UDWQ POTW Nutrient Removal Cost Impact Study: Analysis of City of Logan's Wastewater Lagoon Facility

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COPIES: Logan 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 City of Logan's lagoon facility to meet the four tiers of nutrient standards presented in Table 1.

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

The design capacity of the City of Logan's wastewater lagoon is 19.1 million gallons per day (mgd) and it currently receives an annual average influent flow of 13.1 mgd. After the wastewater is treated in the lagoon and disinfected, it is discharged in the wetlands for further treatment. For this analysis, the wetland treatment was not considered. The facility is regulated for 25 mg/L of TSS and BOD for the lagoon effluent and has seasonal ammonia limits on the wetland effluent. It is also required to monitor and report its effluent total phosphorus concentration. A process flow diagram of the lagoon is presented in Figure 1 and an aerial photo is shown in Figure 2.

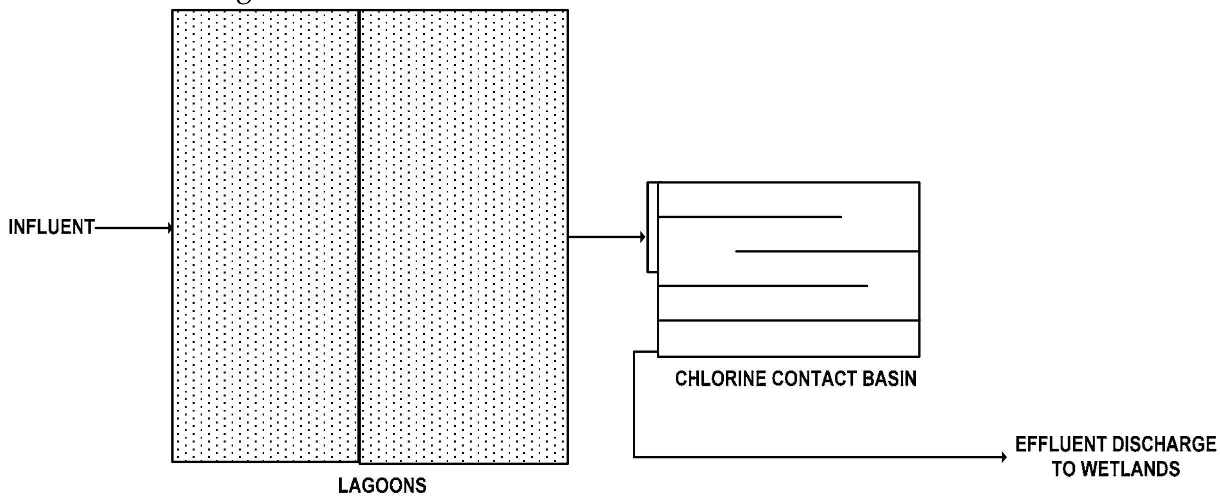

FIGURE 1
Process Flow Diagram

FIGURE 2
Aerial View of the Lagoon

2. Nutrient Removal Alternatives Development, Screening and Selection

The nutrient removal alternatives developed for the lagoon considers biological and chemical phosphorus removal approaches as well as activated sludge configurations for biological nutrient control. The processes that were modeled and described in subsequent sections are considered proven methods for meeting the nutrient limits. There may be ways to further optimize the suggested methods that are not captured here.

The City of Logan's lagoon facility is primarily designed to remove TSS and BOD only. To meet the different Tiers of nutrient standards, more conventional chemical and biological treatment processes will be required. Phosphorus can be removed using chemical or biological treatment processes, while nitrogen removal will require a biological process. Keeping this in mind, it was decided to keep the lagoon and add additional infrastructure for Tiers 2 and 1, and build an entirely new mechanical treatment process for Tier 2N and Tier 1N.

Data Evaluation and Modeling of Upgrades

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

- Step 1. Review and summarize the information obtained from the Utah Division of Water Quality
- Step 2. Develop and calibrate a base model of the existing POTW using the summarized data
- Step 3. Using the design flow and load, build upon the base model by modifying it to include unit process additions for the different tiers of nutrient control and use model outputs to determine unit process sizing and operating requirements
- Step 4. Summarize model output for the capital and O&M cost development.

