provided by the POTW

Increased O&M relative to the current O&M cost (Tier 3) are presented in Table 8 and shown graphically in Figure 8.

TABLE 8
Estimated Impact of Nutrient Control on O&M Costs

	Tier 2		Tier 2N		Tier 1		Tier 1N	
	2009	2029	2009	2029	2009	2029	2009	2029
Biosolids	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000	$0.000
Metal-salt	$0.092	$0.103	$0.056	$0.076	$0.092	$0.112	$0.064	$0.073
Polymer	$0.003	$0.003	$0.002	$0.003	$0.005	$0.005	$0.004	$0.004
Power	$0.001	$0.001	$0.016	$0.021	$0.016	$0.017	$0.062	$0.075
Total O&M	**$0.096**	**$0.107**	**$0.074**	**$0.099**	**$0.113**	**$0.135**	**$0.129**	**$0.152**

Note: $ Million (US) in December 2009

Costs shown are the annual differential costs relative to the base line O&M cost of the POTW

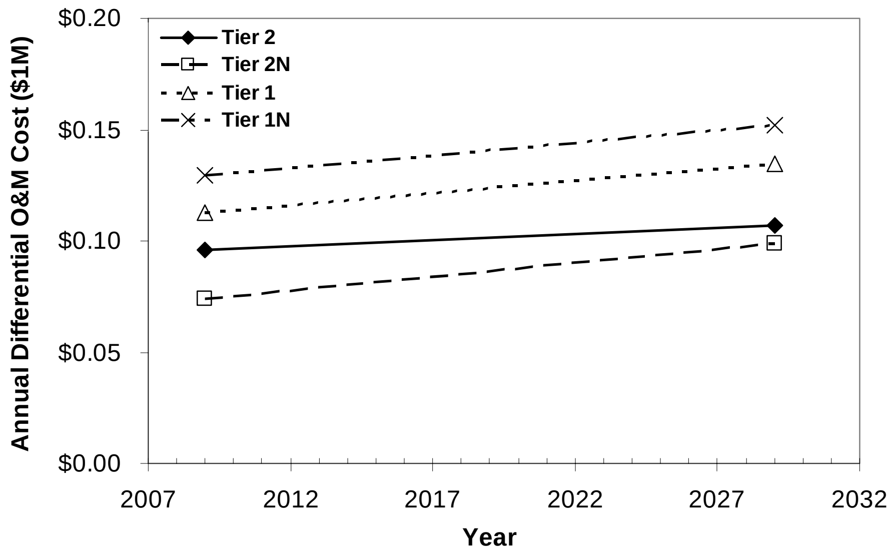

FIGURE 8
Impact of Nutrient Control on O&M Costs over 20 year evaluation period

5. Financial Impacts

This section presents the estimated financial impacts that will result from the implementation of nutrient discharge standards for the State of Utah. Financial impacts were summarized for each POTW on the basis of three primary economic parameters: 20-year life cycle costs, user charge impacts, and community financial impacts. The basis for the financial impact analysis is the estimated capital and incremental O&M costs established in the previous sections.

Life Cycle Costs

Life cycle cost analysis refers to an assessment of the costs over the life of a project or asset, emphasizing the identification of cost requirements beyond the initial investment or capital expenditure.

For each treatment upgrade established to meet the studied nutrient limits (Tier 2, Tier 2N, Tier 1, and Tier 1N), a multi-year life cycle cost forecast was developed that is comprised of both capital and O&M costs. Cost forecasts are organized with initial capital expenditures in year 0 (2009), and incremental O&M forecasts from year 1 (2010) through year 20 (2029). The cost forecast for each treatment alternative was developed in current (2009) dollars, and discounted to yield the net present value (NPV).

The NPV was divided by the estimated 20-year nutrient discharge mass reduction for each tier, resulting in a cost per pound estimate for nutrient removal. This calculation represents an appropriate matching of costs with receiving stream load reduction over the same time period. Table 9 presents the results of the life cycle cost analysis for PCWID.

