UDWQ POTW Nutrient Removal Cost Impact Study: Analysis of Payson City Wastewater Treatment Plant

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COPIES: Payson City Wastewater Treatment Plant

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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 Payson City Wastewater Treatment Plant (PCWWTP) 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 Ditches (OD)
- Activated Sludge (AS)
- Membrane Bioreactors (MBR)
- Trickling Filters (TF)
- Hybrid Processes (Trickling Filter/Solids Contact (TF/SC) or Trickling Filter/Activated Sludge (TF/AS))

The PCWWTP fits in the Hybrid Process 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	Base condition

1. Facility Overview

PCWWTP has a design flow of 4.5 million gallons per day (mgd) and currently receives an average annual influent flow of approximately 1.3 mgd. The facility operates a hybrid trickling filter/activated sludge system using STM-Aerotors™. Aeration tanks have been constructed downstream of the intermediate clarifiers but are not currently operated. Instead, settled trickling filter effluent discharges directly to the Aerotor™ basins for biological treatment. Secondary effluent is filtered with a traveling bridge filter and disinfected with chlorine prior to discharge. Primary and wasted solids are stabilized in anaerobic digesters, dewatered in sludge drying beds, and hauled to landfill for disposal. A process flow diagram is presented in Figure 1 and an aerial photo of the POTW is shown in Figure 2. The major existing unit processes are listed in Table 2.

