UDWQ POTW Nutrient Removal Cost Impact Study: Analysis of Central Davis Sewer District

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COPIES: Central Davis Sewer 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 Central Davis Sewer District (CDSD) 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 Central Davis Sewer District (CDSD) fits in the Hybrid 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

The CDSD wastewater treatment plant has a design flow of 12 million gallons per day (mgd) and currently receives an average annual influent flow of approximately 7 mgd. The plant currently operates two parallel treatment trains with a common headworks facility. One train consists of primary clarifiers and trickling filters with secondary clarification and the second train consists of oxidation ditches with secondary clarification. Solids processing includes anaerobic digestion of primary solids from the trickling filter train, and WAS thickening from the oxidation ditches. Waste sludge from the trickling filter train is transferred to the primary clarifiers for co-settling. Dewatered residuals are composted on site to create a Class A biosolids and sold to the public.

Both treatment trains disinfect with a gaseous chlorine system. Treated and disinfected effluent from the two trains is combined and discharged to the outfall system that enters wetlands, and ultimately to the Great Salt Lake. A process flow schematic is presented as Figure 1 and an aerial photo of the POTW is shown in Figure 2. The major existing unit processes are summarized in Table 2.

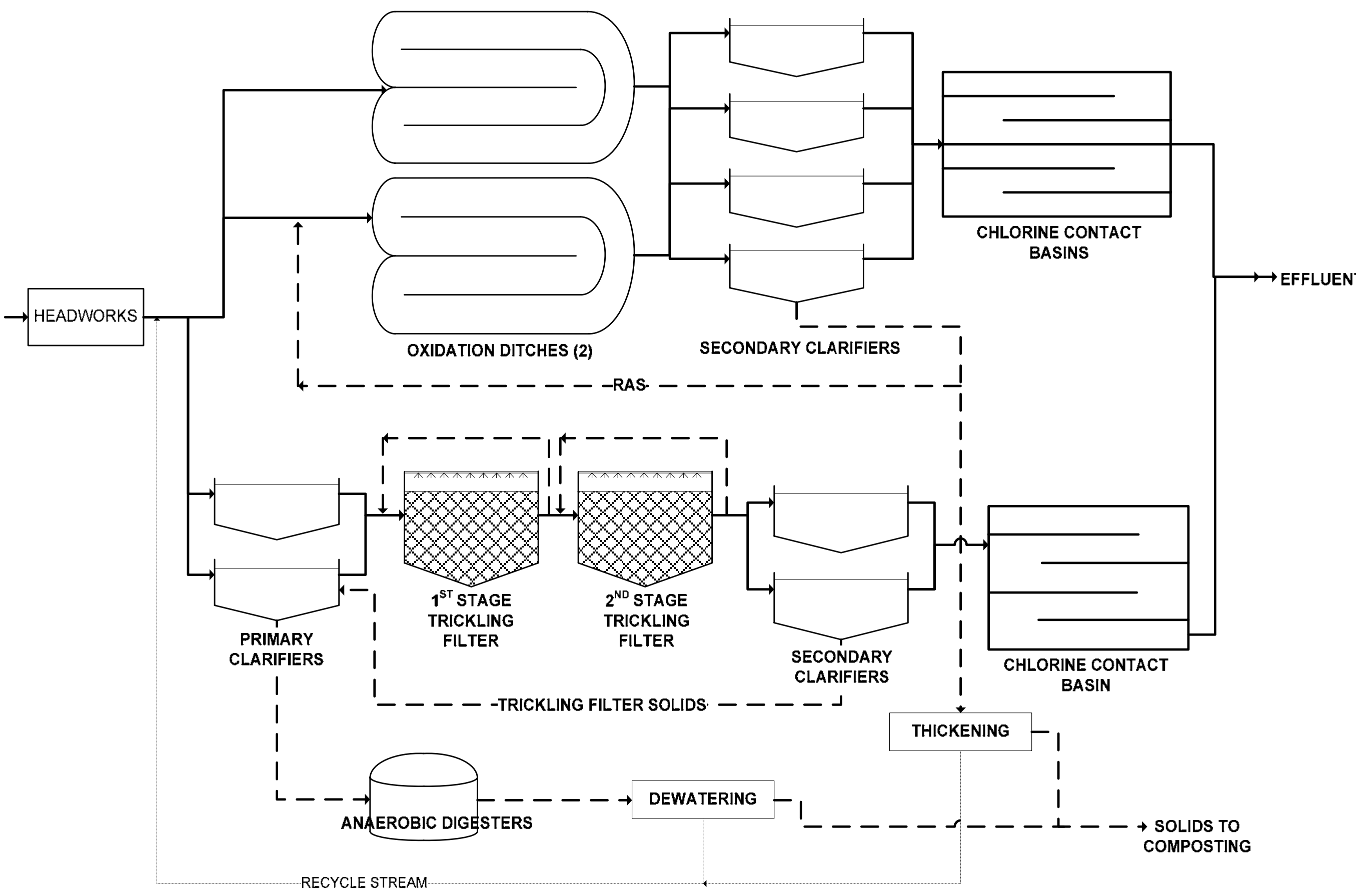

FIGURE 1
Process Flow Diagram

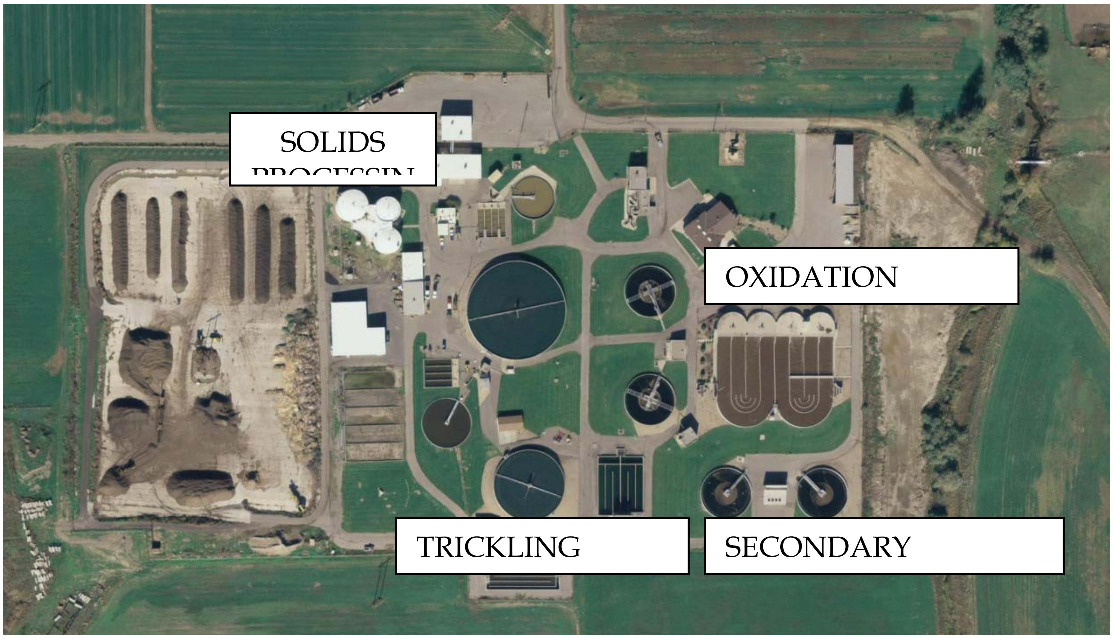

FIGURE 2
