Appendix A
Truck Loading Facility - Assessment of Capacity Requirements

Truck Loading Facility
Assessment of Capacity Requirements

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DATE: November 5, 2012

PROJECT NUMBER: 436645

Executive Summary

This Technical Memorandum establishes the design bases for sludge digestion, biogas management systems, and the truck loading facility. The design bases are derived for two conditions, first for the predicted serviced population in 20 years (2032) – 547,060 people; and second for the predicted population that would be served when the plant reached its ultimate capacity - 671,780 people. The ultimate capacity was back-calculated by dividing the hydraulic capacity of the plant (219 ML/d) by the unit wastewater generation rate predicted for the future (326 L/c/d in the Facilities Forecast, TSH, 2006). Unit wastewater generation rates have been dropping consistently over the last 15 years, suggesting that the predicted value of 326 L/c/d could be achieved.

The organic and solids loads delivered to the plant under certain conditions have been predicted on the basis of unit loads – 68.5 gBOD/c/d and 100 gTSS/c/d being the critical values. Peaking factors that can be used to derive maximum month and maximum week loads were established on the basis of the last few years of plant operation (2009 to 2011 data).

A mass balance was developed based on CH2M HILL's computer based plant simulator – Pro2D. This tool generates a whole plant mass balance as a key components of its output. The mass balance accounts for internal recycle flows in the derivation of key process loading values. Treatment through the liquid stream and through anaerobic digestion are both based on IWA published models (Activated Sludge Model – ASM and Anaerobic Digestion Model – ADM) to predict performance through these key biological processes. Other critical performance parameters for solids liquid separation technologies were selected to the degree possible on the basis of historical performance of the plant's unit processes.

The mass balance results were used to derive loading factors to use in the design of the anaerobic digesters, biogas management systems and the truck loading facility. Table 6, Table 7, and Table 8 in the text tabulate these design bases. These tables are reproduced in this Executive Summary as ES-1, ES-2, and ES-3.

TABLE ES-1
Design Basis for Anaerobic Digestion

Parameter	2032			Ultimate Capacity (219 ML/d)		
Condition	Average	Maximum Month Load	Maximum Week Load	Average	Maximum Month Load	Maximum Week Load
Primary Sludge						
Flow, m^3/d	1,160	1,690	2,000	1,420	2,110	2,460
TS Load, kg/d	38,440	55,860	66,155	46,945	69,675	81,035
VS Load, kg/d	28,170	40,890	48,465	34,385	51,010	59,260
TWAS						
Flow, m^3/d	410	560	630	500	690	780
TS Load, kg/d	20,275	28,130	31,470	25,170	34,470	39,025
VS Load, kg/d	14,820	19,800	22,050	18,335	24,280	27,325
Total Sludge to Digestion						
Flow, m^3/d	1,570	2,260	2,630	1,930	2,800	3,240
TS Load, kg/d	58,715	83,990	97,625	72,115	104,145	120,060
VS Load, kg/d	42,990	60,880	70,505	52,720	75,290	86,585
Basic Design Parameters						
Minimum SRT		15	12		15	12
Calculated Volume Requirement, m^3		33,900	31,560		42,000	38,880
Minimum Volume, m^3		33,900			42,000	
VS Loading at Min. Volume, kg/m^3/d	1.27	1.80	2.08	1.26	1.79	2.06

TABLE ES-2
Design Basis for Biogas Management

Parameter	2032	Ultimate Plant Capacity
Biogas Generation Rate		
Average, m^3/d	21,000	25,235
Maximum Month[1], m^3/d	28,715	35,425
Maximum Week[2], m^3/d	32,830	38,820
Peak Diurnal	45,960	54,350
Methane Fraction (at condition noted)		
Average, percent	0.58	0.58
Maximum Month[1], percent	0.58	0.58
Maximum Week[2], percent	0.58	0.58

Notes:
1. Maximum month projections are based on the maximum 30 day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7 day running average during a specific annual period.

TABLE ES-3
Design Basis for Truck Loading Facility

Parameter	2032	Ultimate Plant Capacity
Dewatered Biosolids Generation Rate		
Average, m^3/d	123	154
Maximum Month[1], m^3/d	179	222
Maximum Week[2], m^3/d	210[3]	260[4]
Storage Period, d	**5.5**	**5.5**
Total Volume, m^3	**1,155**	**1,430**

Notes:
1. Maximum month projections are based on the maximum 30 day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7 day running average during a specific annual period.
3. Value of 210 m^3/d is rounded up from 206 m^3/d
4. Value of 260 m^3/d is rounded up from 259 m^3/d

In each case, design of new facilities at the Highland Creek Treatment Plant will be based on predicted 2032 requirements; however, allowing for reasonable expansion of the facilities to handle the capacity needs of plant development to handle the ultimate capacity. It must be recognized that future changes in wastewater and sludge treatment technologies will influence the sizing of these facilities, so the flexibility to reasonably change to meet these future needs is critical to the success of the plant in the future.

1. Introduction

1.1 Project Background

Over the last 10 years, The City of Toronto has been working toward the development and implementation of a Biosolids Management Strategy that meets their overall economic, environmental and social objectives. Key milestones during this period include the following:

- Biosolids and Residuals Master Plan (BRMP), 2002. The City initiated this project to assess options and determine a direction for the future management of biosolids and water residuals generated by the City's water and wastewater treatment plants to the year 2025. This report was released for public comment in 2004.
- BRMP Peer Review, 2005. The results of the BRMP were subjected to a peer review, specifically to assess the decision making model and methodology.
- BRMP Update, 2008. The BRMP was updated to incorporate the recommendations of the peer review and to revise projected quantities and quality to reflect trends since the implementation of the Biosolids and Residuals Master Plan. Water treatment residuals were dropped from this work; hence, the project became known as the Biosolids Master Plan (BMP). The BMP was completed in draft and issued for public review in 2009. The recommended alternative for the HCTP remained thermal reduction.
- Council Directive, 2010. The Council did not approve the recommended thermal reduction alternative for HCTP, directing City staff to implement a beneficial use biosolids management strategy for HCTP, with landfilling as a contingent option.
- Staff Report, 2011. A report was forwarded to Council in 2011 outlining the findings of the BMP for HCTP and outlining the implications of proceeding with either fluidized bed incineration (thermal reduction technology) or a truck loading facility as needed for a beneficial use program. Council voted to proceed with the biosolids truck loading facility.

In 2012, The City retained CH2M HILL Canada Limited (CH2M HILL) to prepare a conceptual design for a biosolids truck loading facility and accompanying odour control features at the Highland Creek Treatment Plant.

1.2 Project Objectives

The project aims to achieve the following objectives:

1. Develop three conceptual layout options for the truck loading facility, all of which incorporate odour control systems. The three potential options advanced by the City for the truck loading facility include:
    a. Utilize the existing Sludge Treatment Building to locate the truck loading facility.
    b. Expand the existing Sludge Treatment Building to accommodate a new truck loading facility.
    c. Construct a new Truck Loading Facility on site, and close to the existing Sludge Treatment Building.
2. Assess the capacity requirements associated with the Truck Loading Facility in terms of biosolids handling capabilities as well as the needs of major ancillary systems.
3. Considering the differences in sludge treatment requirements for beneficial use rather than thermal reduction, assess the capacity of the existing four anaerobic digesters and associated ancillaries (gas handling system, waste gas burners, etc.) based on the updated mass balance and the current waste activated sludge (WAS) thickening project. Identify expansion requirements and develop alternatives, with conceptual layout plans for these alternatives.
4. Recommend a preferred conceptual design that best meets the City's requirements for the truck loading facility and for the existing anaerobic digestion system.

1.3 Project Deliverables

- The project work has been segregated into a series of logical steps that allows review of progress as the project team arrives at specific milestones where major decisions are finalized. The deliverables associated with these work elements are as follows:
- Technical Memorandum (TM) 1: Assessment of Capacity Requirements
- TM 2: Truck Loading Facility Siting
- TM 3: Digester and Waste Gas Burner Capacity Assessment

These Technical Memoranda will be compiled and attached to the final Truck Loading Facility Conceptual Design Report. This report will also include the evaluation of options for silos/hoppers, odour control requirements and alternatives, and logistical demands of the recommended Truck Loading Facility.

1.4 Scope of TM 1 – Assessment of Capacity Requirements

Preliminary estimates of dewatered sludge quantities were prepared by AECOM in the development of the Biosolids Master Plan (BMP, 2011). In TM 1, the intent is to refine these estimates to reflect recent projects that have been undertaken and those that are planned in the near future. This work entails the following:

1. Review plant historical data to establish accurate predictions for future biosolids generation rates.
2. Establish a more up-to-date plant mass balance that considers other projects undergoing or planned for the HCTP that could influence the amount of biosolids generated.
3. Recommend a design basis for the truck loading facility founded on the results of the mass balance exercise.

1.5 Reference Documents

The following background information and reference documents provided information that was used to develop TM 1:

- Plant historical operating data between 2009 and 2011;
- City of Toronto (2009 to 2011). HCTP Annual Reports;
- TSH Consultants (2005). HCTP Facilities Forecast;
- AECOM (2009). HCTP NFPA Code Review and Assessment, (TM 14);
- HCTP Record Drawings from various contracts;
- AECOM (2011). City of Toronto Biosolids Master Plan;
- AECOM (2012). HCTP WAS Thickening and Sludge Storage Upgrades Design Report

1.6 Organization of Document

Following this introduction, Technical Memorandum 1 has been arranged to logically present the material and evaluations undertaken to this point in the project. The following sections are as follows:

- Section 2: Review of Historical Data
- Section 3: Mass Balance Development
- Section 4: Recommended Design Basis for Truck Loading Facility
- Section 5: Summary

2. Review of Historical Data

2.1 Highland Creek Facilities Forecast

In 2005, TSH Engineers, Architects and Planners (TSH) prepared a report that predicted wastewater flows and loads through a 20 year period as a first step in assessing future needs and requirements of the facilities. Based on data from 1996 to 2003, they derived a unit flow rate for the catchment – 380 L/c/d. The serviced population at the time was approximately 460,000.

The Facilities Forecast recognized that the City's water efficiency program was having an impact on plant flows and recommended a 15 percent decrease in per capita wastewater generation by the end of the study period (2024) to approximately 326 L/c/d.

The trend toward reducing wastewater generation unit rates is partially evident in the data available for the HCTP. Figure 1 illustrates the measured wastewater generation rates calculated for the plant for the period from 1996 to 2011.

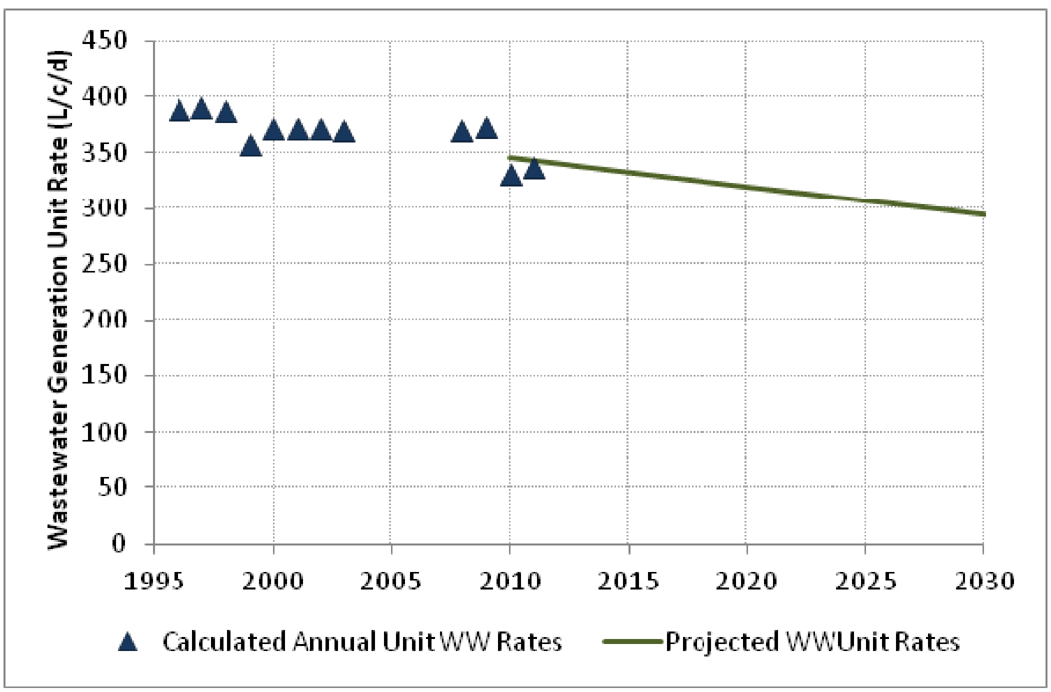


FIGURE 1
Wastewater Generation Unit Rates for the Period 1996 to 2011

The solid line shown in Figure 1 is the extension of the best fit line into the future, showing a definite trend toward lower wastewater generation rates. The slope of the line is about -2.6 L/c/d per year. This information tends to validate the assumption that wastewater generation rates will significantly decline in the near term.