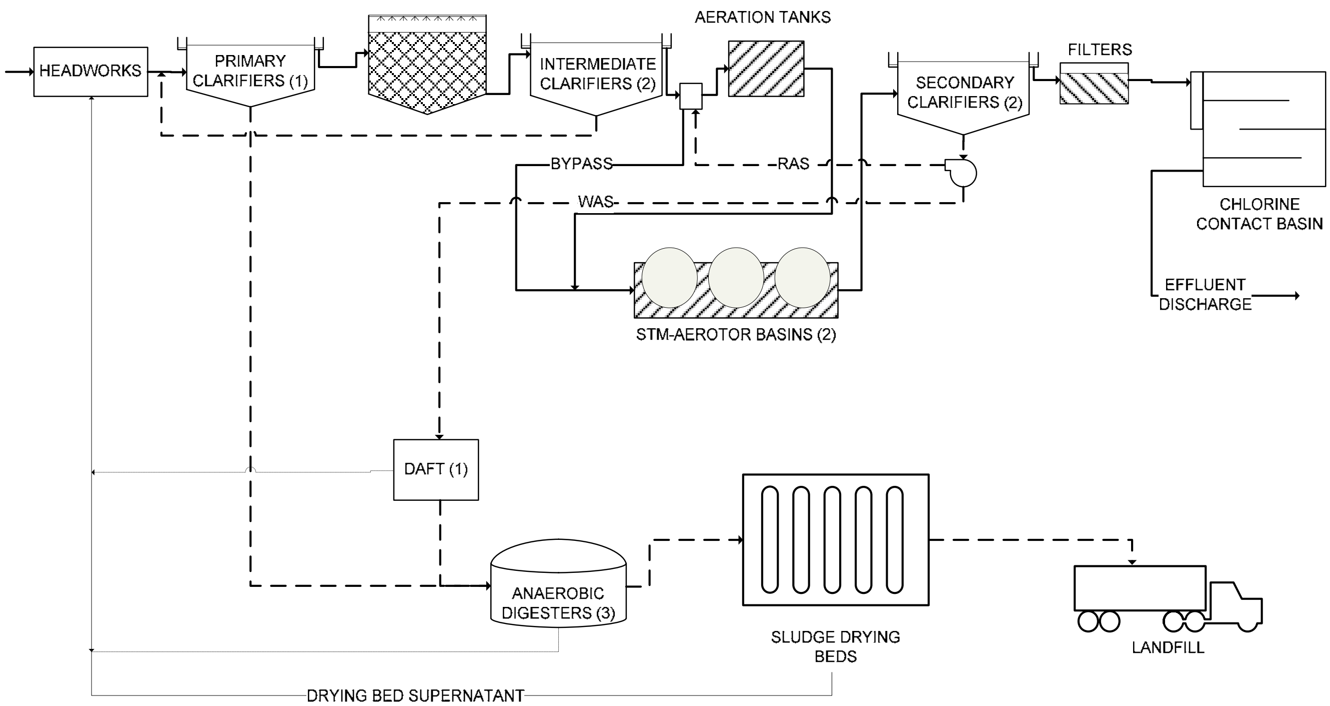

FIGURE 1
Process Flow Diagram

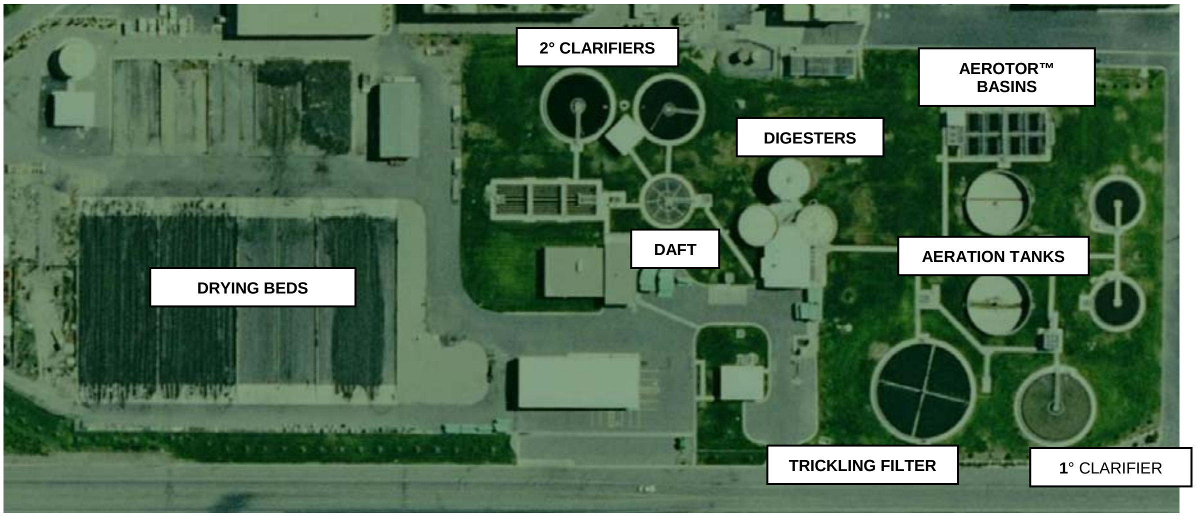

FIGURE 2
Aerial View of the Facility (Source: Google Earth)

TABLE 2
Summary of Major Unit Processes

Treatment step	Number of Units	Size, each	Details
Primary Clarifier	1	70-ft diameter, 8-ft SWD	Round
Trickling Filter	1	102-ft diameter, 7-ft media depth	Rock media
Intermediate Clarifiers	2	45-ft diameter, 7-ft SWD	
Aeration Tanks	2	0.28 MG & 0.26 MG	Not currently used
Aeration Basins	2	0.23 MG, 15.5-ft SWD	STM-Aerotor™
Final Clarifiers[(1)]	3	60-ft diameter (1) 70-ft diameter (2)	(1) 8-ft SWD & (2) 15-ft SWD
Sand Filters	2	840-ft^2	Traveling bridge
Sludge Thickener	1	45-ft diameter	DAFT
Anaerobic Digestion	3	0.21 MG & 0.27 MG primaries; 0.21 MG secondary	Mesophilic, Internal draft tube mixing
Sludge Drying Beds	9	104,200-ft^2 total area	----

(1) An additional clarifier was included in the base model (Tier 3) to maintain the existing POTW design capacity

2. Nutrient Removal Alternatives Development

A nutrient removal alternatives matrix was prepared in order to capture an array of viable approaches for hybrid 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 the 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.

PCWWTP currently operates a hybrid trickling filter/activated sludge (STM Aerotor™) process with primary treatment. Because the trickling filter contains rock media with a depth of only 7-ft, it was decided to phase out the trickling filter and utilize the remainder of the plants infrastructure to the extent possible. **Process modeling efforts show that the POTW would require an additional secondary clarifier to maintain the plant design capacity (4.5 mgd). This was included in the base model (Tier 3) in order to avoid any capital cost estimation involving POTW expansion.** Figure 3 shows the selected upgrade approach used between each tier of nutrient control with the bullet points A through D describing each upgrade step:

A. From Tier 3 (existing) to Tier 2 phosphorus control, metal-salt addition was initiated at the primary and the secondary clarifiers for chemical phosphorus removal.

B. To go from Tier 2 to Tier 2N, the trickling filters were abandoned and the existing aeration basin was expanded to include and an anaerobic and anoxic zones for biological nutrient removal. In addition, mixed liquor return (MLR) pumps were needed to return nitrate-rich liquor to the anoxic zone for denitrification.