Aerial View of the Facility (Source: Google Earth)

TABLE 2
Summary of Major Unit Processes

Treatment step	Number of Units	Size, each	Details
Primary Clarifiers	2	7,540-ft^2, total	8-ft SWD
Trickling Filters	2	120-ft & 170-ft diameter	6-ft depth, rock
Oxidation Ditch	2	1.5-MG volume	Surface aerators
Secondary Clarifiers	6	70-ft diameter (2), 80-ft diameter (4)	

2. Nutrient Removal Alternatives Development

A nutrient removal alternatives matrix was prepared to capture an array of viable approaches for facilities with Hybrid Processes (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.

CDSD currently operates two trickling filter units with primary treatment in parallel with two oxidation ditches. As with all of the POTWs, the approaches were developed with the goal of utilizing the existing infrastructure to the maximum extent possible. Because the facility's unique process configuration, it was decided to enhance the current process operations while maintaining separation of the two secondary treatment trains. 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, the existing primary and secondary treatment system was supplemented with a metal-salt feed and storage facility for chemical phosphorus removal.

B. To go from Tier 2 to Tier 2N, an anaerobic basin was installed upstream of the oxidation ditches for biological phosphorus removal in the oxidation ditch train. Metal salt was added to the trickling filter secondary clarifiers for chemical phosphorus removal. A metal salt dosing point at the oxidation ditch secondary clarifiers were retained as a redundant system for phosphorus removal. No upgrades were required for total nitrogen removal as the facility was already meeting the limit with existing mode of operations.