TABLE 9

Nutrient Removal: 20-Year Life Cycle Cost per Pound [1]

	Tier 2	Tier 2N	Tier 1	Tier 1N
Phosphorus Removal (pounds)[2]	251,163	251,163	352,717	352,717
Nitrogen Removal (pounds)[2]	-	1,171,002	-	2,299,382
Net Present Value of Removal Costs[3]	**$ 2,203,395**	**$ 6,477,774**	**$ 14,707,080**	**$ 20,892,923**
NPV: Phosphorus Allocation	2,203,395	2,203,395	14,707,080	14,707,080
NPV: Nitrogen Allocation[4]		4,274,379		6,185,843
TP Cost per Pound[5]	**$ 8.77**	**$ 8.77**	**$ 41.70**	**$ 41.70**
TN Cost per Pound[5]		**$ 3.65**		**$ 2.69**

1 - For facilities that are already meeting one or more nutrient limits, "meets limit" is displayed for nutrient removal mass and "NA" is displayed for cost per pound metrics

2 - Total nutrient removal over a 20-year period, from 2010 through 2029

3 - Net present value of removal costs, including capital expenditures and incremental O&M over a 20-year period

4 - For simplicity, it was assumed that the nitrogen cost allocation was the incremental difference between net present value costs across Tiers for the same phosphorus limit (i.e. Tier 2 to Tier 2N); differences in technology recommendations may result in different cost allocations for some facilities

5 - Cost per pound metrics measured over a 20-year period are used to compare relative nutrient removal efficiencies among treatment alternatives and different facilities

Customer Financial Impacts

The second financial parameter measures the potential impact to user rates for those customers served by the POTW. The financial impact was measured both in terms of potential rate increases for the POTW's associated service provider, and the resulting monthly bill impacts for the typical residential customer of the system.

Customer impacts were estimated by calculating annual increased revenue requirements for the POTW. Implementation of each treatment upgrade will increase the annual revenue requirements for debt service payments (related to initial capital cost) and incremental O&M costs.

The annual cost increase was then divided by the number of customers served by the POTW, as measured by equivalent residential units (ERUs), to establish a monthly rate increase per ERU. The monthly rate increase associated with each treatment alternative was estimated by adding the projected monthly rate increase to the customer's current average monthly bill. Estimated financial impacts for customers of the PCWID are presented in Table 10.

TABLE 10

Projected Monthly Bill Impact per Equivalent Residential Unit (ERU) for Treatment Alternatives

	Tier 2	Tier 2N	Tier 1	Tier 1N
Initial Capital Expenditure	$ 653,000	$ 5,152,000	$ 12,818,000	$ 18,744,000
Estimated Annual Debt Service[1]	$ 52,400	$ 413,400	$ 1,028,500	$ 1,504,100
Incremental Operating Cost[2]	96,700	75,600	114,000	130,700
Total Annual Cost Increase	$ 149,100	$ 489,000	$ 1,142,500	$ 1,634,800
Number of ERUs	8,120	8,120	8,120	8,120
Annual Cost Increase per ERU	$18.36	$60.22	$140.70	$201.33
Monthly Cost Increase per ERU[3]	**$1.53**	**$5.02**	**$11.73**	**$16.78**
Current Average Monthly Bill[4]	$19.03	$19.03	$19.03	$19.03
Projected Average Monthly Bill[5]	**$20.56**	**$24.05**	**$30.75**	**$35.81**
Percent Increase	**8.0%**	**26.4%**	**61.6%**	**88.2%**

1 - Assumes a financing term of 20 years and an interest rate of 5.0 percent

2 - Incremental annual increase in O&M for each upgrade, based on chosen treatment technology, estimated for first operational year

3 - Projected monthly bill impact per ERU for each upgrade, based on estimated increase in annual operating costs

4 - Estimated 2009 average monthly bill for a typical residential customer (ERU) within the service area of the facility

5 - Projected average monthly bill for a typical residential customer (ERU) if treatment upgrade is implemented

Community Financial Impacts

The third and final parameter measures the financial impact of nutrient limits from a community perspective, and accounts for the varied purchasing power of customers throughout the state. The metric is the ratio of the projected monthly bill that would result from each treatment alternative to an affordable monthly bill, based on a parameter established by the State Water Quality Board to determine project affordability.