The tributary population was projected to grow to 533,300 by 2021 and 545,805 by 2031.

2.2 Unit Loads

Although the Facilities Forecast (TSH) included the data required, it did not consider the unit loads of wastewater contaminants. This information has been extracted from the report and augmented with data from the Wastewater Treatment Annual Reports published for the period from 2008 to 2011. The calculated unit loads are shown in Table 1.

TABLE 1
Unit Loads for the Period 1996 to 2011

Year[1]	Population	BOD Unit Load (g/c/d)	TSS Unit Load (g/c/d)	Total Phosphorus Unit Load (g/c/d)
1996	433,308	60.9	77.2	1.71
1997	435,663	60.2	80.1	1.68
1998	438,019	66.8	85.2	1.78
1999	440,374	69.1	78.2	1.71
2000	442,730	78.3	78.9	1.67
2001	445,085	71.7	78.1	1.64
2002	451,157	71.3	74.6	1.67
2003	457,229	61.0	70.6	1.55
2008	489,101	51.9	98.2	2.07
2009	495,928	76.6	110.0	2.01
2010	502,756	81.5	103.5	1.85
2011	509,583	62.5	80.3	1.59
Overall Average		67.6	84.6	1.74
Average 2008 to 2011		68.1	98.0	1.88

Notes: 1. Data for the years 1996 to 2003 are taken from the *Facilities Forecast*, TSH, 2005. Data for the years 2008 to 2011 are taken from the *Highland Creek Wastewater Treatment Plant 2011 Annual Report*, City of Toronto, 2012

The BOD unit load has remained relatively constant. The TSS and Total Phosphorus unit loads have increased in recent years. Based on this information, somewhat conservative unit loading rates, 'rounded up' from 2009 to 2011 data averages, have been selected, as follows:

- BOD Unit Load 68.5 g/c/d
- TSS Unit Load 100 g/c/d
- TP Unit Load 1.9 g/c/d

2.3 Flow and Load Variability

Through the year, flow and contaminant loads vary due to specific conditions in the catchment – weather, industrial operation, etc. Maximum month conditions (maximum 30-day rolling average through a period of record) and maximum week conditions (maximum 7-day rolling average through a period of record) are key parameters in the sizing of biosolids handling facilities. Appendix A of this TM graphically represents the variability of the flows and loads for 2009 to date. On the basis of this data, the peaking factors for flows BOD loads, and TSS loads are shown in Table 2.

TABLE 2
Peaking Factors

Parameter	Ratio of Maximum Month to Average[1]	Ratio of Maximum Week to Average[2]
Flow	1.2	1.4
BOD Load	1.3	1.6
TSS Load	1.5	1.75

Notes: 1. Maximum month projections are based on the maximum 30-day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7-day running average during a specific annual period.

2.4 Basic Design Influent Conditions

There are two basic design influent conditions that will be considered in the assessment of the Truck Loading Facility. The first occurs in 20 years (2032), while the second would be consistent with the future date when the plant reached its ultimate capacity – 219 ML/d.

The predicted population for 2032 has been extrapolated from the serviced population values included in the Facilities Forecast (TSH, 2005). For 2032, the predicted population is 547,060. The serviced population associated with the ultimate capacity of 219 ML/d has been derived by dividing this flow by the unit wastewater flow rate. The unit wastewater flow rate is 15 percent less than the value noted for present conditions in the Facility Forecast (TSH, 2006), or 326 L/c/d (380 L/c/d * 0.85). The result of this calculation is a derived serviced population of 671,780 people.

Table 3 summarizes the flows and loads associated with those two conditions.

TABLE 3
Design Conditions

Parameter	2032	Ultimate Plant Capacity
Population	**547,060**	**671,780**
Flow, m^3/d		
Average	178,340	219,000
Maximum Month[1]	214,010	262,800
Maximum Week[2]	249,680	306,600
Average BOD Load, kg/d		
Average	37,475	46,015
Maximum Month[1]	48,715	59,820
Maximum Week[2]	59,960	73,625
Average TSS Load, kg/d		
Average	54,705	67,180
Maximum Month[1]	82,060	100,765
Maximum Week[2]	95,735	117,560

Notes:
1. Maximum month projections are based on the maximum 30-day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7-day running average during a specific annual period.

2.5 Raw Sludge Flow and Solids Loading Variation

There are two sources of sludge at the Highland Creek facility – primary sludge and waste activated sludge (WAS). Currently, WAS is removed from the secondary treatment process and returned to the primary clarifier influent channel so that it can be removed and co-thickened in the primary clarifiers. This combined sludge stream (termed raw co-thickened sludge) is then pumped to digestion or to storage and then digestion. The variations of raw co-settled sludge flows and loads measured from 2009 to 2011 are summarized in Table 4.

TABLE 4
Raw Sludge Flow and Load Variation

Parameter	Average Value	Ratio of Maximum Month to Average[1]	Ratio of Maximum Week to Average[2]
Flow	1,870 m^3/d	1.3	1.7
TSS Load	45,200 kg/d	1.3	1.8
VSS Load	28,000 kg/d	1.5	2.0

Notes:
1. Maximum month projections are based on the maximum 30-day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7-day running average during a specific annual period.

2.6 Centrifuge Performance

An evaluation of centrifuge performance was conducted based on data obtained for the period from 2009 to 2011. The relationships between incoming wastewater flows, solids loading to the plant, digested sludge loading to the centrifuges, and dewatered sludge solids concentration are depicted in Appendix B. Examination of these figures illustrates the following points:

- During high flow events (wet weather periods), the inert solids content, as a proportion of the total suspended solids, increases substantially. The presence of this inert load appeared to enhance centrifuge performance in terms of dewatered sludge solids concentrations.
- The peak solids loads to the plant, and consequently the peak sludge loads, occur during wet weather events.
- During average influent load periods, dewatering was able to achieve about 27 percent dewatered sludge (cake) solids.
- During peak influent load periods when a higher inert fraction is present in the sludge, dewatering seems able to achieve a higher solids concentration. However, we have assumed that this concentration remains constant at 27 percent.
- The average capture in the centrifuges is 96 percent, achieved with an average polymer dosage of 10.9 kg/T.

2.7 Biogas Generation

Biogas generation from the existing plant will not fully reflect the biogas generated from an upgraded facility. The longer SRT obtained in the digesters from current improvements and future enhancements will substantially increase the amount generated. Nonetheless, some assessment of biogas generation fluctuations will allow consideration of possible variations in biogas production in the future. To assess biogas generation variability, hourly biogas flows for 2010 were obtained. The average, maximum month, maximum week, and peak flows during this period are summarized in Table 5.

TABLE 5
Biogas Generation Characteristics – 2010

Parameter	Value	Ratio of Value to Annual Average
Annual Average, m^3/d	505	-
Maximum month[1], m^3/d	675	1.34
Maximum week[2], m^3/d	692	1.37
Maximum day[3], m^3/d	795	1.57
Peak hour, m^3/d	1,197	2.37

Notes:
1. Maximum month projections are based on the maximum 30-day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7-day running average during a specific annual period.
3. Maximum day projections are based on the maximum 24 hour running average during a specific annual period.

The peak hour value is significantly higher than the other maximums and could be due to meter malfunctions, equipment issues, or some other source of error. Figure 2 illustrates a statistical plot of the data, showing that there were four relatively random occurrences of high gas flows during 2010.

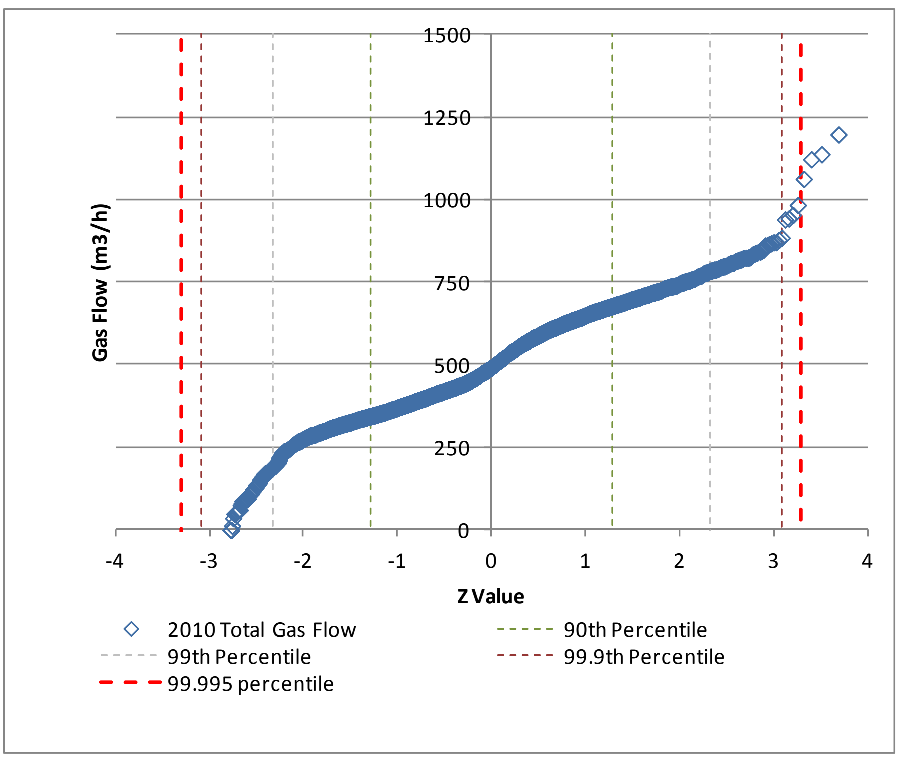


FIGURE 2
Statistical Variability of Biogas Flows – 2010

The 99.995th percentile value is a relatively conservative estimate of the peak flow that might reasonably be addressed in design. For 2010 data, there would be four hourly periods in which flows were higher. In each case, the biogas flow rates measured directly prior to and after were significantly lower, suggesting that the very high measurement could be due to mechanical issues or meter malfunctions. For this reason, the 99.95th percentile value is recommended for use as the peak value for this data set. Its value is 975 m^3/d, which is about 1.95 times the annual average value.

3. Plant Wide Mass Balance Development

3.1 Basis for Development of Plant Wide Mass Balance

The plant mass balance was developed using CH2M HILL's biological treatment simulator, Pro2D. This computer based model is a whole plant simulator that incorporates IWA's activated sludge models (ASMs) and anaerobic digestion models (ADMs). It has been modified to incorporate biological nutrient removal and ancillary liquid-solids separation processes. Key process performance criteria that have been incorporated in the model are described in the following paragraphs.

1. Primary treatment performance: The data from 2009 to 2011 indicated that the median influent TSS concentration was about 282 mg/L and the median primary effluent TSS concentration was about 167 mg/L. These values suggest that the solids removal rate through primary treatment was approximately 35 percent. However, secondary sludge is recycled to the head of the primary clarifiers and when these solids are included in the calculations; the apparent solids removal rate is about 56 percent. Further, ferrous addition at the head of the plant will increase the influent solids, although these solids are not included in the measurement of influent measurements. When these chemically precipitated solids also are included in the assessment of primary treatment performance, total solids removal through this process is estimated to average 60 percent. For the mass balance calculations, 60 percent primary treatment solids removal was used to predict the material removed through this process, including the chemically precipitated solids. It is realized that performance will vary when the WAS thickening process is placed in service and could exhibit some seasonal and load related fluctuations. However, 60 percent removal is considered a reasonable estimate at this time given the data available.