C. To go from Tier 2 to Tier 1 phosphorus control, granular media filters were added downstream of the existing secondary clarifier units. An additional metal salt feed point was located upstream of the filter system.

D. To go from Tier 2N to Tier 1N, the trickling filter recirculation piping was modified enabling recirculation of the second stage filter effluent to the first stage filter for nitrification and partial denitrification. Deep bed granular media filters were installed downstream of the secondary clarifiers with metal salt addition.

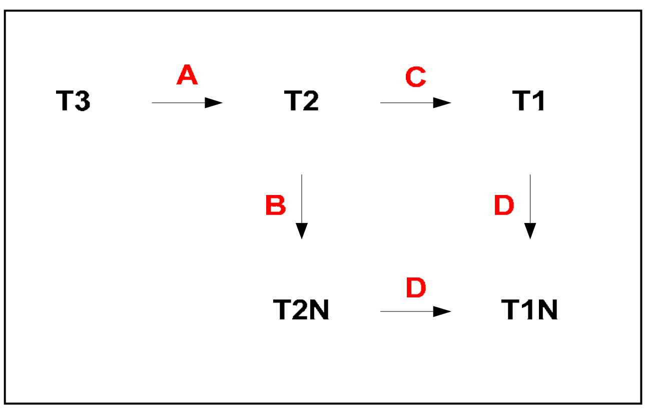

FIGURE 3
Upgrades Scheme for Meeting Increasingly More Stringent Nutrient Control

Data Evaluation, Initial Modeling, and Calibration

The selected progression of upgrades conceived for meeting the different tiers of nutrient control for CDSD 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 CDSD 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.

TABLE 3
Summary of Input Conditions

Input Parameter	2009 (1)	2029 (2)	Design (3)
Flow, mgd	7.0	10	12
BOD, lb/day	10,220 (175 mg/L)	14,600 (175 mg/L)	17,520 (175 mg/L)
TSS, lb/day	11,700 (200 mg/L)	16,680 (200 mg/L)	20,020 (200 mg/L)
TKN, lb/day	1,400 (24 mg/L)	1,750 (21 mg/L)	2,100 (21 mg/L)
TP, lb/day	340(6 mg/L)	490 (6 mg/L)	590 (6 mg/L)

(1) Historic conditions 2007-2009
(2) Projected by the POTW
(3) Design maximum month capacity

The main sizing and operating design criteria that were associated with the system upgrade for the CDSD facility 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)	10 deg C
Anaerobic fraction of bioreactor (T2N, T1N)	10%
Target metal:PO_4-P molar Ratio (Tier 1 and 1N)	1:1, 2:1, 7:1 [(1)]
Metal salt storage (All Tiers)	14 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 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. CDSD can achieve this limit using a multi-point metal salt addition approach with minimal plant modifications. This approach dosed metal salt upstream of the primary clarifiers and secondary clarifiers. A metal salt storage building was required housing both storage tanks and metering pumps. The process flow diagram for this approach is shown in Figure 4.