The Division employs an affordability criterion that is widely used to assess the affordability of projects. The affordability threshold is equal to 1.4 percent of the median annual gross household income (MAGI) for customers served by a POTW. The MAGI estimate for customers of each POTW is multiplied by the affordability threshold parameter, then divided by 12 (months) to determine the monthly 'affordable' wastewater bill for the typical customer.

The projected monthly bill for each nutrient limit was then expressed as a percentage of the monthly affordable bill. The resulting affordability ratio for each nutrient limit for the PCWID is shown in Table 11.

TABLE 11

Community Financial Impacts: Affordability of Treatment Alternatives

	Tier 2	Tier 2N	Tier 1	Tier 1N
Median Annual Gross Income (MAGI)[1,2]	$ 39,600	$ 39,600	$ 39,600	$ 39,600
Affordability Threshold (% of MAGI)[3]	1.4%	1.4%	1.4%	1.4%
Monthly Affordability Criterion	**$46.20**	**$46.20**	**$46.20**	**$46.20**
Projected Average Monthly Bill	$20.56	$24.05	$30.75	$35.81
Meets State's Affordability Criterion?	Yes	Yes	Yes	Yes
Estimated Bill as % of State Criterion	**45%**	**52%**	**67%**	**78%**

1 - Based on the average MAGI of customers within the service area of the facility

2 - MAGI statistics compiled from 2008 census data

3 - Parameter established by the State Water Quality Board to determine project affordability for POTWs

6. Environmental Impacts of Nutrient Control Analysis

This section summarizes the potential environmental benefits and impacts that would result from implementing the process upgrades established for the various tiers of nutrient control detailed in Section 3. The following aspects were considered for this evaluation:

- Reduction of nutrient loads from POTW to receiving water bodies
- Changes in chemical consumption
- Changes in biosolids production
- Changes in energy consumption
- Changes in emissions from biosolids hauling, disposal and energy consumption

As per the data received from PCWID and per process modeling of the base condition (Tier 3), PCWID is able to achieve some nutrient removal with its existing infrastructure, but not enough to meet the effluent limits of the specified Tiers of nutrient standards. Table 12 summarizes the annual reduction in nutrient loads in PCWID effluent discharge if the process upgrades were implemented. The values shown are for the current (2009) flow and load conditions. It should be noted that any increase in flow or load will result in higher reductions.

TABLE 12

Estimated Environmental Benefits of Nutrient Control

	Tier 2	Tier 2N	Tier 1	Tier 1N
Total phosphorus removed, lb/year	12,630	12,630	17,565	17,565
Total nitrogen removed, lb/year	----	53,655	----	108,450

Note: Nutrient loads shown are the annual differential loads relative to the baseline (Tier 3) condition of the POTW for the year 2009.

The nutrient content of POTWs' discharges and their receiving waters were also summarized to examine the potential of various treatment alternatives for reducing nutrient loads to those water bodies. The POTW loads were paired with estimated loads in the upstream receiving waters to create estimated downstream combined loads. Those combined stream and POTW loads could then be examined for the potential effects of future POTW nutrient removal alternatives. The average total nitrogen and phosphorus concentrations discharged by each POTW were either provided by the POTW during the data collection process or obtained from process modeling efforts. Upstream receiving historical water quality data was obtained from STORET. Data from STORET was summarized in order to yield average total nitrogen and total phosphorus concentrations that could then be paired with the appropriate POTW records. It should be noted that the data obtained from STORET were not verified by sampling and possible anomalies and outliers could exist in historical data sets due to certain events or errors in measurement.