C. To go from Tier 2 to Tier 1 phosphorus control, a deep bed granular media filtration system replaced the traveling bridge filter for more reliable phosphorous removal. Metal-salt added upstream of the filters enhanced soluble phosphorus removal.

D. To go from Tier 1 to Tier 1N, the trickling filters were abandoned and the existing aeration basin was expanded to include and an anaerobic and anoxic zones for biological nutrient removal. In addition, mixed liquor return (MLR) pumps were needed to return nitrate-rich liquor to the anoxic zone for denitrification. Deep bed granular media filters were installed for chemical phosphorus polishing.

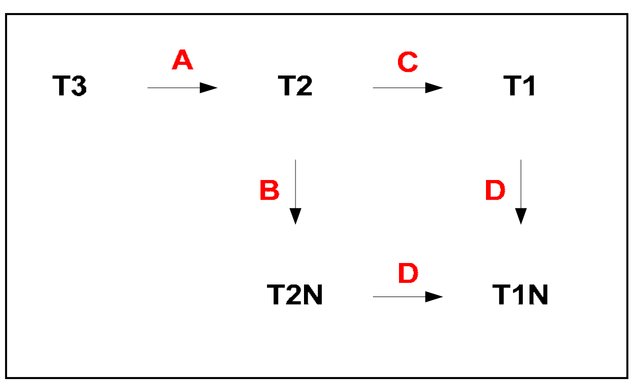

FIGURE 3
Upgrades Scheme for Meeting Increasingly More Stringent Nutrient Control

Data Evaluation, Initial Modeling, and Calibration

The selected progression of upgrades conceived for meeting the different tiers of nutrient control for PCWWTP 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 by PCWWTP per the initial data request was evaluated to (a) develop, and validate the base process model, and (b) size facilities to conserve the POTW's current rated capacity. Table 3 provides a summary of the reported information used as the model input conditions. See process modeling protocol for additional information.

Projected 2029 influent flow conditions provided by the utility exceed the facility's reported design capacity. Because this study is evaluating the cost impacts of nutrient removal and not capacity expansion, the 2029 average annual condition was modified to remain below plant capacity. This modification was made to maintain similarity between POTWs for the financial analysis.

TABLE 3
Summary of Input Conditions

Input Parameter	2009 (1)	2029 (2)	Design (3)
Flow, mgd	1.3	3	4.5
BOD, lb/day	2,040 (184 mg/L)	4,400(176 mg/L)	5,280 (140 mg/L)
TSS, lb/day	703 (63 mg/L)	1,500 (60 mg/L)	1,800 (48 mg/L)
TKN, lb/day	460 (41 mg/L)	976 (39 mg/L)	1,171 (31 mg/L)
TP, lb/day	58 (5 mg/L)	125 (5 mg/L)	150 (4mg/L)

(1) Historic conditions 2007-2009

(2) Reported 2029 flow conditions exceed design condition. (Reported 2029 Flow = 6.0 mgd), thus assumed

(3) Design maximum month capacity of POTW

Composition of influent wastewater is considered significant data when selecting applicable nutrient control strategies. Data received from the POTW shows desirable BOD:P ratios of approximately 35:1. These data also show an atypical BOD:TSS ratio that is nearly 3:1. Because of this, a thorough wastewater characterization should be conducted to verify and better understand these relationships prior to moving forward with the approaches presented herein.

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

TABLE 4
Main Unit Process Sizing and Operating Design Parameters

Design Parameter (Nutrient Tier)	Value
Influent design temperature (All Tiers)	14 deg C
Anaerobic fraction of bioreactor (All Tiers)	10%
Anoxic fraction of bioreactor (T2N, T1N)	20%
Target metal:PO_4-P molar Ratio (T1 and T1N)	1:1, 2:1, 7:1 (1)
Metal salt storage (All Tiers)	14 days
Fraction of mixed-liquor return flow to influent flow	150%
Bioreactor SRT (T2N, T1N)	8 days
Granular filter loading rate (T1 and T1N)	5 gpm/ft^2 (2)

(1)Target dosing ratio at the primary clarifiers, secondary clarifiers and upstream of polishing filter, respectively. Note that polishing filter are included in T1 and T1N only.

(2)Hydraulic loading rate at peak hourly flow

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 alternatives is 1.0 mg/L total phosphorus. PCWWTP can achieve this limit by implementing a metal-salt feed system to the existing unit process facilities. The process modeling effort simulated a dual-feed strategy with metal-salt, at both the primary and the secondary clarifiers. The process flow diagram for this approach is shown in Figure 4.