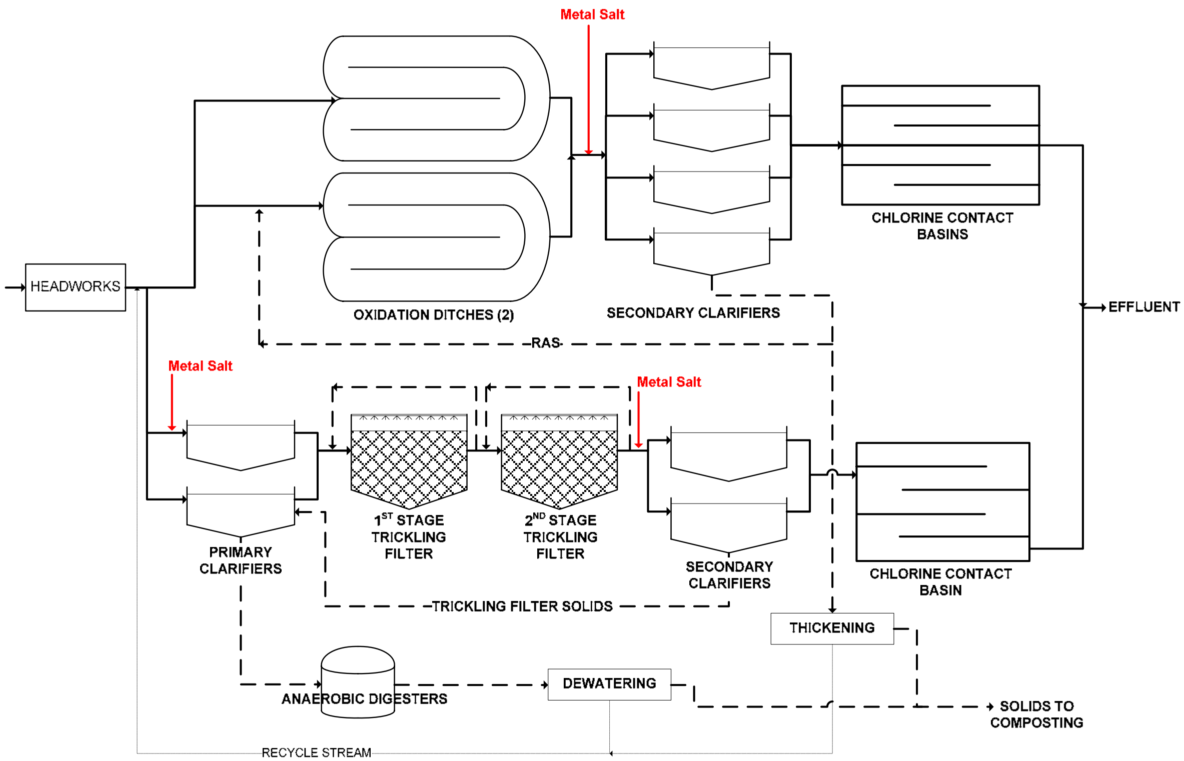

FIGURE 4
Modifications to POTW for Tier 2 Nutrient Control

Tier 2N – Phosphorus & Nitrogen (B)

The effluent limit for this alternative is 1.0 mg/L total phosphorus and 20 mg/L total nitrogen. A combination of both biological and chemical phosphorus removal was proposed herein to achieve Tier 2N level of phosphorus control. First, the flow distribution to the two treatment trains was altered to favor the oxidation ditch train with approximately 60 percent of the flow. An anaerobic selector was installed upstream of the oxidation ditches to promote biological phosphorus removal. The recycle stream from the solids processing system (thickening) was modified so that it discharged to the anaerobic basin to favor EBPR, as this stream is rich in VFAs. An additional secondary clarifier was required.

Metal salt was dosed upstream of the TF secondary clarifiers in the trickling filter train for phosphorus removal as needed. No modifications were required for total nitrogen, as the facility was already meeting the specified limit with its existing process configuration and mode of operation. A process flow diagram for this T2N approach is shown in Figure 5.