The facility information and data received from the Division of Water Quality on City of Logan's lagoon 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. If data was not available, assumptions were made. Table 2 provides a summary of information used as the model input condition for City of Logan's lagoon POTW. See process modeling protocol (Attachment B) for additional information.

TABLE 2
Summary of Input Conditions for City of Logan

Input Parameter	2009[(1)]	2029[(2)]	Design[(3)]
Flow, mgd	13.1	18.0	19.1
BOD, lb/day	16,400 (150 mg/L)	22535 (150 mg/L)	23,910 (150 mg/L)
TSS, lb/day	19,680 (180 mg/L)	27,000 (180 mg/L)	28,700 (180 mg/L)
TKN, lb/day	3,300 (30 mg/L)	4,500 (30 mg/L)	4,785 (30 mg/L)
TP, lb/day	550 (5 mg/L)	750 (5 mg/L)	800 (5 mg/L)

(1) Historic conditions provided by the POTW

(2) The flow and loads were calculated assuming an annual growth rate of 1.6%

(3) Reported design capacity of the lagoon. The designed loads were assumed based on current loads.

The main sizing and operating design criteria that were important for capturing the costs associated with the selected upgrade approach for lagoon facilities are summarized in Table 3.

TABLE 3
Main Unit Process Sizing and Operating Design Parameters

Design Parameter (Nutrient Tier)	Value
Target metal:PO_4-P molar Ratio to the secondary clarifier and filters (All Tiers)	2:1, 7:1
Metal-salt storage (Tier 2N)	5 days
Metal-salt storage (Tier 1, Tier 1 and Tier 1N)	14 days
Mixed-Liquor return pumping ratio as a percent of influent Flow (Tier 2N and Tier 1N)	100% to 150%
Granular filter loading rate (Tier 1 and Tier 1N)	5 gpm/ft^2 (1)

(1) 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

The nutrient limit of this alternative is 1.0 mg/L total phosphorus. The lagoon facility can achieve this limit by adding a secondary clarifier which would receive the effluent from the lagoons. A metal-salt feed point would be implemented ahead of the clarifier for chemical phosphorus removal. A process flow diagram for this treatment approach is presented in Figure 3.