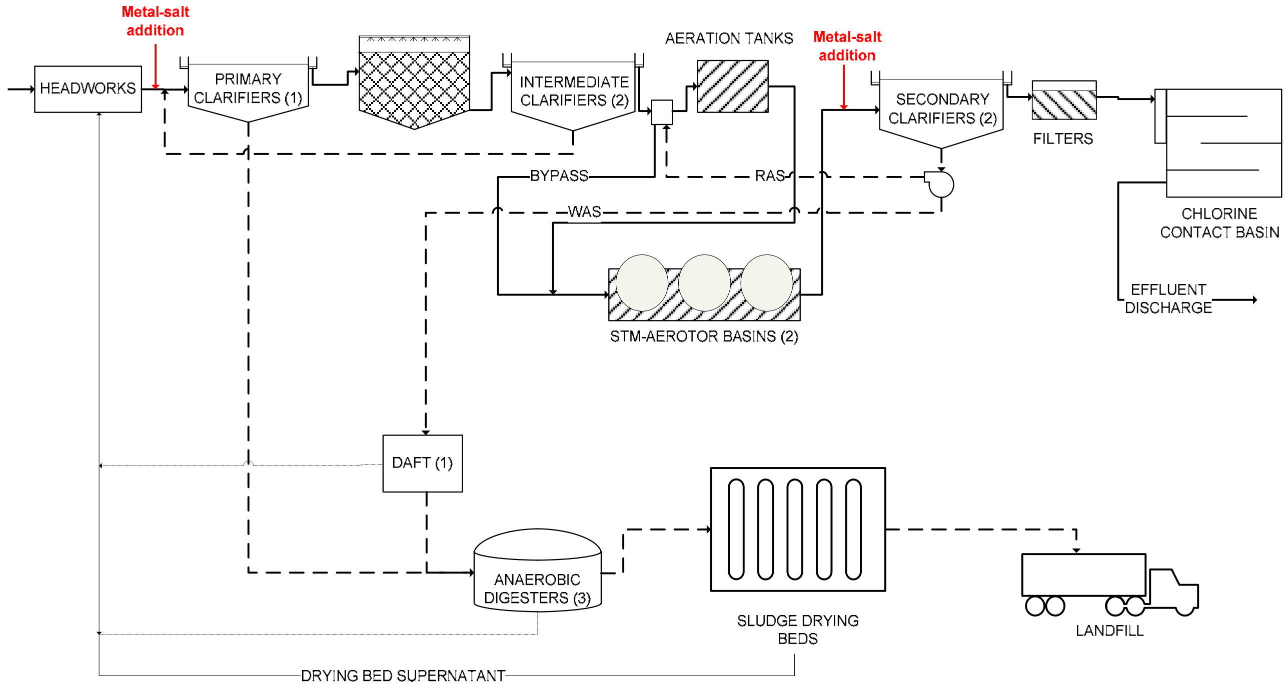

FIGURE 4
Modifications to POTW for Tier 2 Nutrient Control

Tier 2N – Phosphorus & Nitrogen (B)

The effluent limit for this alternative is 1.0 mg/L total phosphorus and 20 mg/L total nitrogen. This approach builds upon the Tier 2 approach by incorporating a biological nitrogen removal process, and abandoning the trickling filter. Process modeling efforts show that implementing an anaerobic and anoxic zone ahead of the expanded aeration basins enhanced biological phosphorus and nitrogen removal. In addition mixed-liquor recycle pumps were needed to convey nitrate-rich mixed-liquor within the Aerotor™ basins to the anoxic zone for denitrification. The metal salt feed points presented in Tier 2 were retained as a back-up to the biological phosphorous removal system. The process flow diagram for this approach is shown in Figure 5.