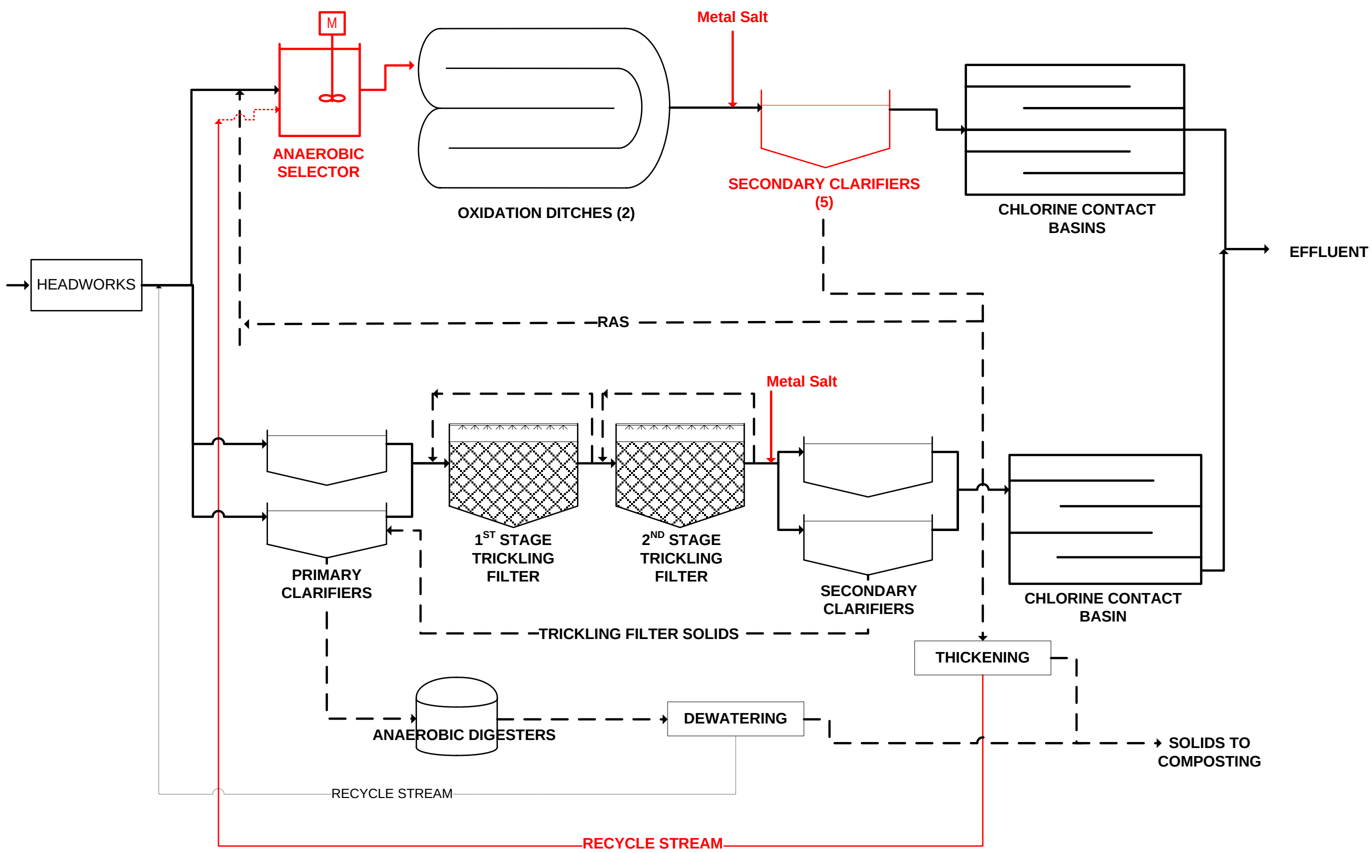

FIGURE 5
Modifications to POTW for Tier 2N Nutrient Goal

Tier 1 –Phosphorus (C)

The effluent limit for this alternative is 0.1 mg/L total phosphorus. This approach built upon the Tier 2 approach for phosphorus control. The dosing rate of metal salts was increased from Tier 2. In addition, new deep bed granular media filters with chemical feed were needed to remove particulate phosphorus from the liquid stream prior to final discharge. The filtration system required secondary effluent pumps to provide adequate head, as well as backwash pumps and other ancillary equipment. A process flow diagram for this chemical phosphorus approach is shown in Figure 6.