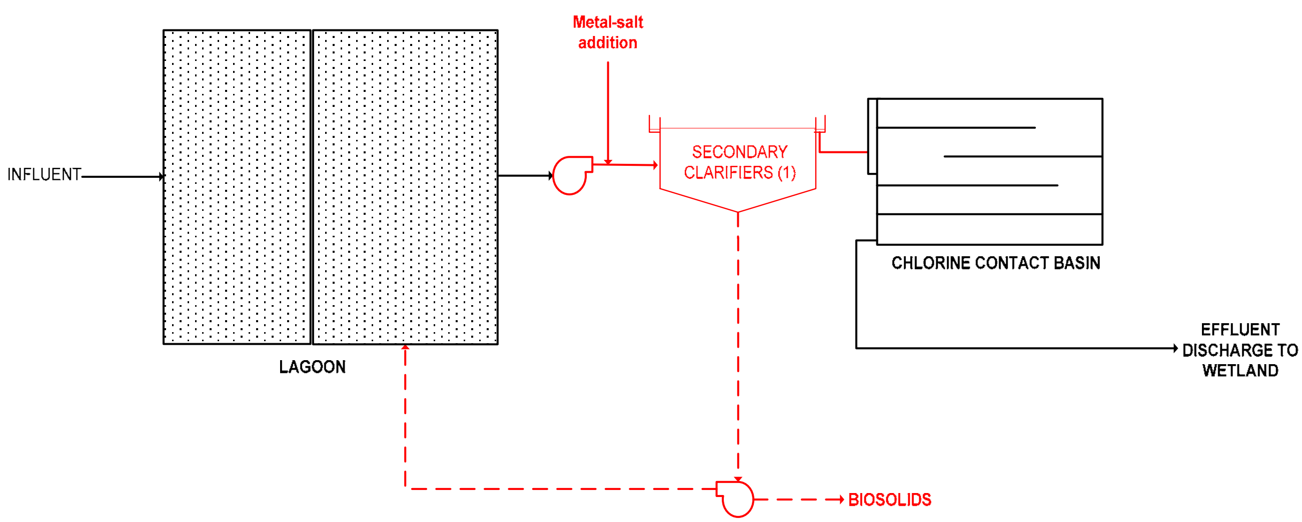

FIGURE 3
Modifications to POTW for Tier 2 Nutrient Control

Tier 2N – Phosphorus & Nitrogen

To accommodate the 1.0 mg/L total phosphorus and 20 mg/L total nitrogen limit of this Tier, the existing lagoon treatment process would be abandoned and a new mechanical treatment facility would be built to replace it. The new mechanical facility would have headworks, primary clarifiers and a biological nutrient removal process with engineered anaerobic, anoxic and aerobic zones and a mixed liquor recirculation system for efficient biological phosphorus and nitrogen removal. New secondary clarifiers would be installed with a metal-salt feed facility ahead of it that would serve as a back-up to the biological phosphorus removal process. Additional metal-salt facility would also be added ahead of the dewatering system. This would provide the utility an option to add metal-salt either upstream of the secondary clarifiers or ahead of dewatering, whichever is optimum. The effluent would be disinfected using an UV disinfection system, before being discharged to receiving stream. The primary solids would be thickened and fermented in the gravity thickeners. The volatile fatty acid (VFA) rich supernatant of the gravity thickeners would be combined with the primary clarifier effluent. The VFA rich gravity thickener supernatant and the primary clarifier effluent will be fed to the anaerobic zone of the aeration basin to augment polyphosphate accumulating organism growth. A chemical salt system would be included for back-up purposes, in case the enhanced biological phosphorus removal system failed. Waste activated solids (WAS) would be thickened, combined with the thickened primary solids, and stabilized in anaerobic digesters. The stabilized biosolids would be used for agricultural land application. The biogas produced from the digesters would be utilized to generate heat and power to be used within the new facility, using a cogeneration system. A process flow diagram for this treatment approach is presented in Figure
4.