2. Primary sludge thickening: Primary sludge will continue to be thickened in situ. Previous performance measured when co-thickening does not allow a reasonable prediction of the thickening performance that can be achieved when thickening only primary sludge. The maximum solids concentration that can be obtained is a function of wastewater characteristics, clarifier physical characteristics, and flow variability. The key consideration is the sludge blanket height that can be maintained without compromising clarifier performance. When sludge blankets are greater, sludge concentrations increase but there is greater risk of sludge washout during peak flow events. Based on experience at other plants, the primary sludge solids concentration likely will be between 2.0 and 4.5 percent. In their work on the plant, AECOM (WAS Thickening Design Report, 2011) predicted a primary sludge solids concentration of 3.3 percent. This

value is relatively low, so is conservative when considering the impact on downstream process units. The concentration of 3.3 percent has been adopted for this work as well.

3. Ferrous addition: Ferrous chloride is added to the primary treatment influent flow to obtain phosphorus removal, as required by the plant's C of A. The average ferrous dosage between 2009 and 2011 was 7.15 mg/L (as Fe) and the average influent phosphorus concentration was 5.2 mg/L (as P). At those concentrations, the molar ratio between iron and phosphorus is (7.15/56)/(5.2/31) = 0.79. At this dosage, the effluent phosphorus concentration measured during 2009 to 2011 averaged 0.52 mg/L. To be somewhat conservative, the molar ratio used to determine the dosage in the mass balance was 0.9, which generally resulted in predicted effluent TP of 0.65 to 0.80 mgP/L.

4. Secondary treatment performance: Secondary treatment performance was modeled using the ASM model embedded in Pro2D. Based on IWA's models, it also includes provisions for nitrogen and phosphorus removal. The critical parameter that will influence secondary solids generation rates is the solids retention time (SRT). Generally, the HCTP operates at an SRT of about 7.0 days, a value that is sufficiently high to achieve some level of nitrification. The assumed solids retention time (SRT) used for the mass balance was slightly lower – 5.0 days. This value would be sufficient to maintain nitrification when wastewater temperatures are above 14°C and because it is somewhat lower than the norm, it will predict slightly higher secondary waste sludge loads so is conservative.

5. WAS Thickening Performance: Centrifuge thickening regularly achieve thickened waste activated sludge (TWAS) solids concentration greater than 5 percent TS. Solids capture is dependent upon polymer addition. Generally without polymer, the capture rates are only 85 percent. With polymer addition, capture rates are much higher, usually over 90 percent. For the purpose of this mass balance, it was assumed that the capture rate would be optimized as a result of polymer addition, with a capture rate of 93 percent. The WAS thickening capture rate has little impact on predicted plant performance when the centrate is returned to the liquid stream treatment process. The SRT in the secondary treatment system will depend upon the amount of TWAS, not the amount of WAS.

   Based on this rationale, the TWAS thickening performance has been based on achieving a thickened solids concentration of 5 percent TS and 93 percent capture.

6. Digestion Performance: The digesters convert influent volatile solids to biogas and anaerobic biomass. The net decrease in volatile solids is termed the volatile solids reduction (VSr) and will vary according to the characteristics of the sludge, the operating conditions, and the solids retention time in the digester. Based on 2009 to 2011 data, the current four operating digesters achieve about 47.5 percent VSr at an SRT of about 14 days. However, this SRT is optimistic considering the amount of displaced volume associated with inert solids accumulations. The recent Digester 5 cleaning operation suggests that as much as 30 percent of the digesters' volume is unavailable. Given that the actual SRT is likely closer to 10 or 11 days, the measured 47.5 percent VSr is excellent.

The approach taken to digestion in the derivation of plant mass balances has been to assume that the available volume will be expanded so that it is sufficient to provide a minimum effective SRT of 15 days at the maximum month sludge loads. The IWA anaerobic digestion model (ADM) used in Pro2D then predicts the VSr based on inlet sludge characteristics and that SRT. Generally, the calculated VSr for average conditions at the HCTP is about 52 percent, dropping to slightly less than 50 percent when maximum week loads are applied.

No allowance has been made for enhancing digestion in the future. Conversion of the digesters to an acid-gas configuration, adding sludge pretreatment (thermal hydrolysis, electric pulsing, homogenization, etc.) would improve the VSr, especially during high loading periods. Further, there has been no allowance for separate primary sludge thickening, which would increase the SRT without the need for physical expansion of the digestion complex. A review of these options is beyond the purview of this work; however, it is recommended that these optional approaches to improving digestion be considered in the future prior to conventional expansion of the complex.

7. Dewatering Performance: Based on 2009 to 2011 data, the existing centrifuges appear able to achieve 27 percent dewatered sludge solids concentrations (cake solids) with polymer dosages of about 11 kg per tonne of dry solids fed to the centrifuges (11 kg/Tds). Of interest, the maximum solids loads to digestion coincide with peak wet weather events. During these periods, large amounts silt, sand, and other inert solids are scoured from the wastewater collection system and enter the plant. This inert load, when fed to the centrifuges, generally improves performance. There is some evidence of improved performance at Highland Creek; however, the data does not provide sufficient proof that it can be assumed that during maximum week loads the dewatering process can achieve better performance. It has been assumed that during maximum month conditions and maximum week conditions, a cake solids concentration of 27.5 percent would be achieved.

   The capture rate achieved during the 2009 to 2011 period averaged 96 percent. This level of performance has been incorporated in the mass balance.

   An ongoing project will replace five of the existing six centrifuges and refurbish the dewatered sludge conveyance systems. Possibly, these new centrifuges may be able to out-perform the existing units. However, the historical performance indicators for the dewatering system have been adopted for the development of the mass balances.

3.2 Mass Balance Scenarios

Mass balances have been prepared for two scenarios considered for future plant development. These scenarios are described in the following:

Growth Until 2032. The tributary population for the HCTP catchment is predicted to grow to about 547,060 people by 2032, 20 years from the date of preparation for this report. Influent flows and loads were derived for this contributing population under the conditions of average, maximum month, and maximum week loading conditions.

Growth to Ultimate Plant Capacity. The ultimate hydraulic capacity for the HCTP is 219 ML/d based on average flows. The predicted moderate wastewater unit flow is 326 L/c/d (*Facility Forecast*, TSH, 2005). HCTP's tributary population would grow to about 671,780 people to generate this flow. Influent flows and loads were derived for this contributing population under the conditions of average, maximum month, and maximum week loading conditions.

3.3 Mass Balance Results

The results of the mass balances have been depicted in graphic format, attached to this TM in Appendix C. The key results are summarized in Table 6.

TABLE 6
Key Mass Balance Results for HCTP Growth Scenarios

Parameter	2032			Ultimate Capacity (219 ML/d)		
Condition	Average	Maximum Month Load	Maximum Week Load	Average	Maximum Month Load	Maximum Week Load
Population Served	547,060			671,780		
Plant Influent						
Flow, ML/d	178.3	178.3	178.3	219	219	219
BOD Load, kg/d	37,475	52,465	59,960	46,015	64,425	73,625
TSS Load, kg/d	54,705	46,010	95,735	56,500	100,765	117,560
VSS Load, kg/d	42,670	36,810	74,675	45,200	78,600	91,700
Ferrous Dosage, kgFe/d	**1,185**	**1,660**	**1,895**	**1,490**	**2,050**	**2,475**
Primary Effluent						
Flow, ML/d	184.7	184.6	184.6	225.2	225.3	225.2
BOD Load, kg/d	21,230	28,920	32,075	26,260	35,070	39,755
TSS Load, kg/d	25,640	38,800	44,225	31,860	46,600	54,965
VSS Load, kg/d	18,970	28,675	32,715	23,555	34,445	40,585
Primary Sludge						
Flow, m^3/d	1,160	1,690	2,000	1,420	2,110	2,460
TS Load, kg/d	38,440	55,860	66,155	46,945	69,675	81,035
VS Load, kg/d	28,170	40,890	48,465	34,385	51,010	59,260

TABLE 6
Key Mass Balance Results for HCTP Growth Scenarios

Parameter	2032			Ultimate Capacity (219 ML/d)		
TWAS						
Flow, m^3/d	410	560	630	500	690	780
TS Load, kg/d	20,275	28,130	31,470	25,170	34,470	39,025
VS Load, kg/d	14,820	19,800	22,050	18,335	24,280	27,325
Digested Sludge						
Flow, m^3/d	1,570	2,260	2,630	1,930	2,800	3,240
TS Load, kg/d	34,570	51,210	60,090	43,180	63,650	75,450
VS Load, kg/d	21,300	31,235	36,785	26,715	38,885	46,480
Dewatered Sludge						
Flow, m^3/d	123	182	214	154	226	268
TS Load, kg/d	33,109	49,160	57,685	41,450	61,100	72,430
VS Load, kg/d	20,445	29,985	35,310	25,645	37,330	44,620

3.4 Comparison to WAS Thickening Design Report Findings

The results of this mass balance differ from the mass balance prepared by AECOM for the WAS Thickening Design Report. Most importantly, they used historical average BOD and TSS concentrations (167 mg/L and 257 mg/L, respectively) which would result in a serviced population between 534,000 and 562,000. As a result, WAS Thickening Design Report predicted solids loads to the various processes that are similar to those predicted above for 2032. That report did not account for the decrease in unit flows predicted in the Facilities Forecast (TSH, 2006).

Other minor differences are ascribed to the following points:

- The assumed primary treatment performance used in the WAS Thickening Design Report was just over 52 percent removal rather than the 56 percent removal used in this work. The background to the use of 56 percent is described previously.
- WAS thickening capture rates were 90 percent rather than the 93 percent used in this work. As noted earlier, the higher value was selected on the premise that polymer would be used as necessary to achieve better thickening performance.
- VSr in the digestion process was assumed to equal 45 percent rather than closer to 50 percent used in this work.

4. Design Basis

4.1 General

The mass balances derived for various conditions have been used to establish specific design parameters for the digestion process and for the truck loading facility. The design basis for these two processes is described in the following subsections.

4.2 Anaerobic Digestion

CH2M HILL's standard for anaerobic digestion design for a blend of primary and secondary sludge is to allow for a total digestion volume that provides an SRT of 15 days, at the maximum month sludge loads, with the largest digester out of service. This standard inherently allows for up to 20 percent lost volume due to grit and scum accumulations; hence, if there are reasons that grit and scum accumulations are greater than 20 percent, the 15 day SRT has to be increased. Further, the SRT at maximum week loads should be greater than 12.5 days. Again, this period allows for 20 percent displaced volume so that there is no time that the sustained load to the digesters creates a situation where the actual SRT is less than 10 days. Below an SRT of 10 days, there is judged to be unacceptable risk that digestion will fail due to washout of the bacteria responsible for the first stage of biodegradation of secondary treatment waste biomass. If only primary sludge is to be digested, these minimum SRT standards can be relaxed.

Another restriction on the loading rate is related to the VS loading on a volumetric basis. To ensure that foaming does not occur in anaerobic digesters due to overloading, the VS loading during maximum month conditions should be limited to 3.5 kgVS/m^3/d. The VS loading during maximum week conditions should not exceed 4.5 kgVS/m^3/d. Generally, these loading rates are only a concern where the sludge is thickened to a solids concentration greater than about 6 percent. Again, the limits can be relaxed somewhat where primary sludge is the primary or only type of sludge entering the digesters.

The design basis for anaerobic digestion, considering these constraints is summarized in Table 7.