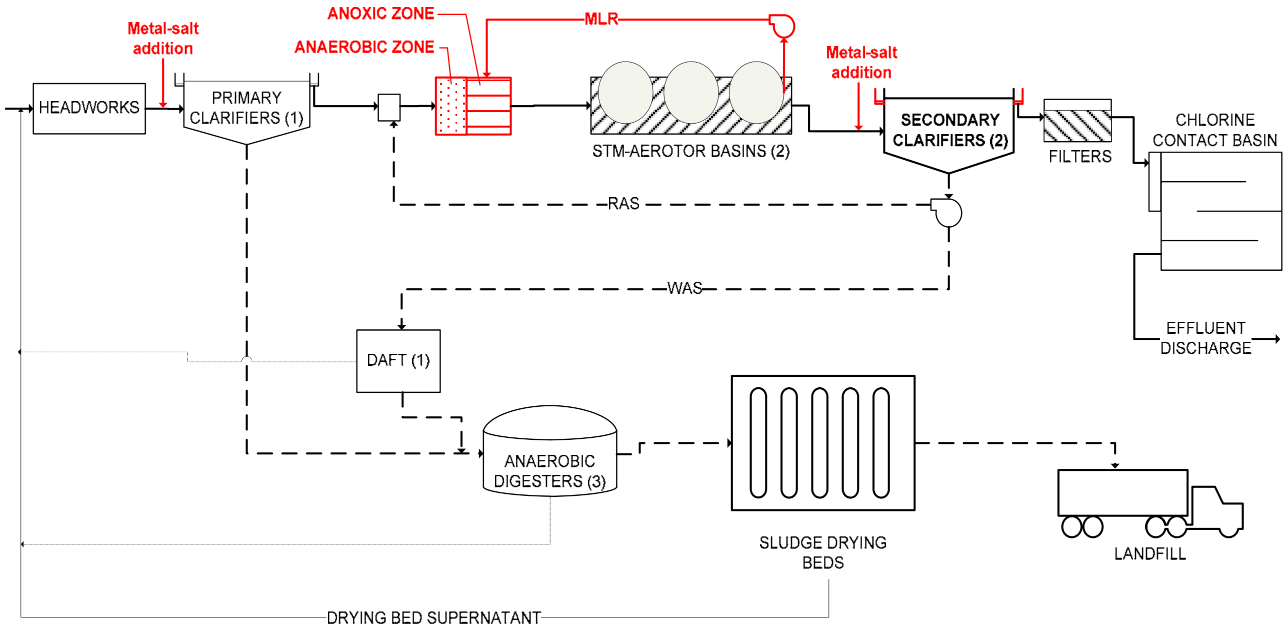

FIGURE 5
Modifications to POTW for Tier 2N Nutrient Goal

Tier 1 –Phosphorus (C)

The effluent limit for this alternative is 0.1 mg/L total phosphorus. This approach builds upon the Tier 2 approach for phosphorus control. The existing traveling bridge filter was replaced with deep bed filters that are more effective at capturing phosphate particulates. It should be noted that an intermediate pump station may be required depending on the facility's hydraulic profile. A process flow diagram for this chemical phosphorus polishing approach is shown in Figure 6.