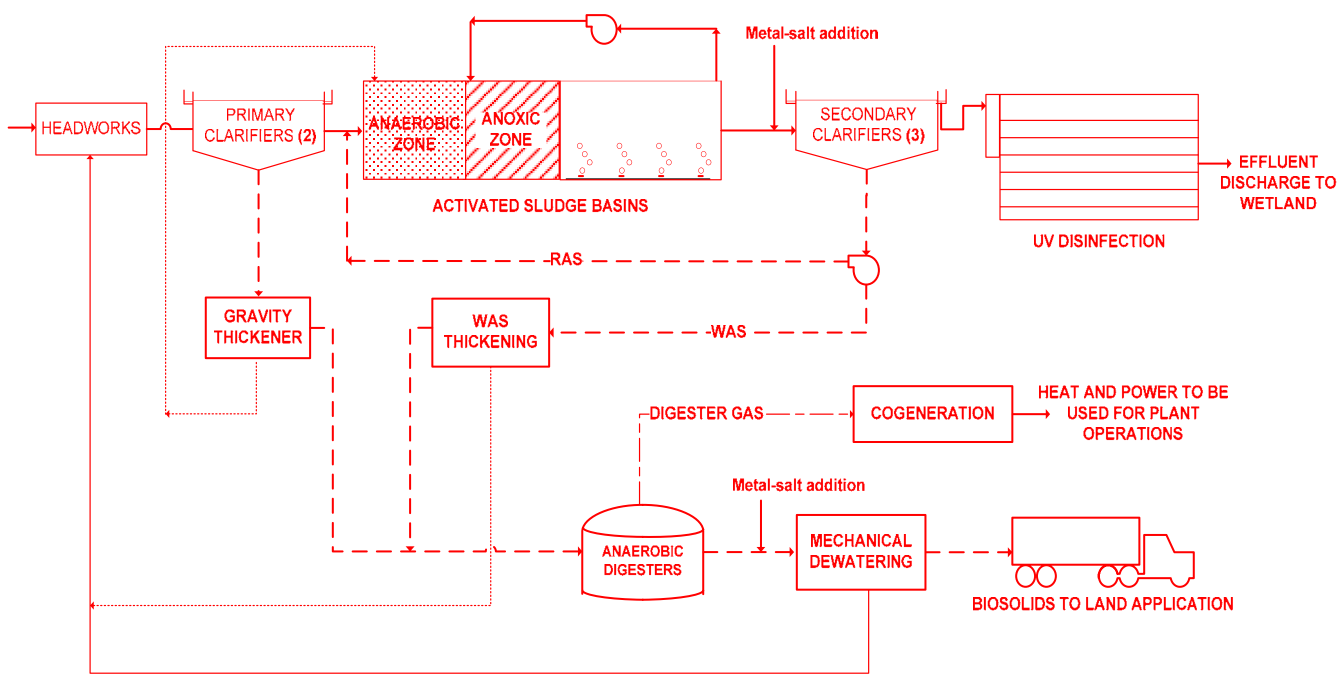

FIGURE 4
Modifications to POTW for Tier 2N Nutrient Control

Tier 1 Phosphorus (C)

This alternative builds upon the Tier 2 approach for phosphorus control. Phosphorus would be chemically removed by adding metal-salt to the secondary clarifiers and ahead of new deep bed granular media filters to achieve the 0.1 mg/L TP limit. Settled secondary effluent would be pumped to the new granular media filters for chemical phosphorus polishing. A process flow diagram for this treatment approach is presented in Figure 5.

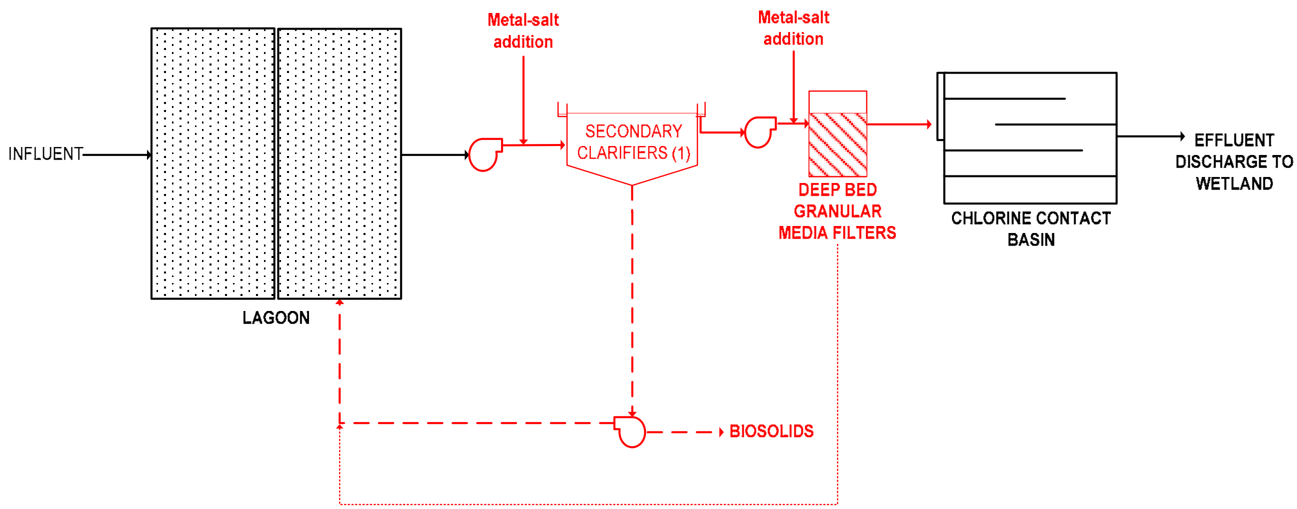

FIGURE 5
Modifications to POTW for Tier 1 Nutrient Control

Tier 1N Phosphorus & Nitrogen (D)

This approach builds on Tier 2N. Total phosphorus and nitrogen would be removed biologically as in Tier 2N using a new mechanical treatment facility and phosphorus would be chemically polished down to 0.1 mg/L via the filtration as described in Tier 1. A process schematic of this approach is presented in Figure 6.