TABLE 7
Design Basis for Anaerobic Digestion

Parameter	2032			Ultimate Capacity (219 ML/d)		
Condition	Average	Maximum Month Load	Maximum Week Load	Average	Maximum Month Load	Maximum Week Load
Primary Sludge						
Flow, m^3/d	1,160	1,690	2,000	1,420	2,110	2,460
TS Load, kg/d	38,440	55,860	66,155	46,945	69,675	81,035
VS Load, kg/d	28,170	40,890	48,465	34,385	51,010	59,260
TWAS						
Flow, m^3/d	410	560	630	500	690	780
TS Load, kg/d	20,275	28,130	31,470	25,170	34,470	39,025
VS Load, kg/d	14,820	19,800	22,050	18,335	24,280	27,325
Total Sludge to Digestion						
Flow, m^3/d	1,570	2,260	2,630	1,930	2,800	3,240
TS Load, kg/d	58,715	83,990	97,625	72,115	104,145	120,060
VS Load, kg/d	42,990	60,880	70,505	52,720	75,290	86,585
Basic Design Parameters						
Minimum SRT		15	12		15	12
Calculated Volume Requirement, m^3		33,900	31,560		42,000	38,880
Minimum Volume, m^3		33,900			42,000	
VS Loading at Min. Volume, kg/m^3/d	1.27	1.80	2.08	1.26	1.79	2.06

Currently, there are four 6,600 m^3 anaerobic digesters in service. This tankage provides a total capacity of 26,400 m^3 and a firm capacity (largest unit out of service) of 19,800 m^3. Digestion will need to be expanded to effectively handle the predicted sludge loads for 2032. The initial expansion should consider the need to further expand the digesters in the future to handle the flows and loads associated with the ultimate plant capacity. For instance, the following options are viable:

Existing four digesters at 6,600 m^3	
Three new digesters at 6,600 m^3 for 2032	Firm capacity of 39,600 m^3
One new digesters at 6,600 m^3 for Ultimate Plant Capacity	Firm Capacity of 46,200 m^3
Existing four digesters at 6,600 m^3	
Two new digesters at 14,100 m^3 for 2032	Firm capacity of 33,900 m^3
One new digester at 14,100 m^3 for Ultimate Plant Capacity	Firm Capacity of 48,000 m^3
Existing four digesters at 6,600 m^3	
Two new digesters at 11,100 m^3 for 2025	Firm capacity of 30,900 m^3
One new digester at 11,100 m^3 for Ultimate Plant Capacity	Firm Capacity of 42,000 m^3

These options and others will be considered in Technical Memorandum 3.

4.3 Biogas Management

Biogas is generated by the anaerobic decomposition of organic material. The quantity generated usually varies between 0.85 and 1.1 m^3 per kg of VS removed, depending upon the characteristics of the sludge and feed variability. Further, the methane content of biogas varies as well. Typically, it ranges between 55 and 65 percent of the biogas generated. The remainder of the biogas is carbon dioxide (CO_2), ammonia, hydrogen sulfide, and other volatile organic gases. Pro2D predicts the quantity and quality of the biogas generated based on the material being digested and the operating characteristics of the system.

Biogas generation varies diurnally due to changes in feed rates fluctuations in operating temperature. Further, the apparent flow can be influenced by changes in atmospheric pressure and by ambient temperature fluctuations. For this reason, it is prudent to apply a diurnal peaking factor to the predicted biogas generation rates for conveyance appurtenances and equipment that will need to handle the maximum biogas flows. In this instance, a diurnal peaking factor of 1.95 has been selected for application to the average annual biogas generation rate, based on the assessment of 2010 biogas flows in Section 2.

Based on the Pro2D findings and the above peaking factors, the biogas quantities that will need to be managed have been determined and are summarized in Table 8.

TABLE 8
Design Basis for Biogas Management

Parameter	2032	Ultimate Plant Capacity
Biogas Generation Rate		
Average, m^3/d	21,000	25,235
Maximum Month[1], m^3/d	28,715	35,425
Maximum Week[2], m^3/d	32,830	38,820
Peak Diurnal	40,950	49,210
Methane Fraction (at condition noted)		
Average, percent	0.58	0.58
Maximum Month[1], percent	0.58	0.58
Maximum Week[2], percent	0.58	0.58

Notes: 1. Maximum month projections are based on the maximum 30-day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7-day running average during a specific annual period.

These predicted gas generation rates are based on the presumption that digestion is expanded as summarized in the previous section. If digestion is not expanded as noted, the biogas generation rates predicted above will be greater than actual values. However, if digestion is improved through the addition of digestion enhancement technologies, then biogas generation rates will exceed those noted above and appropriate modifications will need to be made to the gas handling facilities to account for the higher predicted biogas generation rates that would occur as a result.

4.4 Truck Loading Facility

The truck loading facility requires sufficient capacity to handle the dewatered biosolids generated over a period when normal operations might be disrupted, such as during winter storms or during periods in the summer when extremely wet conditions halt normal operations. It is imperative that operation of the truck loading facility not influence operation of upstream processes – dewatering, digestion, or liquid stream treatment. Should the ability to move materials off site to beneficial use be constrained such that it is necessary to begin storing solids for longer periods than the plant was designed, there is a significant risk that effluent quality will suffer. For this reason, it is necessary that a conservative storage volume be selected.

Generally, hauling interruptions due to weather or holidays are limited to about three days. However, it is not always evident when an interruption will occur and some allowance must be made for the typical inventory that might already be in storage and the time necessary for startup to occur. For this reason, it is recommended that storage generally be limited to two days of dewatered material and that 0.5 days be allowed for the restart of operations. Hence, the total storage time that will be provided will be as follows:

Existing inventory	2 days
Interruption period	3 days
Re-start period	0.5 days
Total Storage Required	5.5 days

The total storage must be available at all times because interruptions can be unplanned. Further, it is likely that hauling interruptions will occur during critical loading periods because interruptions and high loads to treatment occur due to the same cause – inclement weather. For this reason, it is prudent to plan storage based on the predicted maximum week loads rather than upon some other less critical load.

Based on this storage period and loading condition, the basic design parameters for the truck loading facility are summarized for 2032 and for the ultimate plant capacity in Table 9.

TABLE 9
Design Basis for Truck Loading Facility

Parameter	2032	Ultimate Plant Capacity
Dewatered Biosolids Generation Rate		
Average, m^3/d	123	154
Maximum Month[1], m^3/d	182	222
Maximum Week[2], m^3/d	215[3]	270[4]
Storage Period, d	5.5	5.5
Total Volume, m^3	1,185	1,485

Notes:
1. Maximum month projections are based on the maximum 30-day running average during a specific annual period.
2. Maximum week projections are based on the maximum 7-day running average during a specific annual period.
3. Value of 215 m^3/d is rounded up from 214 m^3/d
4. Value of 270 m^3/d is rounded up from 268 m^3/d

The design for the truck loading facility should be based on the projected 2032 loads and should be sufficient to handle maximum week loads. The resultant volume of 1,185 m^3 would only provide storage for about 4.5 days when the plant reaches its ultimate capacity, and generating sludge at a maximum week rate. However beyond 2032, it is likely that technology changes will influence the amount of sludge that will be generated by wastewater treatment or that advances dewatering techniques will reduce the water content and hence the volume of dewatered sludge generated. Incurring capital costs at this time for sludge volumes beyond those predicted for 2032 are not justified because of these uncertainties.

Given that the facility has been designed to provide 5.5 days of storage, consideration of the maximum week load is most appropriate. Generally, maximum day loads are associated with maintenance activities (cleaning out a sludge storage tank or digester) and in most instances, prudent planning can ensure that the facility can accommodate these short term peaks. Emergencies do occur that could stress the facility; however, the management of dewatered sludge during these unexpected periods will need to be managed within the context of contingency planning to allow for unforeseen circumstances. It is expected that the plant will operate the TLF at a minimal filled level, so unexpected high loads for short periods can be accommodated.

5. Summary

This Technical Memorandum has established the design bases for sludge digestion, biogas management systems, and the truck loading facility. The design bases are derived for two conditions, first for the predicted serviced population in 20 years (2032) – 547,060 people; and second for the predicted population that would be served when the plant reached its ultimate capacity - 671,780 people. The ultimate capacity was back-calculated by dividing the hydraulic capacity of the plant (219 ML/d) by the unit wastewater generation rate predicted for the future (326 L/c/d). Unit wastewater generation rates have been dropping consistently over the last 15 years, suggesting that the predicted value would reasonably be achieved.

The organic and solids loads delivered to the plant under certain conditions have been predicted on the basis of unit loads – 68.5 gBOD/c/d and 100 gTSS/c/d being the critical values. Peaking factors that can be used to derive maximum month and maximum week loads were established on the basis of the last few years of plant operation (2009 to 2011 data).

Table 7, Table 8, and Table 9 in the text tabulate the design bases for anaerobic sludge digestion, biogas management, and the truck loading facility, respectively. In each case, design of new facilities at the Highland Creek Treatment Plant will be based on predicted 2032 requirements; however, allowing for reasonable expansion of the facilities to handle the capacity needs of plant development to handle the ultimate capacity. It must be recognized that future changes in wastewater and sludge treatment technologies will influence the sizing of these facilities, so the flexibility to reasonably change to meet these future needs is critical to the success of the plant in the future.