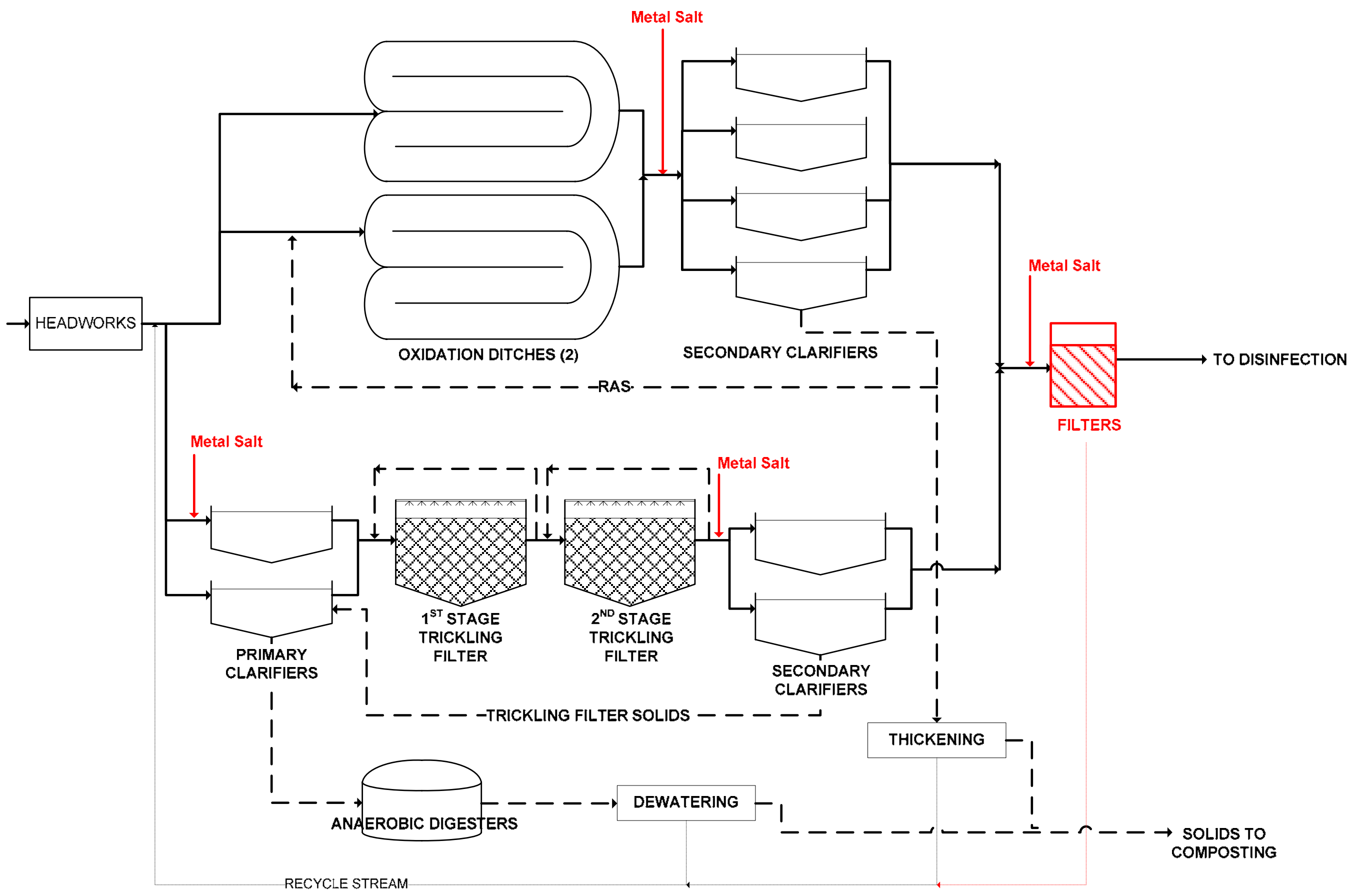

FIGURE 6
Modifications to POTW for Tier 1 Nutrient Goal

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 added a granular media filter system to the combined secondary effluent stream. The multi-point metal salt feed system remained as a redundant means of phosphorus removal.

Piping modifications was also required in the trickling filter train so that the nitrate-rich recycle flow from the 2nd stage would be introduced to the 1st stage filter, thereby promoting denitrification within the first filter. The 60:40 flow split favoring the oxidation ditch train decreased the loading to the filters to promote a nitrifying environment in the 2nd stage. A process flow diagram is shown as Figure 7.