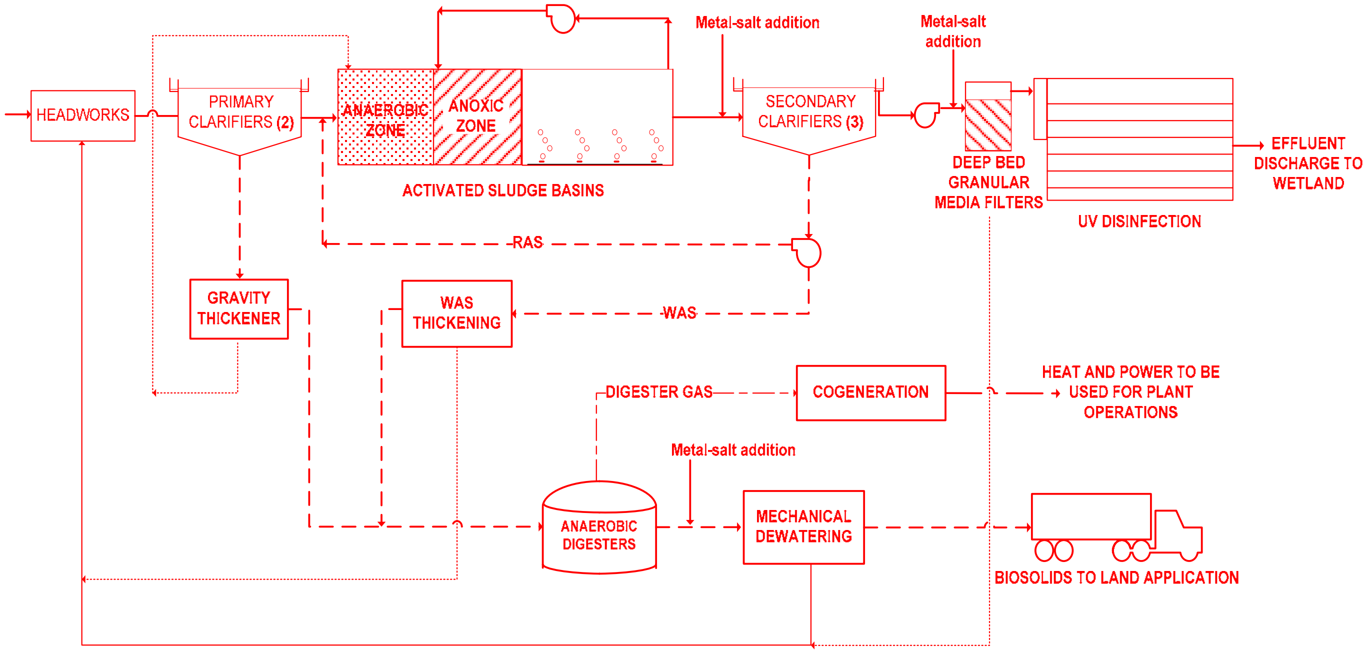

FIGURE 6
Modifications to POTW for Tier 1N Nutrient Control

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

Table 4 presents a summary of the major facility upgrade components identified for meeting each tier of nutrient control.

For Tier 2, a lift station and a secondary clarifier with a metal-salt feed facility would be required. This would also require some piping modifications. To go to Tier 2N, a mechanical treatment facility, complete with headworks, biological nutrient removal process, primary and secondary clarifiers, thickeners, mechanical dewatering facility, anaerobic digesters, cogeneration system and a UV disinfection system would be required. For Tier 1, in addition to the facilities proposed for Tier 2, a new deep bed granular media filtration system with a secondary effluent pump station would be required. For Tier 1N, deep bed granular media filtration system would be added to the facilities proposed for Tier 2N.