Appendix A
Variability of the Flows and Loads for 2009 to Date

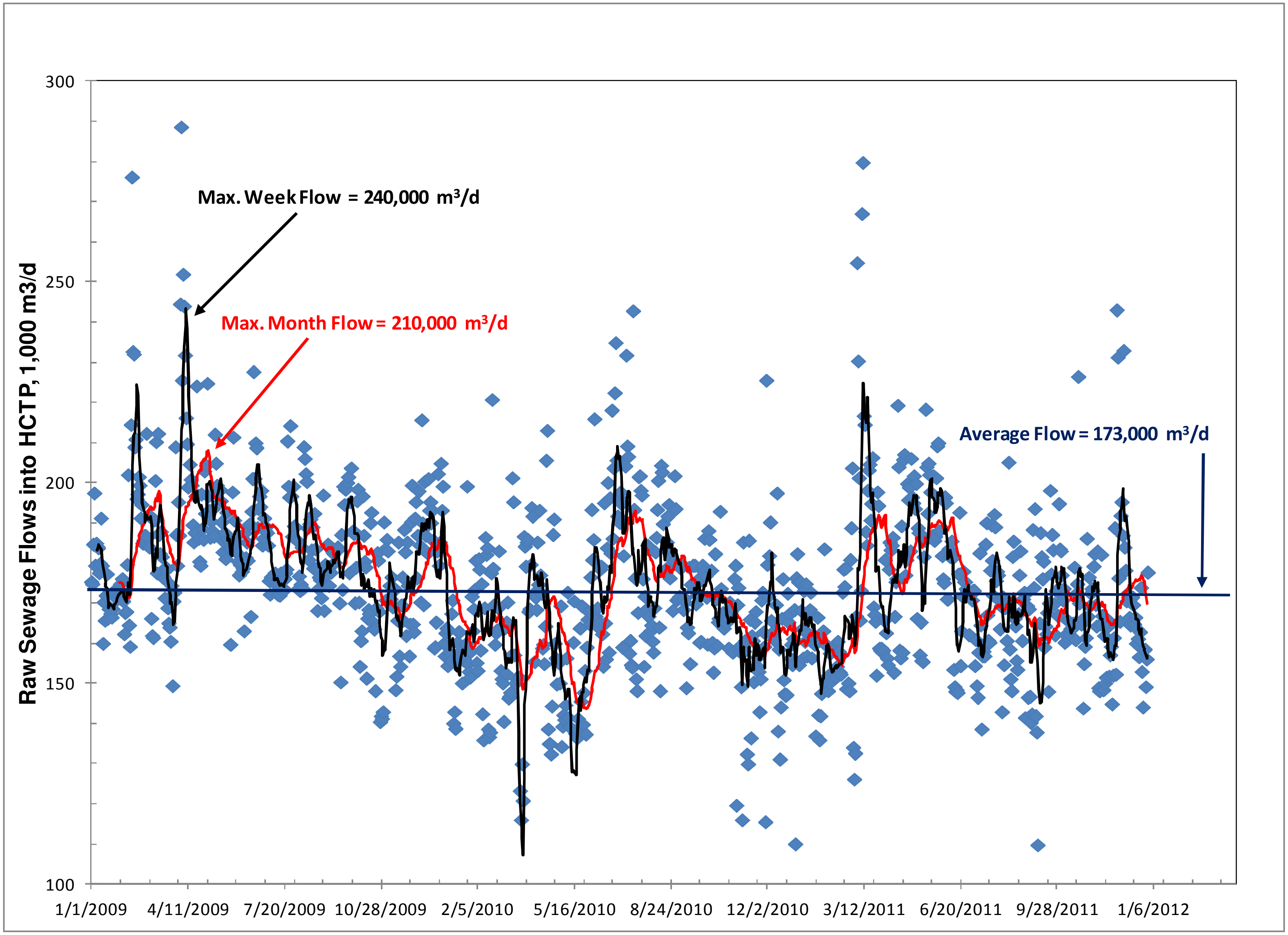


Figure 1.A: Raw Sewage Flowrate

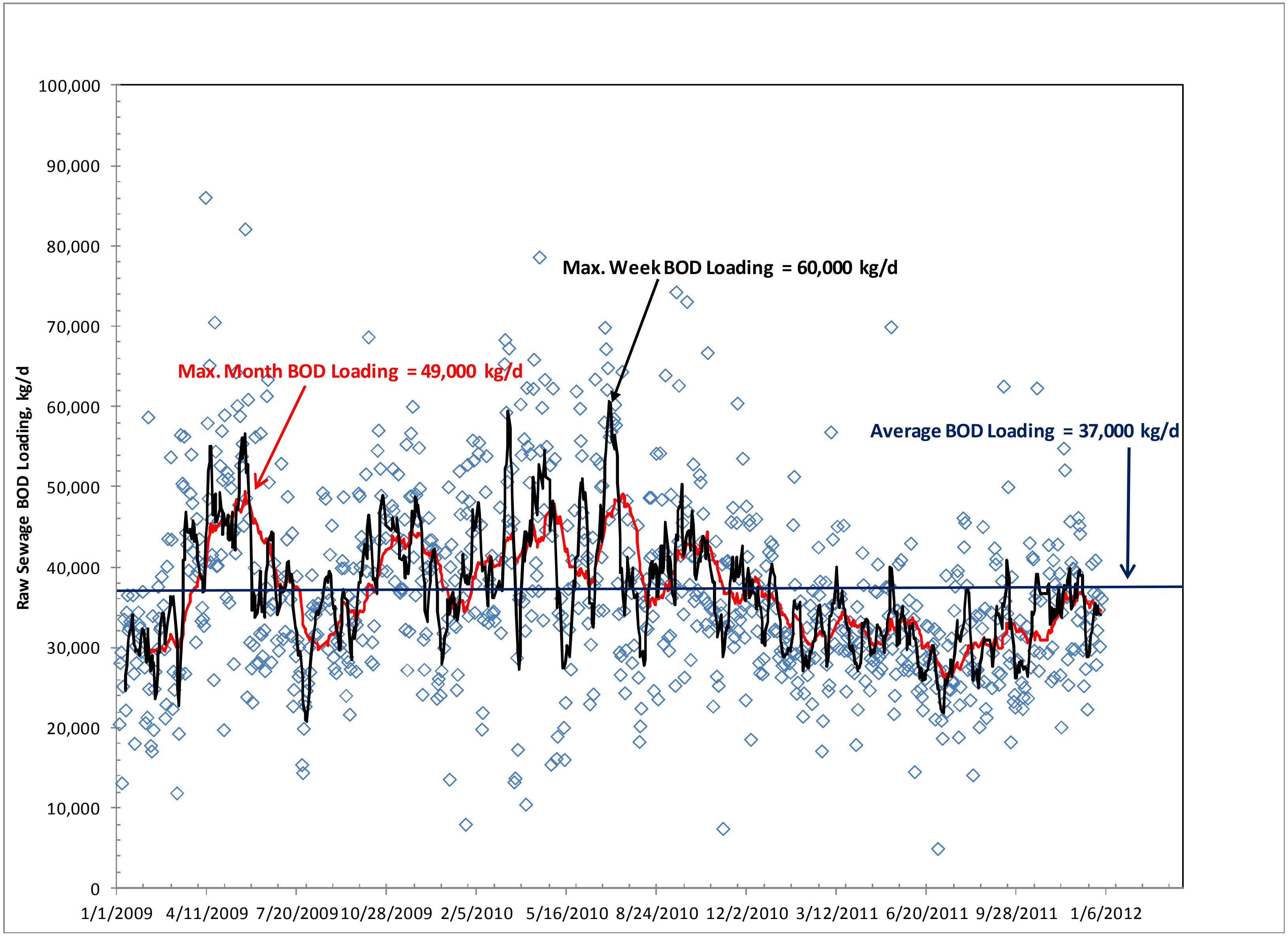


Figure 1.B: Raw Sewage BOD Loading

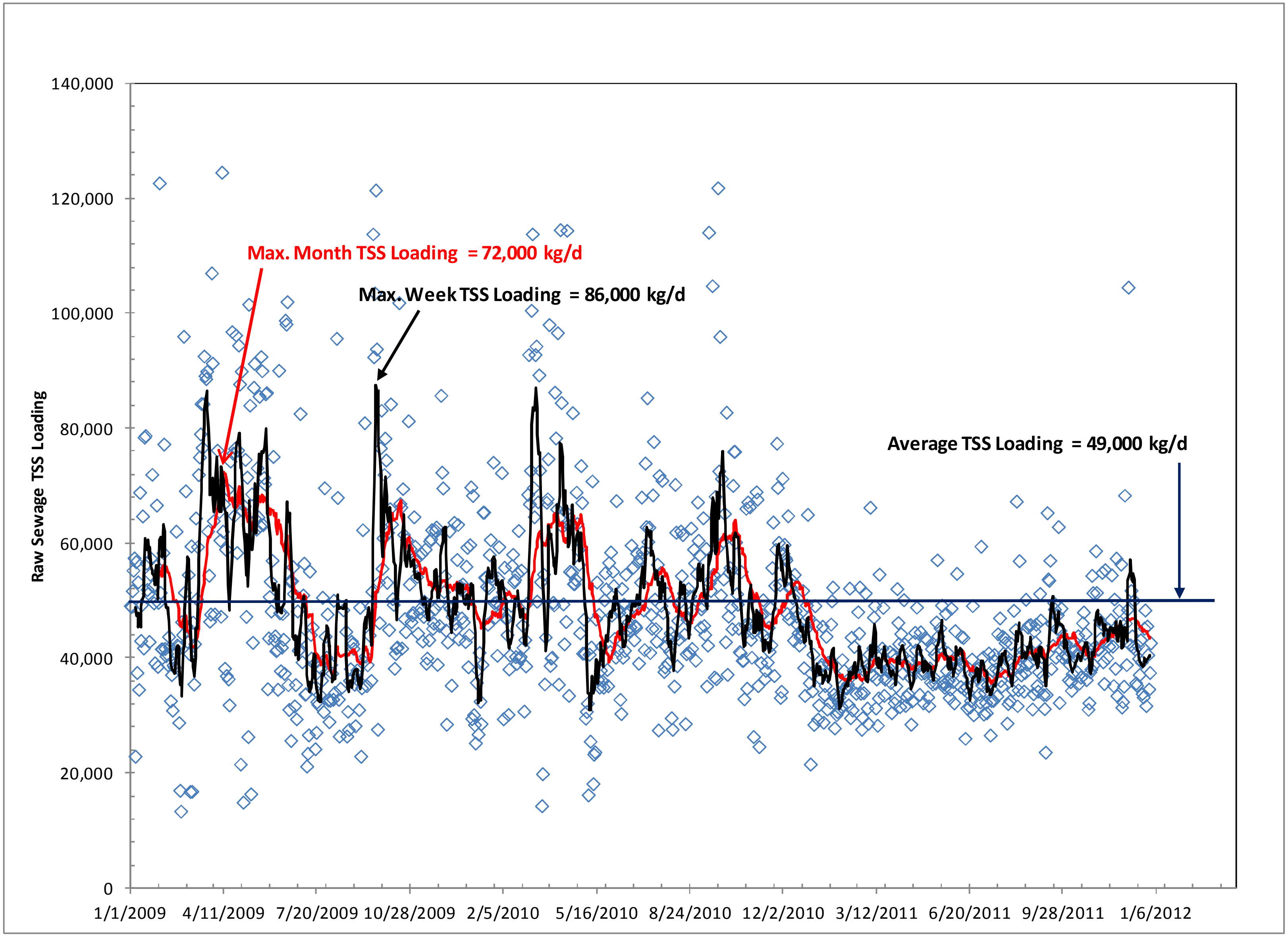


Figure 1.C: Raw Sewage TSS Loading

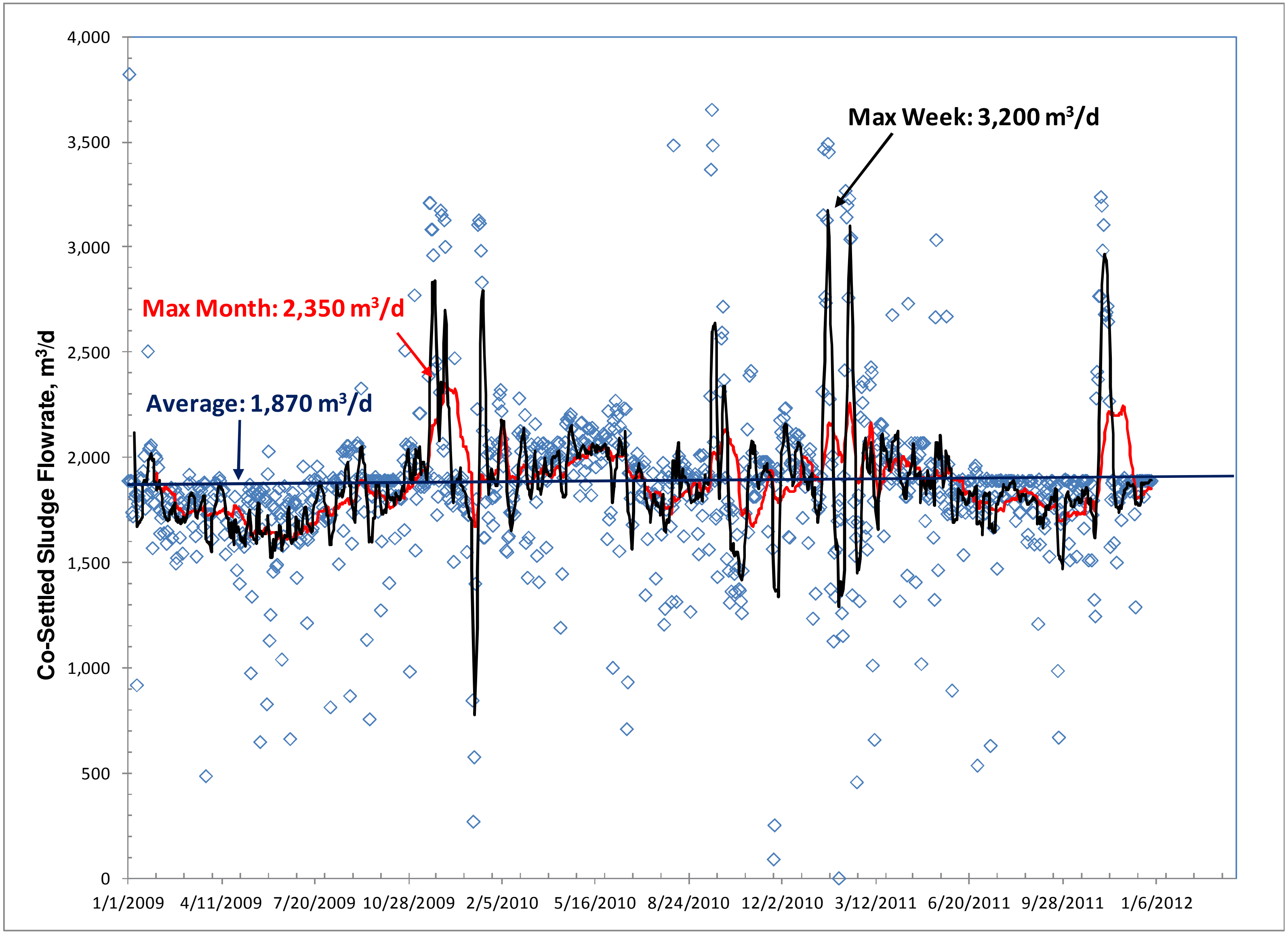


Figure 2.A: Co-Settled Sludge Flowrate

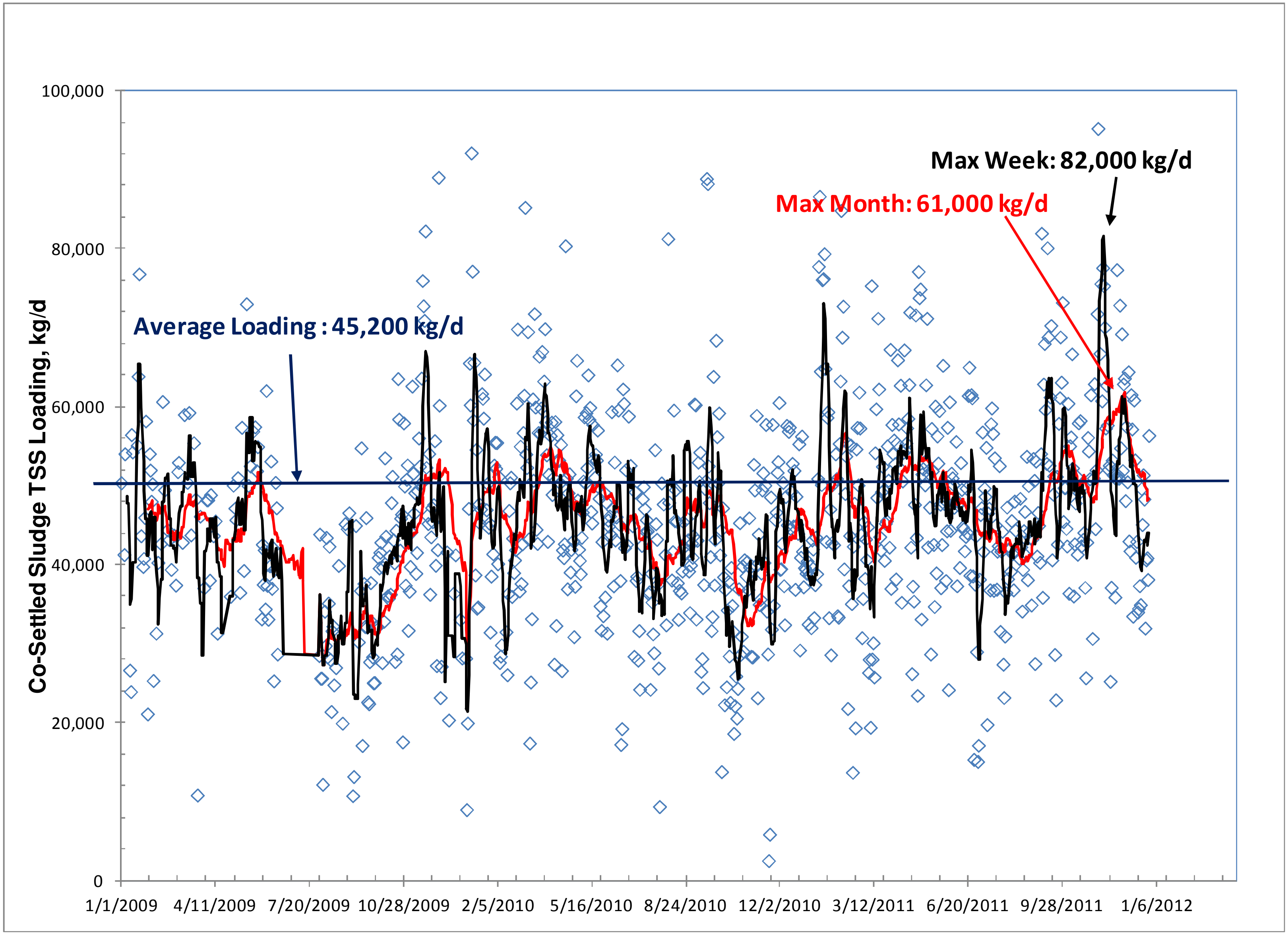


Figure 2.B: Co-Settled Sludge TSS Loading

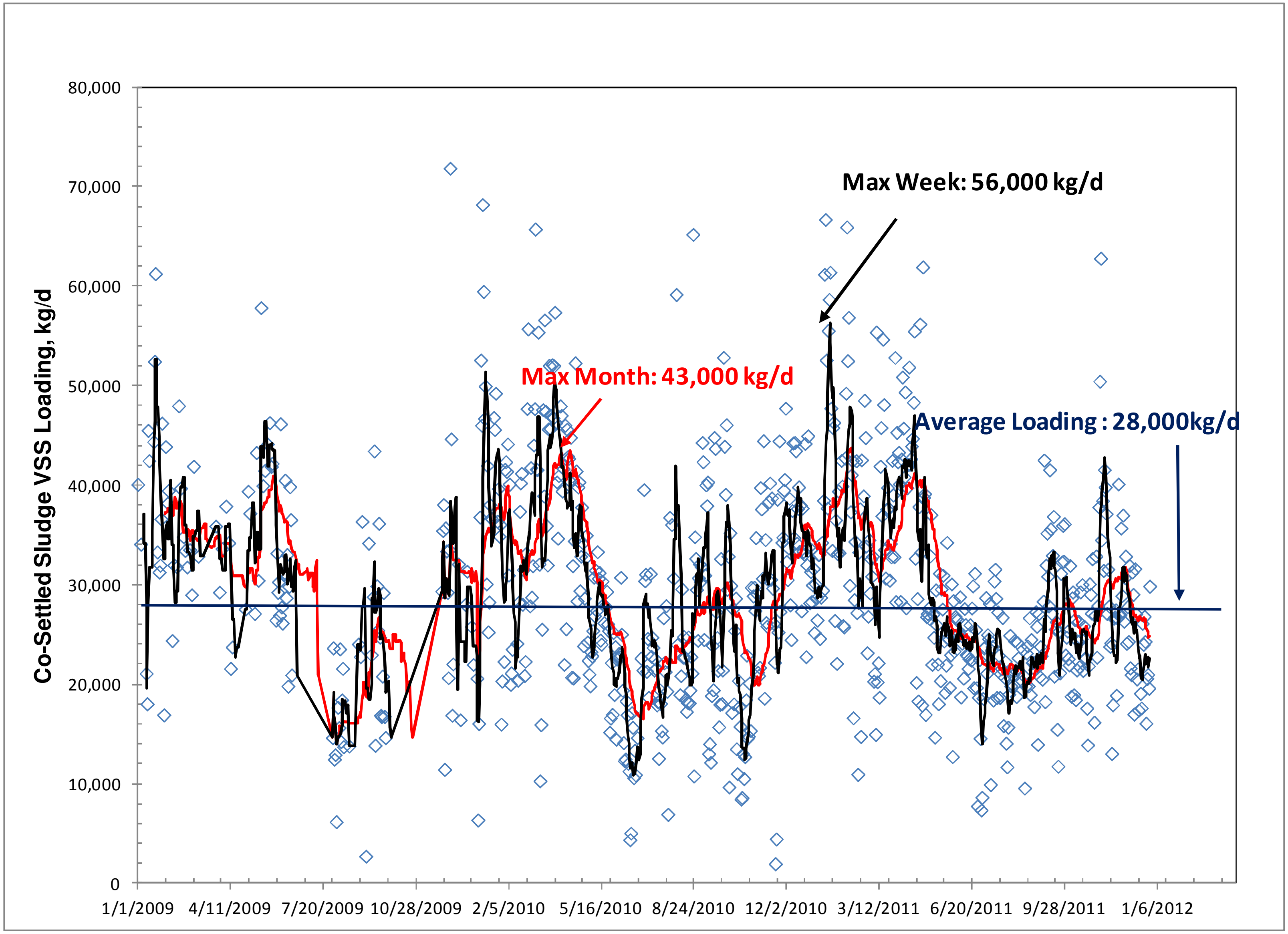


Figure 2.C: Co-Settled Sludge VSS Loading

Appendix B
Centrifuge Performance

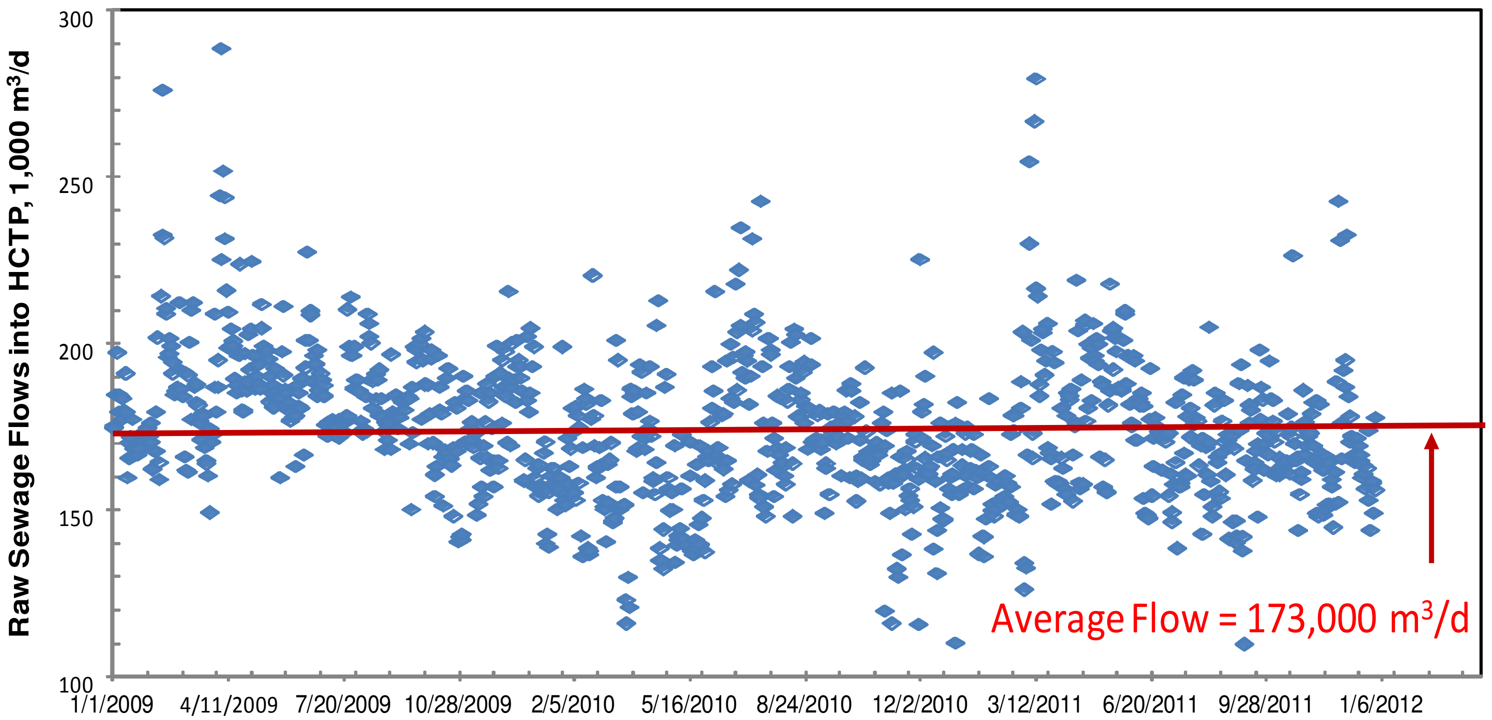


Figure 3.A

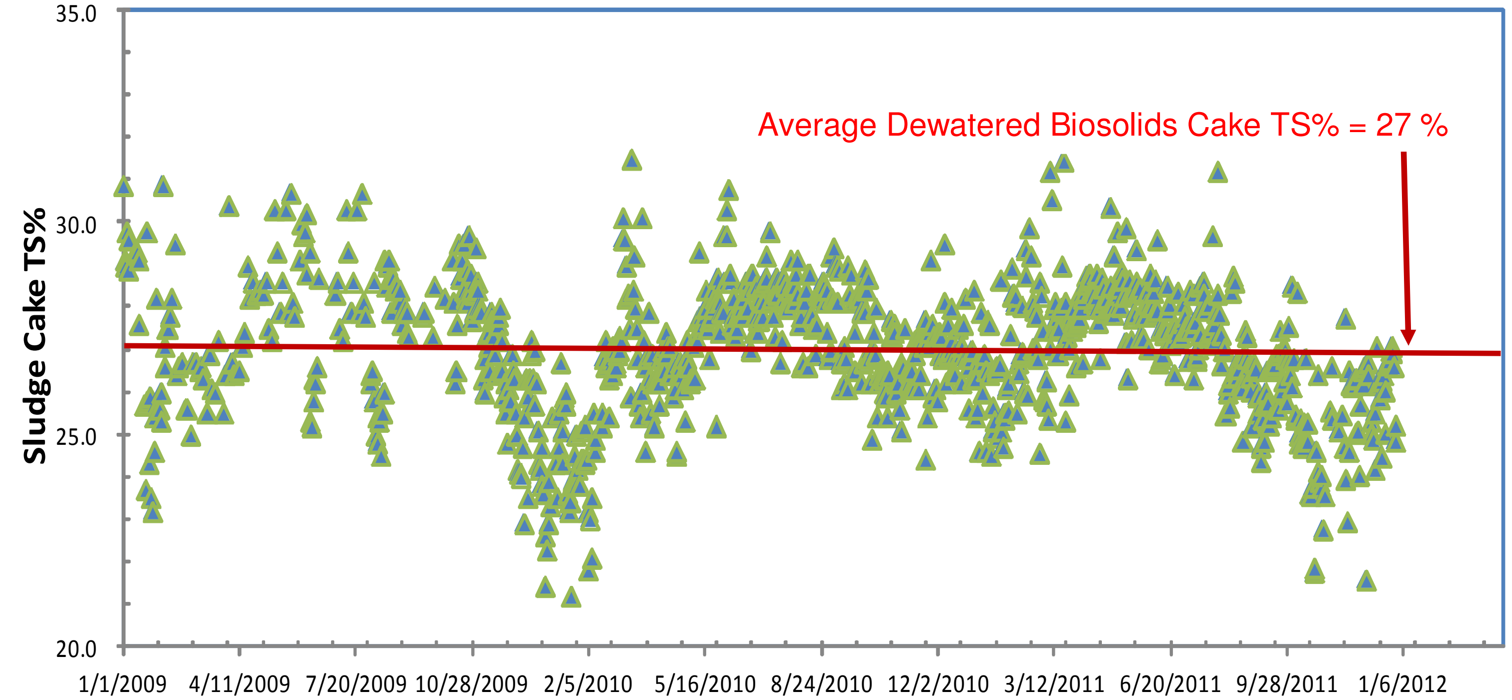


Figure 3.C

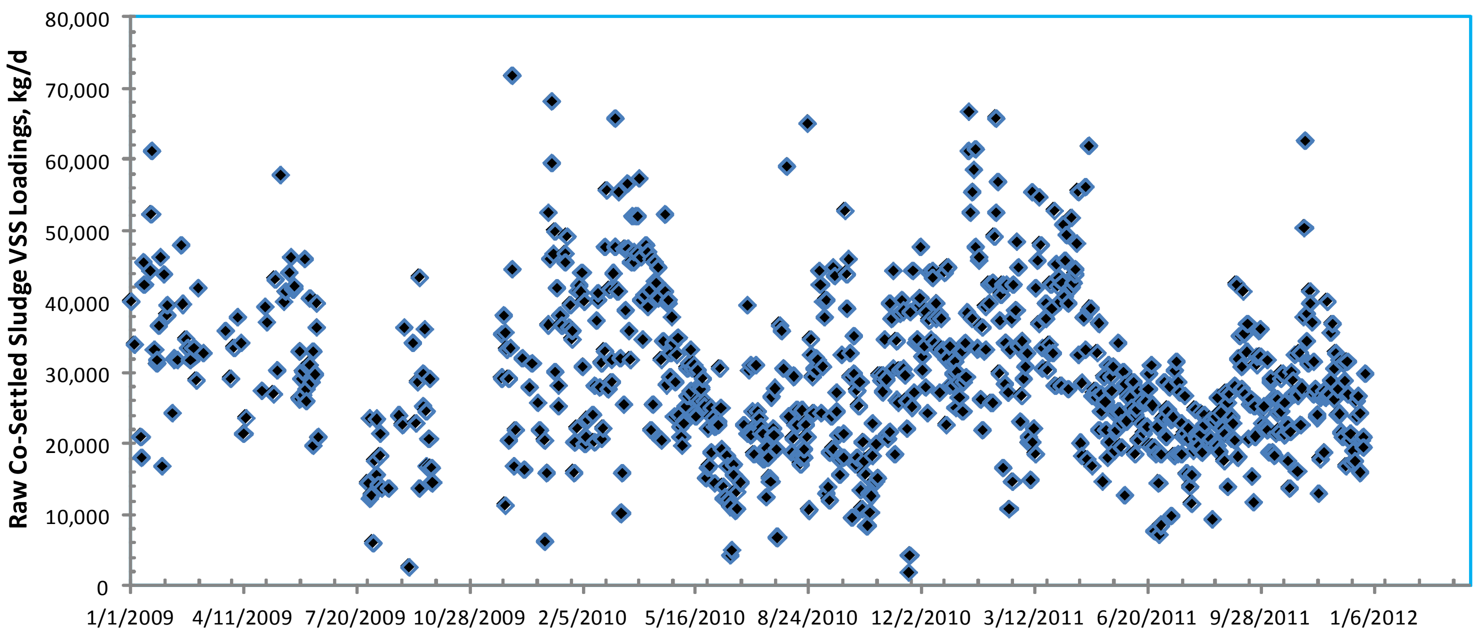


Figure 3.B

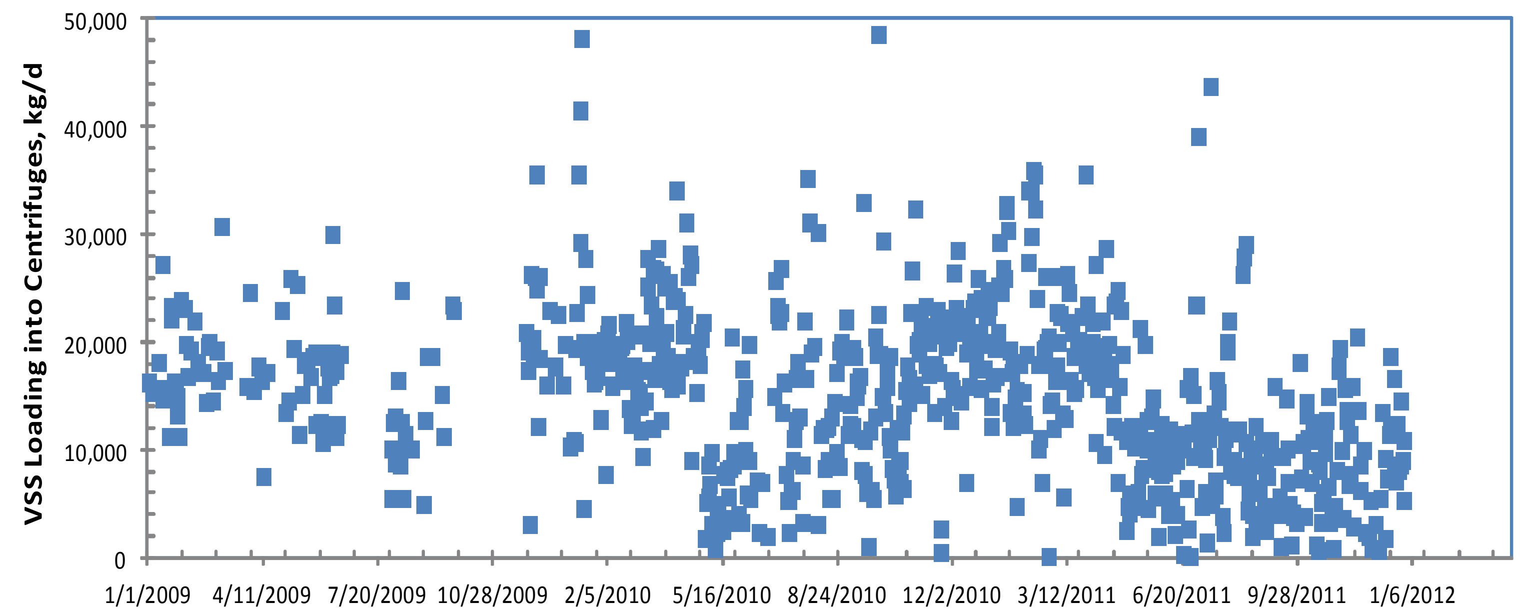


Figure 3.D

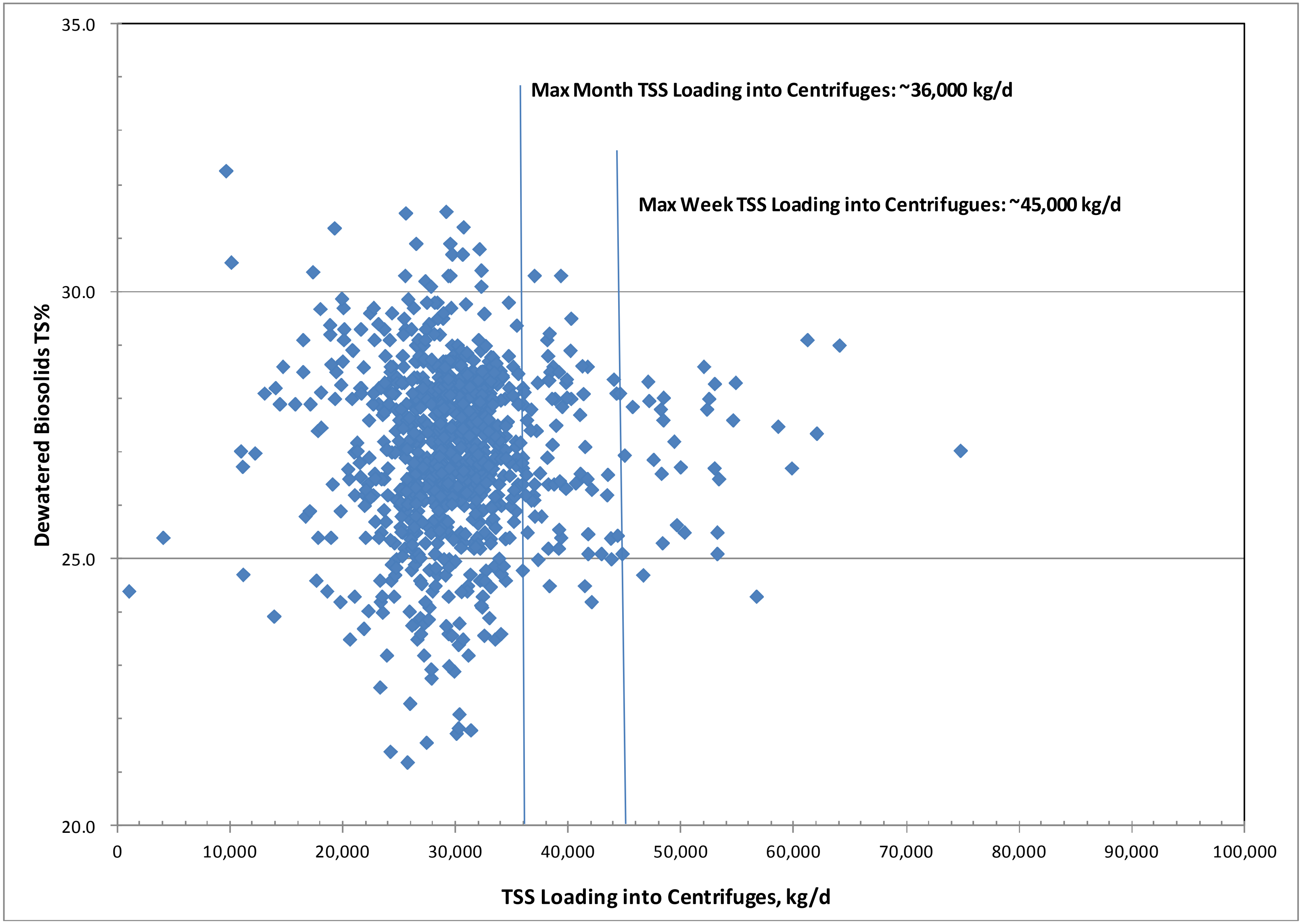


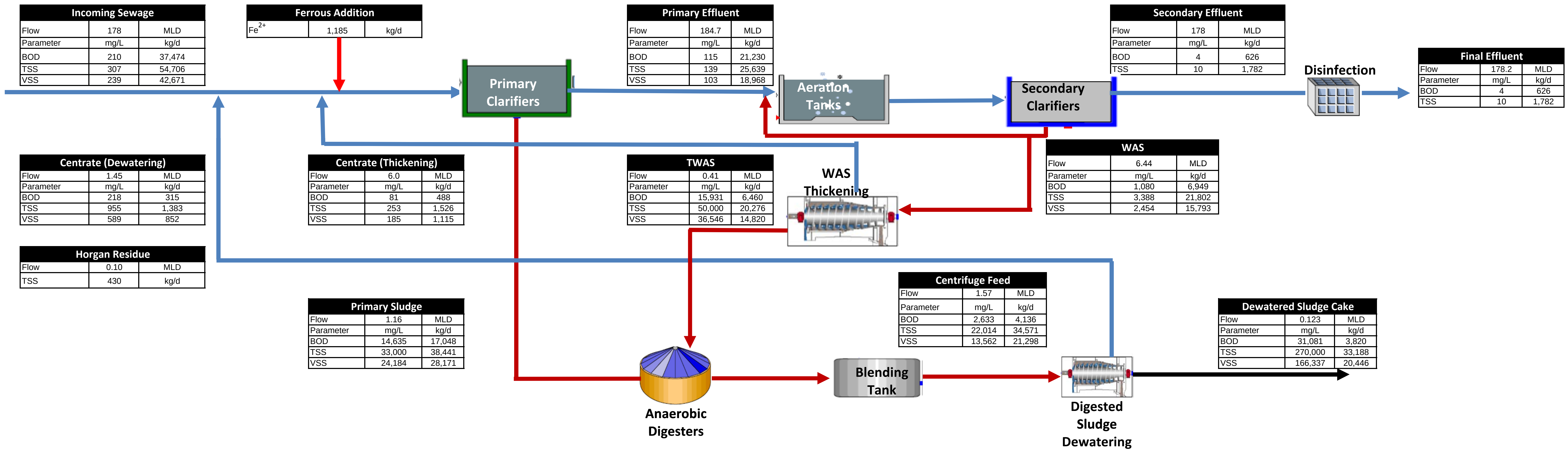
Figure 3.E: Centrifuge TSS loading vs. Dewatered Biosolids TS%