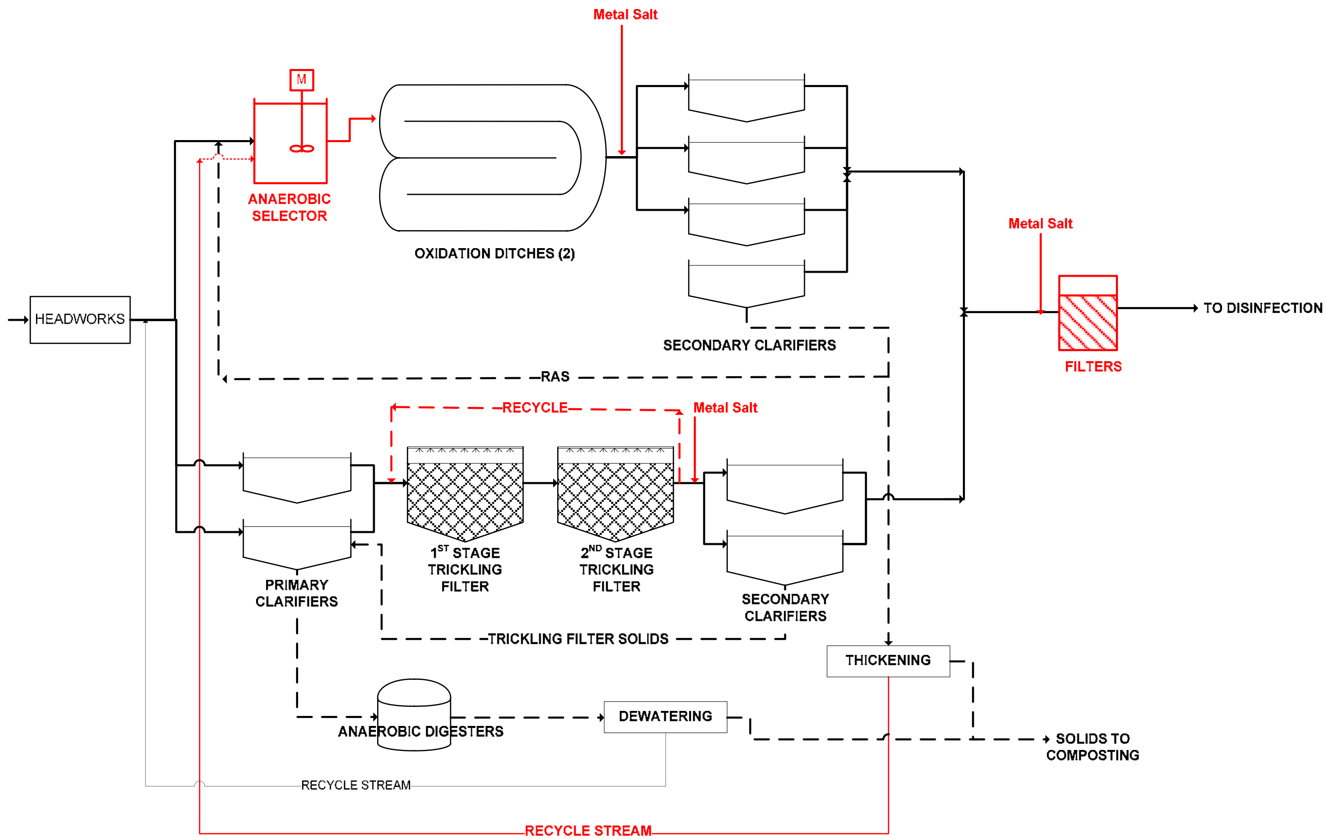

FIGURE 7
Modifications to POTW for Tier 1N Nutrient Goal

3. 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 all tiers, a metal salt feed and storage facility was required along with minor mechanical modification at the specific dosing points. Tier 2N required an anaerobic basin upstream of the oxidation ditch, recycle stream piping modifications and secondary clarifiers. Tier 1 implemented a deep bed granular media filtration system. Tier 1N required all modifications specified for Tier 2N in addition to TF recirculation piping modifications and the granular media 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
Anaerobic basins and recycle stream pipe modifications		X		X
Secondary clarifiers		X		X
Recirculation piping and pump modifications				X
Secondary effluent pump station			X	X
Granular media filtration system			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 system	$0.90	$0.49	$0.90	$0.49
Anaerobic basins and recycle stream pipe modifications	$0.00	$1.46	$0	$1.46
Secondary Clarifiers	$0.00	$5.57	$0	$5.57
Recirculation piping and pump modifications	$0.00	$0.00	$0	$0.46
Granular media filtration system	$0.00	$0.00	$16.22	$16.22
Secondary Effluent Pumps	$0.00	$0.00	$4.72	$4.72
TOTAL TIER COST	**$0.90**	**$7.52**	**$21.84**	**$28.92**

December 2009 US Dollars

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)	None
Ferric chloride	$1000/ton
Polymer	$1/lb
Power	$0.06/kwh

(1) CDSD composts all biosolids onsite

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	$0.11	$0.17	$0.00	$0.00	$0.15	$0.22	$0.05	$0.09
Polymer	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Power	$0.00	$0.00	$0.03	$0.05	$0.05	$0.07	$0.08	$0.13
Total O&M	**$0.11**	**$0.17**	**$0.04**	**$0.06**	**$0.20**	**$0.29**	**$0.14**	**$0.22**