TABLE 4
Major Facility Upgrade Summary

Processes	Tier 2	Tier 2N	Tier 1	Tier 1N
Influent Pump Station		X		X
Headworks		X		X
Primary Clarifiers		X		X
Metal-Salt Feed Facility		X		X
Anaerobic Basin with mixers		X		X
Anoxic Basin with Mixers		X		X
Aerobic Basin		X		X
NRCY Pumps		X		X
Flow Split Structure		X		X
Blower Building		X		X
Secondary Clarifiers	X	X	X	X
RAS/WAS Pumps		X		X
Piping	X	X	X	X
UV Disinfection		X		X
Gravity Thickeners		X		X
Gravity Belt Thickeners		X		X
Anaerobic Digesters		X		X
Cogeneration System for Heat and Power		X		X
Dewatering System		X		X
Electrical Substation	X	X	X	X
Secondary Effluent Pumps			X	X
Deep Bed Granular Media Filters			X	X

The capital cost estimates shown in Table 5 were generated for the facility upgrades summarized in Table 4 for the City of Logan POTW. 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 7 and 8 is -30%/+50%.

TABLE 5
Capital Cost Estimates

Unit Process Facility	Tier 2	Tier 2N	Tier 1	Tier 1N
Influent Pump Station	$0	$5,441,549	$0	$5,441,549
Headworks	$0	$5,927,660	$0	$5,927,660
Metal-Salt Feed Facility	$1,330,156	$1,233,418	$1,910,588	$1,644,557
Primary Clarifiers	$0	$6,288,012	$0	$6,288,012
Anaerobic Basin with mixers	$0	$3,676,068	$0	$3,990,469
Anoxic Basin with Mixers	$0	$6,118,719	$0	$6,940,998
Aerobic Basin	$0	$13,301,563	$0	$14,148,026
NRCY Pumps	$0	$614,864	$0	$860,810
Flow Split Structure	$0	$665,078	$0	$665,078
Blower + Building	$0	$4,595,085	$0	$4,595,085
Secondary Clarifiers	$3,506,776	$9,939,895	$3,506,776	$9,939,895
RAS/WAS Pumps	$0	$2,297,543	$0	$2,297,543
Piping Modifications	$241,847	$725,540	$241,847	$725,540
UV Disinfection	$0	$6,046,165	$0	$6,046,165
Primary Sludge Gravity Thickener	$0	$2,974,713	$0	$2,974,713
WAS Gravity Belt Thickener	$0	$5,997,796	$0	$5,997,796
Dewatering System	$0	$6,650,782	$0	$6,650,782
Electrical Substation	$241,847	$2,902,159	$483,693	$4,353,239
Anaerobic Digesters	$0	$10,230,111	$0	$11,596,545
Co-Gen System	$0	$4,353,239	$0	$4,353,239
Secondary Effluent Pumps	$0	$0	$6,820,074	$6,820,074
Deep Bed Filters	$0	$0	$28,416,976	$28,416,976
Backwash Pumps	$0	$0	$1,934,773	$1,934,773
Mudwell and Pumps	$0	$0	$1,934,773	$1,934,773
TOTAL TIER COST	**$5,320,625**	**$99,979,960**	**$45,249,500**	**$144,544,296**

Note: $ Million (US) in December 2009

Incremental O&M costs associated with meeting each tier of nutrient standard were generated for the year 2009 and 2029. The unit costs were assumed based on the average costs in the State of Utah, and are presented in Table 6. A straight line interpolation was used to estimate the differential cost over the 20-year time horizon. O&M costs for each alternative 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, filtration system and dewatering units

TABLE 6
Operating and Maintenance Unit Costs

Parameter	Value
Biosolids hauling	$8/wet ton
Biosolids tipping fee [1]	None
Hauling distance	20 miles
Alum	$480/ton
Polymer	$1.65/lb
Power	$0.06/kwh

(1) All biosolids are assumed to be utilized for land application

The estimated net impact of nutrient control on O&M relative to the current O&M cost (Tier 3) are presented in Table 7 for the City of Logan lagoon facility and shown graphically in Figure 7, respectively.