Appendix C
Mass Balance

Solids Balance for Projected 2032 Flows and Loads at the HCTP

Flowrate: 178 MLD

Loading: Average



Incoming Sewage

Flow	178	MLD
Parameter	mg/L	kg/d
BOD	210	37,474
TSS	307	54,706
VSS	239	42,671

Ferrous Addition

Fe^{2+}	1,185	kg/d

Primary Effluent

Flow	184.7	MLD
Parameter	mg/L	kg/d
BOD	115	21,230
TSS	139	25,639
VSS	103	18,968

Secondary Effluent

Flow	178	MLD
Parameter	mg/L	kg/d
BOD	4	626
TSS	10	1,782

Final Effluent

Flow	178.2	MLD
Parameter	mg/L	kg/d
BOD	4	626
TSS	10	1,782

Centrate (Dewatering)

Flow	1.45	MLD
Parameter	mg/L	kg/d
BOD	218	315
TSS	955	1,383
VSS	589	852

Centrate (Thickening)

Flow	6.0	MLD
Parameter	mg/L	kg/d
BOD	81	488
TSS	253	1,526
VSS	185	1,115

TWAS

Flow	0.41	MLD
Parameter	mg/L	kg/d
BOD	15,931	6,460
TSS	50,000	20,276
VSS	36,546	14,820

WAS

Flow	6.44	MLD
Parameter	mg/L	kg/d
BOD	1,080	6,949
TSS	3,388	21,802
VSS	2,454	15,793

Horgan Residue

Flow	0.10	MLD