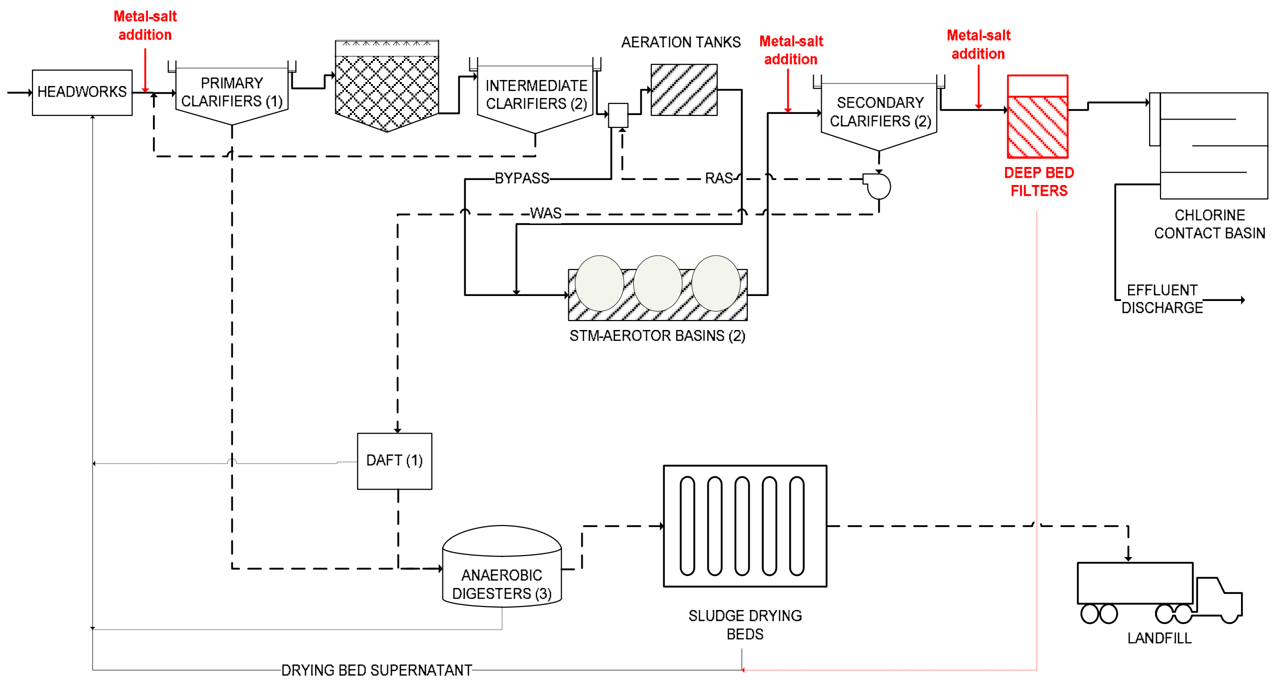

FIGURE 6
Modifications to POTW for Tier 1 Nutrient Goal

Tier 1N – Phosphorus & Nitrogen (D)

The effluent limit for this alternative is 0.1 mg/L total phosphorus and 10 mg/L total nitrogen. This approach combines process elements proposed in both Tier 2N and Tier 1. The anaerobic and anoxic zone and mixed liquor pumps discussed in Tier 2N were added to the process configuration of Tier 1, abandoning the trickling filter. The resulting approach was capable of biologically removing nutrients using anaerobic, anoxic, and aerobic zones. Chemical polishing (from Tier 1) was implemented ahead of the filters to achieve the high level of phosphorus control. The multi-point chemical feed system at the clarifiers remained as a redundant means of phosphorus removal. A process flow diagram is shown as Figure 7.

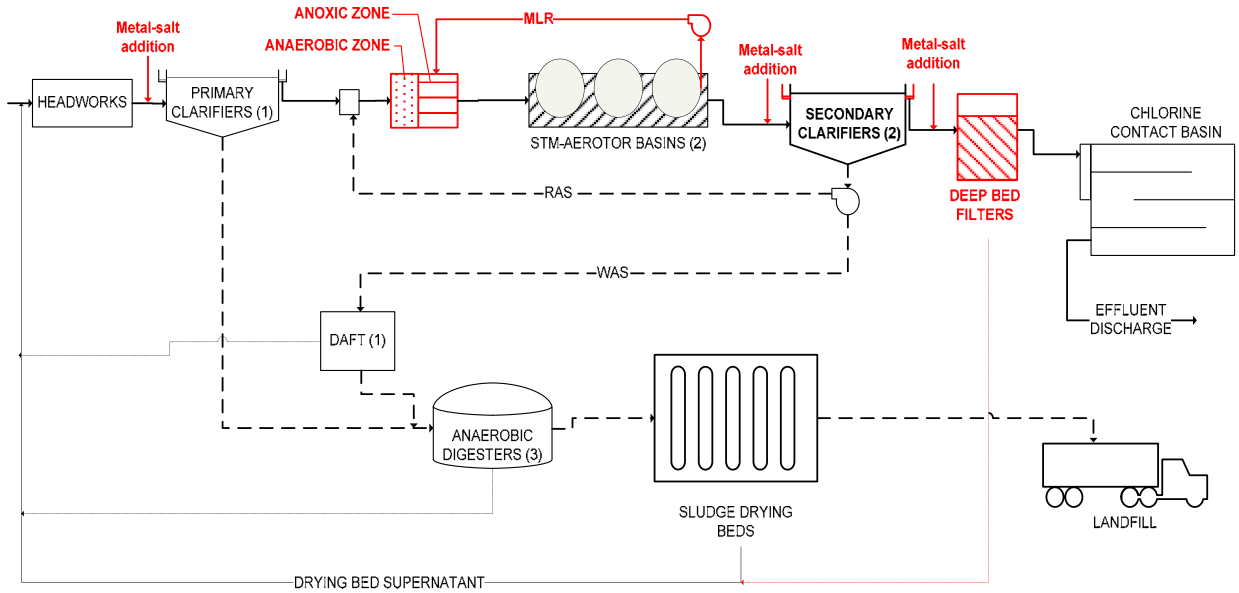

FIGURE 7
Modifications to POTW for Tier 1N Nutrient Goal

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

This section formalizes 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 feed and storage system was required. Tier 2N needed an anaerobic and an anoxic zone with mixed-liquor recycle pumps and, expansion of the aeration basins in addition to those upgrades for Tier 2. Tier 1 and Tier 1N implemented chemical polishing using granular media filters in place of the traveling bridge filters. Depending on the facility's hydraulic profile, secondary effluent pumps may be required for the filtration system.