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

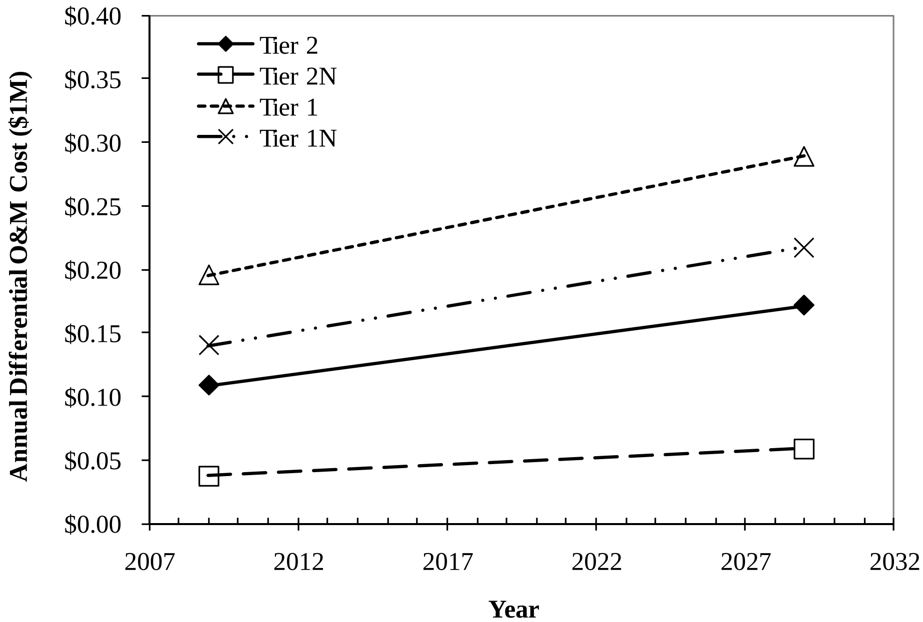

FIGURE 8
Impact of Nutrient Control on O&M Costs over 20 year evaluation period

4. Financial Impacts

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

TABLE 9

Nutrient Removal: 20-Year Life Cycle Cost per Pound [1]				
	Tier 2	**Tier 2N**	**Tier 1**	**Tier 1N**
Phosphorus Removal (pounds)[2]	1,044,627	1,044,627	1,514,709	1,514,709
Nitrogen Removal (pounds)[2]	-	meets limit	-	1,044,627
Net Present Value of Removal Costs[3]	**$ 3,022,096**	**$ 8,232,853**	**$ 20,781,771**	**$ 26,868,212**
NPV: Phosphorus Allocation	3,022,096	3,022,096	20,781,771	20,781,771
NPV: Nitrogen Allocation[4]		5,210,757		6,086,441
TP Cost per Pound[5]	**$ 2.89**	**$ 2.89**	**$ 13.72**	**$ 13.72**
TN Cost per Pound[5]		**NA**		**$ 5.83**

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 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

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 CDSD 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	$ 895,000	$ 7,497,000	$ 21,815,000	$ 28,876,000
Estimated Annual Debt Service[1]	$ 71,800	$ 601,600	$ 1,750,500	$ 2,317,100
Incremental Operating Cost[2]	111,700	39,100	200,700	143,700
Total Annual Cost Increase	$ 183,500	$ 640,700	$ 1,951,200	$ 2,460,800
Number of ERUs	12,660	12,660	12,660	12,660
Annual Cost Increase per ERU	$14.49	$50.61	$154.12	$194.38
Monthly Cost Increase per ERU[3]	**$1.21**	**$4.22**	**$12.84**	**$16.20**
Current Average Monthly Bill[4]	$17.67	$17.67	$17.67	$17.67
Projected Average Monthly Bill[5]	**$18.88**	**$21.89**	**$30.51**	**$33.87**
Percent Increase	**6.8%**	**23.9%**	**72.7%**	**91.7%**

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 CDSD 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]	$ 61,300	$ 61,300	$ 61,300	$ 61,300
Affordability Threshold (% of MAGI)[3]	1.4%	1.4%	1.4%	1.4%
Monthly Affordability Criterion	**$71.52**	**$71.52**	**$71.52**	**$71.52**
Projected Average Monthly Bill	$18.88	$21.89	$30.51	$33.87
Meets State's Affordability Criterion?	Yes	Yes	Yes	Yes
Estimated Bill as % of State Criterion	**26%**	**31%**	**43%**	**47%**

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

5. 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 CDSD and per process modeling of the base condition (Tier 3), CDSD 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 CDSD 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	42,620	42,620	61,800	61,800
Total nitrogen removed, lb/year	----	0	----	42,620

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 CDSD 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**
CDSD	----	10.83	3.00	12.00	1.0	N/A	1.0	20	0.1	N/A	0.1	10
Baer Creek	4990290	3.74	0.20	2.34	----	----	----	----	----	----	----	----
Combined Concentrations			**2.28**	**9.52**	**0.79**	**N/A**	**0.79**	**8.03**	**0.12**	**N/A**	**0.12**	**8.03**

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		600	600	800	300
Polymers, lb/year		1	0	2	1
Biosolids Management:					
Biosolids produced, ton/year		275	0	345	145
Average yearly hauling distance(1)		0	0	0	0
Particulate emissions from hauling trucks, lb/year (2)		0	0	0	0
Tailpipe emissions from hauling trucks, lb/year(3)		0	0	0	0
CO_2 emissions from hauling trucks lb/year(4)		0	0	0	0
Energy Consumption:					
Annual energy consumption, kwh		0	620,821	877,262	1,517,688
Air pollutant emissions, lb/year (5)					
	CO_2	0	559,981	791,291	1,368,955
	NOx	0	869	1,228	2,125
	SOx	0	745	1,053	1,821
	CO	0	41	58	100
	VOC	0	5	7	12
	PM_{10}	0	12	17	30
	$PM_{2.5}$	0	6	9	15

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

(1) CDSD composts all biosolids onsite. Thus no hauling is required

(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)*.