TABLE 7
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	$10,512	$21,024	$121,764	$154,176	$21,024	$31,536	$131,400	$174,616
Metal-salt	$394,200	$569,400	$6,000	$9,600	$630,720	$832,200	$438,000	$569,400
Polymer	$12,045	$24,090	$180,675	$228,855	$24,090	$36,135	$195,129	$258,968
Power	$43,800	$87,600	$431,430	$547,500	$87,600	$175,200	$481,800	$602,250
Total O&M	**$460,557**	**$702,114**	**$739,869**	**$940,131**	**$763,434**	**$1,075,071**	**$1,246,329**	**$1,605,234**

Note: $ Million (US) in December 2009

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

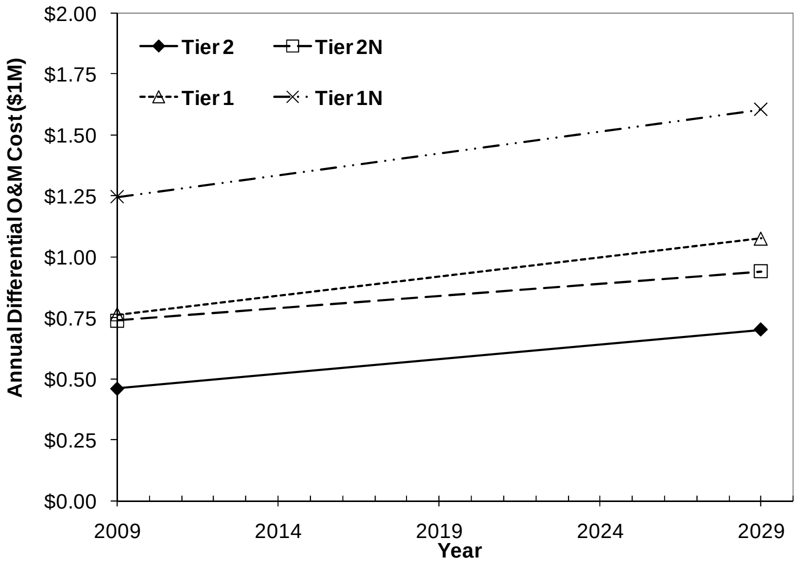

FIGURE 7
Impact of Nutrient Control on O&M Costs over 20 year evaluation period for City of Logan

5. Financial Impacts

This section presents the estimated financial impacts that will result from the implementation of nutrient discharge standards for the City of Logan. 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 8 presents the results of the life cycle cost analysis for City of Logan.

TABLE 8

Nutrient Removal: 20-year Life Cycle Cost per Pound

	Tier 2	Tier 2N	Tier 1	Tier 1N
Phosphorus Removal (pounds)[1]	3,806,950	3,806,950	4,663,514	4,663,514
Nitrogen Removal (pounds)[1]	-	9,517,375	-	19,034,750
Net Present Value of Removal Costs[2]	**$ 14,144,124**	**$ 112,772,397**	**$ 59,226,308**	**$ 166,251,746**
NPV: Phosphorus Allocation	14,144,124	14,144,124	59,226,308	59,226,308
NPV: Nitrogen Allocation[3]		98,628,273		107,025,438
TP Cost per Pound[4]	**$ 3.72**	**$ 3.72**	**$ 12.70**	**$ 12.70**
TN Cost per Pound[4]		**$ 10.36**		**$ 5.62**

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

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

3 - For simplicity, it w as assumed that the nitrogen cost allocation w as the incremental difference betw een 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

4 - 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 City of Logan are presented in Table 9.