TABLE 5
Major Facility Upgrade Summary

Processes	Tier 2	Tier 2N	Tier 1	Tier 1N
Metal-salt feed & storage system	X	X	X	X
Flow split structure and piping modification		X		X
Anaerobic basin with mixers		X		X
Anoxic basin and mixers		X		X
Aeration basin expansion		X		X
Blower and blower building expansion		X		X
Mixed liquor return pumps		X		X
Secondary effluent pumps			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 & storage system	$0.65	$0.53	$0.82	$0.65
Flow split structure and piping modification	$0.00	$0.29	$0.00	$0.29
Anaerobic basin with mixers	$0.00	$1.16	$0.00	$1.16
Anoxic basin and mixers	$0.00	$1.67	$0.00	$1.67
Aeration basin expansion	$0.00	$1.45	$0.00	$1.45
Blower and blower building expansion	$0.00	$1.33	$0.00	$1.33
Mixed liquor return pumps	$0.00	$0.31	$0.00	$0.31
Secondary effluent pumps	$0.00	$0.00	$2.25	$2.25
Deep bed granular media filters	$0.00	$0.00	$10.42	$10.42
TOTAL TIER COST	**$0.65**	**$6.75**	**$13.50**	**$19.54**

December 2009 US Dollars

Incremental O&M costs associated with meeting each tier of nutrient standard were generated for the years 2009 and 2029. These costs were derived from the unit costs either provided by the POTW or assumed based on the average cost 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, mixing, intermediate pumping and mixed-liquor return pumping

TABLE 7
Operating and Maintenance Unit Costs

Parameter	Value
Biosolids hauling	$7.50/wet ton
Biosolids tipping fee	$14/wet ton
Roundtrip hauling distance [1]	14 miles
Ferric Chloride	$1000/ton
Polymer	$1/lb
Power	$0.07/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	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Metal-salt	$0.06	$0.11	$0.00	$0.00	$0.08	$0.15	$0.05	$0.10
Polymer	$0.00	$0.00	$0.00	$0.01	$0.00	$0.00	$0.00	$0.00
Power	$0.01	$0.00	$0.04	$0.05	$0.02	$0.03	$0.05	$0.08
Total O&M	**$0.06**	**$0.11**	**$0.04**	**$0.06**	**$0.10**	**$0.19**	**$0.10**	**$0.18**

Note: $ Million (US) in December 2009
Costs shown are the annual differential costs relative to the base line O&M cost of the POTW

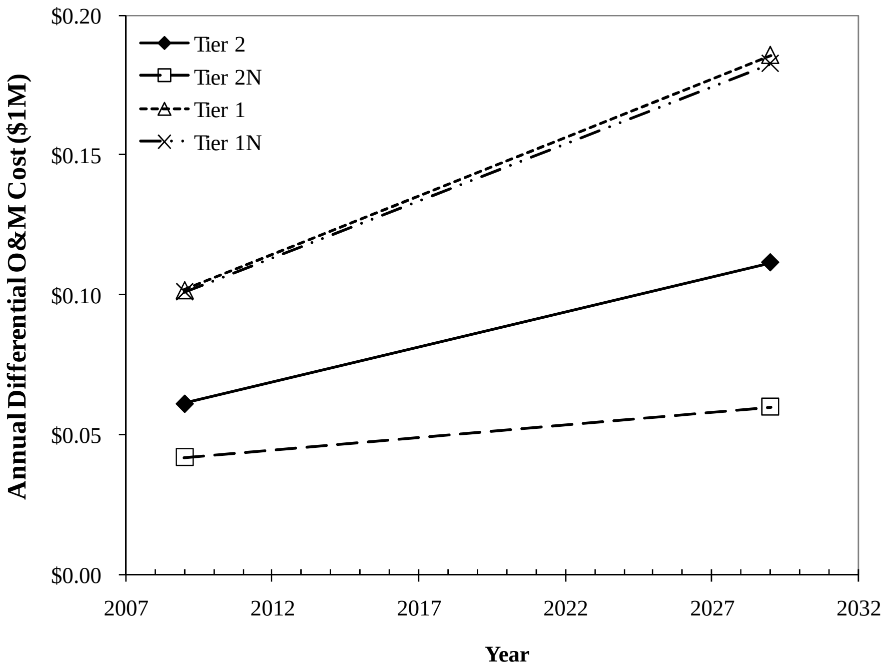

FIGURE 8
Impact of Nutrient Control on O&M Costs over 20 year evaluation period

5. Financial Impacts

This section presents the estimated financial impacts that will result from the implementation of nutrient discharge standards for PCWWTP. 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 PCWWTP.