Table 13 shows the total phosphorus and total nitrogen concentration discharged by PCWID to its receiving waters for baseline condition (Tier 3) and for each Tier of nutrient standard. The STORET ID from where historical water quality data were obtained is also presented in the Table.

TABLE 13
Estimates of Average TN and TP Concentrations for Baseline and Cumulative Treatments to Receiving Waters (mg/L)

			Tier 3		Tier 2		Tier 2N		Tier 1		Tier 1N	
STORET LOCATION	**STORET ID**	**FLOW (cfs)**	**TP**	**TN**	**TP**	**TN**	**TP**	**TN**	**TP**	**TN**	**TP**	**TN**
PCWID	----	2.78	3.30	29.79	1.0	N/A	1.0	20	0.1	N/A	0.1	10
Price River at Wellinton Bridge	4932390	78.75	0.23	1.08	----	----	----	----	----	----	----	----
Combined Concentrations			**0.33**	**2.06**	**0.26**	**N/A**	**0.26**	**1.73**	**0.23**	**N/A**	**0.23**	**1.38**

The process upgrades established to meet the four tiers of nutrient standards require increased energy consumptions, chemical usage and biosolids production. Regular metal-salt addition would be required to meet the more stringent phosphorus limits. This would result in increased chemical sludge generation and consequently increased biosolids production. Process modifications to meet the total nitrogen limits would also result in increased energy consumption and biosolids productions. Table 14 summarizes these environmental impacts of implementing the process upgrades to achieve the various tiers of nutrient control. The values shown are on an annual basis, for the current (2009) flow and load conditions and indicate a differential value relative to the base line condition.

TABLE 14
Estimated Environmental Impacts of Nutrient Control

		Tier 2	Tier 2N	Tier 1	Tier 1N
Chemical Use:					
Metal-salt use, lb/year		184,325	111,325	184,325	127,750
Polymers, lb/year		3,339	2,462	4,863	3,767
Biosolids Management:					
Biosolids produced, ton/year		85	60	125	95
Average yearly hauling distance(1)		40	30	55	45
Particulate emissions from hauling trucks, lb/year (2)		2	2	3	2
Tailpipe emissions from hauling trucks, lb/year(3)		5	4	7	5
CO_2 emissions from hauling trucks lb/year(4)		485	356	705	545
Energy Consumption:					
Annual energy consumption, kwh		9,802	269,077	264,185	1,030,736
Air pollutant emissions, lb/year (5)					
	CO_2	8,842	242,707	238,295	929,724
	NOx	14	377	370	1,443
	SOx	12	323	317	1,237
	CO	1	18	17	68
	VOC	0	2	2	8
	PM_{10}	0	5	5	20
	$PM_{2.5}$	0	3	3	10

Note: Values shown are the annual differential values relative to the base line condition (Tier 3) of the POTW for the year 2009

(1) Based on the assumption of a 10 miles round trip hauling distance and, on the assumption that the facility uses 22 ton trucks for hauling biosolids to land application.

(2) Includes PM_{10} and $PM_{2.5}$ emissions in pounds per year. The emission factors to estimate particulate emissions were derived using the equations from *AP-42, Fifth Edition, Vol. I, Section 13.2.1.: Paved Roads (11/2006)*.

(3) Tailpipe emissions in pounds per year resulting from diesel combustion of hauling trucks were based on *Emission standards Reference guide for Heavy-Duty and Nonroad Engines, EPA420-F-97-014 September 1997.* It was assumed that the trucks would meet the emission standards for 1998+.

(4) CO_2 emission factor in pounds per year for hauling trucks were derived from *Rosso and Chau, 2009, WEF Residuals and Biosolids Conference Proceedings.*

(5) Emission factors for electricity are based on EPA Clean Energy Power Profiler (http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html) assuming PacifiCorp UT region commercial customer and *AP-42, Fifth Edition, Vol. I, Chapter 1, Section 1.1.: Bituminous and Sub bituminous coal Combustion (09/1998)*.