TSS	430	kg/d

Centrifuge Feed

Flow	1.57	MLD
Parameter	mg/L	kg/d
BOD	2,633	4,136
TSS	22,014	34,571
VSS	13,562	21,298

Primary Sludge

Flow	1.16	MLD
Parameter	mg/L	kg/d
BOD	14,635	17,048
TSS	33,000	38,441
VSS	24,184	28,171

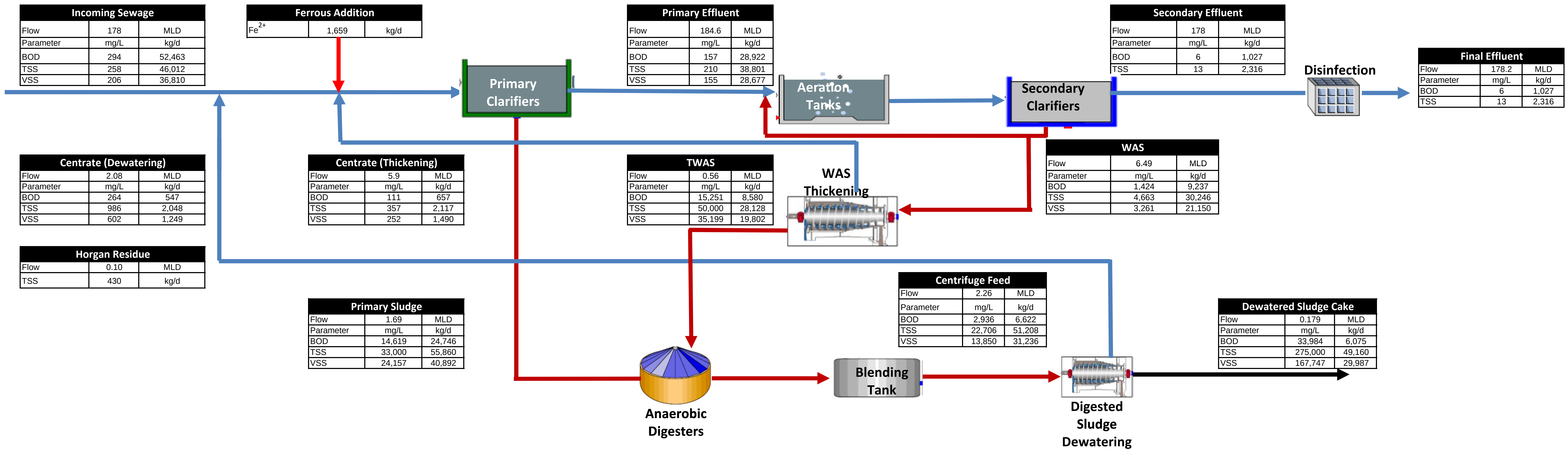
Dewatered Sludge Cake

Flow	0.123	MLD
Parameter	mg/L	kg/d
BOD	31,081	3,820
TSS	270,000	33,188
VSS	166,337	20,446

Solids Balance for Projected 2032 Flows and Loads at the HCTP

Flowrate: 178 MLD

Loading: Maximum Month



Incoming Sewage

Flow	178	MLD
Parameter	mg/L	kg/d
BOD	294	52,463
TSS	258	46,012
VSS	206	36,810

Ferrous Addition

Fe^{2+}	1,659	kg/d

Primary Effluent

Flow	184.6	MLD
Parameter	mg/L	kg/d
BOD	157	28,922
TSS	210	38,801
VSS	155	28,677

Secondary Effluent

Flow	178	MLD
Parameter	mg/L	kg/d
BOD	6	1,027
TSS	13	2,316

Final Effluent

Flow	178.2	MLD
Parameter	mg/L	kg/d
BOD	6	1,027
TSS	13	2,316

Centrate (Dewatering)

Flow	2.08	MLD
Parameter	mg/L	kg/d
BOD	264	547