TABLE 9

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

	Tier 2	Tier 2N	Tier 1	Tier 1N
Initial Capital Expenditure	$ 5,321,000	$ 99,980,000	$ 45,250,000	$ 144,544,000
Estimated Annual Debt Service[1]	$ 427,000	$ 8,022,700	$ 3,631,000	$ 11,598,600
Incremental Operating Cost[2]	472,700	749,900	779,500	1,264,300
Total Annual Cost Increase	$ 899,700	$ 8,772,600	$ 4,410,500	$ 12,862,900
Number of ERUs	29,520	29,520	29,520	29,520
Annual Cost Increase per ERU	$30.48	$297.17	$149.41	$435.74
Monthly Cost Increase per ERU[3]	**$2.54**	**$24.76**	**$12.45**	**$36.31**
Current Average Monthly Bill[4]	$14.75	$14.75	$14.75	$14.75
Projected Average Monthly Bill[5]	**$17.29**	**$39.51**	**$27.20**	**$51.06**
Percent Increase	**17.2%**	**167.9%**	**84.4%**	**246.2%**

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 City of Logan is shown in Table 10.

TABLE 10

Community Financial Impacts: Affordability of Treatment Alternatives

	Tier 2	Tier 2N	Tier 1	Tier 1N
Median Annual Gross Income (MAGI)[1,2]	$ 35,900	$ 35,900	$ 35,900	$ 35,900
Affordability Threshold (% of MAGI)[3]	1.4%	1.4%	1.4%	1.4%
Monthly Affordability Criterion	**$41.88**	**$41.88**	**$41.88**	**$41.88**
Projected Average Monthly Bill	$17.29	$39.51	$27.20	$51.06
Meets State's Affordability Criterion?	Yes	Yes	Yes	No
Estimated Bill as % of State Criterion	**41%**	**94%**	**65%**	**122%**

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

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 DWQ and per process modeling, the lagoons at City of Logan's wastewater facility are able to achieve BOD and TSS removal, but no nutrients. Table 11 summarizes the annual reduction in nutrient loads in Logan's 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 11

Estimated Environmental Benefits of Nutrient Control

	Tier 2	Tier 2N	Tier 1	Tier 1N
Total phosphorus removed, lb/year	159,511	159,511	195,400	195,400
Total nitrogen removed, lb/year	----	398,780	----	797,555

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

The process upgrades established to meet the four tiers of nutrient standards will require increased energy consumptions, chemical usage and biosolids production. Table 12 summarizes these environmental impacts of implementing the modifications and upgrades. The values shown are on an annual basis, for the current (2009) flow and load conditions. For Tier 2 and Tier 1, the impacts indicate a differential value relative to the base line condition (Tier 3), as process upgrades for these tiers are based on modification from Tier 3. Therefore, the impact is not significant. However, for Tier 2N and 1N, since a completely new mechanical plant is proposed, the impacts does not represent a differential value, as no comparison was done between the existing lagoon facility and the mechanical plant. The values shown are the environmental impacts for a new mechanical plant.

TABLE 12
Estimated Environmental Impacts of Nutrient Control

		Tier 2	Tier 2N	Tier 1	Tier 1N
Chemical Use:					
Metal-salt use, lb/year		1,642,500	25,000	2,628,000	1,825,000
Polymers, lb/year		0	110,00	0	118,650
Biosolids Management:					
Biosolids produced, ton/year		166	2,490	330	2,685
Average yearly hauling distance(1)		150	2,260	300	2,445
Particulate emissions from hauling trucks, lb/year (2)		8	127	17	137
Tailpipe emissions from hauling trucks, lb/year(3)		20	290	38	310
CO_2 emissions from hauling trucks lb/year(4)		1,920	28,780	3,840	31,080
Energy Consumption:					
Annual energy consumption, kwh		730,000	7,190,500	1,460,000	8,030,000
Air pollutant emissions, lb/year (5)					
	CO_2	658,460	6,485,831	1,316,920	7,243,060
	NOx	1,022	10,067	2,044	11,242
	SOx	876	8,629	1,752	9,636
	CO	48	472	96	527
	VOC	6	57	12	63
	PM_{10}	14	142	29	158
	$PM_{2.5}$	7	71	14	79

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 20 miles round trip hauling distance and 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)*.