TABLE 9

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

	Tier 2	Tier 2N	Tier 1	Tier 1N
Phosphorus Removal (pounds)[2]	429,742	429,742	549,935	549,935
Nitrogen Removal (pounds)[2]	-	1,712,229	-	3,047,707
Net Present Value of Removal Costs[3]	**$ 1,991,807**	**$ 7,466,324**	**$ 15,708,551**	**$ 21,703,914**
NPV: Phosphorus Allocation	1,991,807	1,991,807	15,708,551	15,708,551
NPV: Nitrogen Allocation[4]		5,474,517		5,995,363
TP Cost per Pound[5]	**$ 4.63**	**$ 4.63**	**$ 28.56**	**$ 28.56**
TN Cost per Pound[5]		**$ 3.20**		**$ 1.97**

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 PCWWTP 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	$ 6,748,000	$ 13,495,000	$ 19,541,000
Estimated Annual Debt Service[1]	$ 52,400	$ 541,500	$ 1,082,900	$ 1,568,000
Incremental Operating Cost[2]	65,200	42,600	108,400	106,000
Total Annual Cost Increase	$ 117,600	$ 584,100	$ 1,191,300	$ 1,674,000
Number of ERUs	5,180	5,180	5,180	5,180
Annual Cost Increase per ERU	$22.70	$112.76	$229.98	$323.17
Monthly Cost Increase per ERU[3]	**$1.89**	**$9.40**	**$19.17**	**$26.93**
Current Average Monthly Bill[4]	$22.49	$22.49	$22.49	$22.49
Projected Average Monthly Bill[5]	**$24.38**	**$31.88**	**$41.65**	**$49.42**
Percent Increase	**8.4%**	**41.8%**	**85.2%**	**119.8%**

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) w ithin 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 PCWWTP is shown in Table 11.

TABLE 11

PAYSON				
Community Financial Impacts: Affordability of Treatment Alternatives				
	Tier 2	**Tier 2N**	**Tier 1**	**Tier 1N**
Median Annual Gross Income (MAGI)[1,2]	$ 41,100	$ 41,100	$ 41,100	$ 41,100
Affordability Threshold (% of MAGI)[3]	1.4%	1.4%	1.4%	1.4%
Monthly Affordability Criterion	**$47.95**	**$47.95**	**$47.95**	**$47.95**
Projected Average Monthly Bill	$24.38	$31.88	$41.65	$49.42
Meets State's Affordability Criterion?	Yes	Yes	Yes	No
Estimated Bill as % of State Criterion	**51%**	**66%**	**87%**	**103%**

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 and disposal and energy consumption

As per the data received from PCWWTP and per process modeling of the base condition (Tier 3), PCWWTP 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 PCWWTP 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 to the POTW 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	12,110	12,110	15,670	15,670
Total nitrogen removed, lb/year	----	53,730	----	93,305

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 PCWWTP 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**
PCWWTP	----	2.01	4.10	34.00	1.0	N/A	1.0	20	0.1	N/A	0.1	10
Beer Creek	4995420	18.64	0.46	2.79	----	----	----	----	----	----	----	----
Combined Concentrations			**0.82**	**5.83**	**0.51**	**N/A**	**0.51**	**4.46**	**0.43**	**N/A**	**0.43**	**3.49**

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		115,981	2,500	164,349	91,250
Polymers, lb/year		656	8	773	358
Biosolids Management:					
Biosolids produced, ton/year		66	1	77	36
Average yearly hauling distance(1)		42	0	49	23
Particulate emissions from hauling trucks, lb/year (2)		2	0	3	1
Tailpipe emissions from hauling trucks, lb/year(3)		5	0	6	3
CO_2 emissions from hauling trucks lb/year(4)		530	0	625	290
Energy Consumption:					
Annual energy consumption, kwh		25,595	580,522	259,149	781,946
Air pollutant emissions, lb/year (5)					
	CO_2	23,087	523,631	233,753	705,315
	NOx	36	813	363	1,095
	SOx	31	697	311	938
	CO	2	38	17	51
	VOC	0	5	2	6
	PM_{10}	1	11	5	15
	$PM_{2.5}$	0	6	3	8

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 14 miles round trip hauling distance and, on the assumption that the facility uses 22 ton trucks for hauling biosolids to the landfill.

(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)*.