TSS	986	2,048
VSS	602	1,249

Centrate (Thickening)

Flow	5.9	MLD
Parameter	mg/L	kg/d
BOD	111	657
TSS	357	2,117
VSS	252	1,490

TWAS

Flow	0.56	MLD
Parameter	mg/L	kg/d
BOD	15,251	8,580
TSS	50,000	28,128
VSS	35,199	19,802

WAS

Flow	6.49	MLD
Parameter	mg/L	kg/d
BOD	1,424	9,237
TSS	4,663	30,246
VSS	3,261	21,150

Horgan Residue

Flow	0.10	MLD
TSS	430	kg/d

Centrifuge Feed

Flow	2.26	MLD
Parameter	mg/L	kg/d
BOD	2,936	6,622
TSS	22,706	51,208
VSS	13,850	31,236

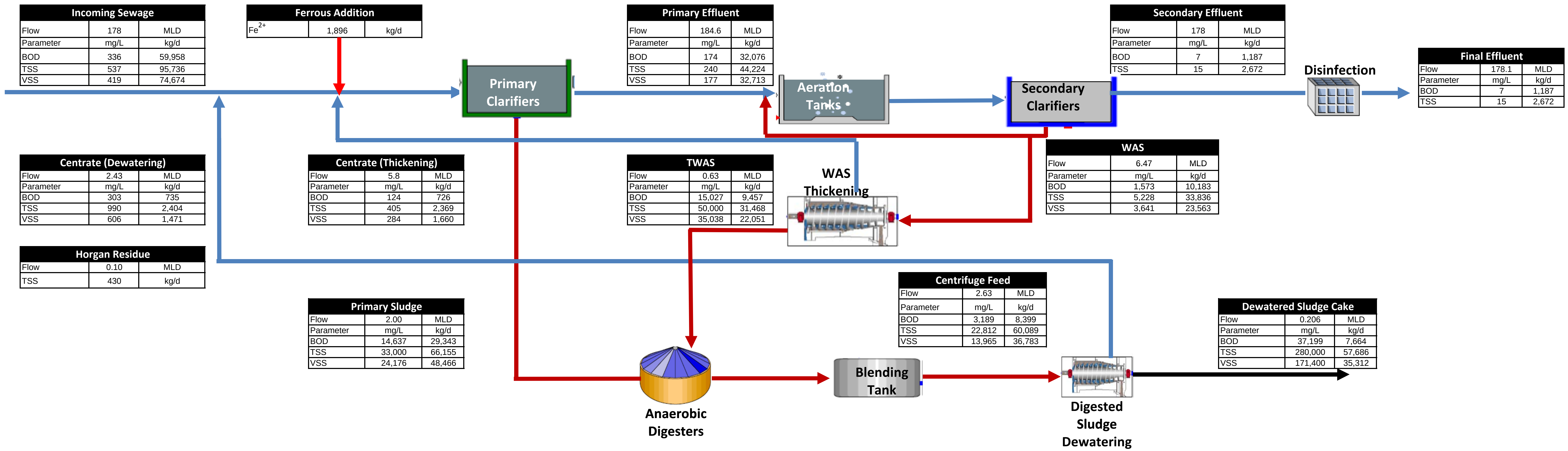
Primary Sludge

Flow	1.69	MLD
Parameter	mg/L	kg/d
BOD	14,619	24,746
TSS	33,000	55,860
VSS	24,157	40,892

Dewatered Sludge Cake

Flow	0.179	MLD
Parameter	mg/L	kg/d
BOD	33,984	6,075
TSS	275,000	49,160
VSS	167,747	29,987

Solids Balance for Projected 2032 Flows and Loads at the HCTP
Flowrate: 178 MLD
Loading: Maximum Week



Incoming Sewage		
Flow	178	MLD
Parameter	mg/L	kg/d
BOD	336	59,958
TSS	537	95,736
VSS	419	74,674

Ferrous Addition		
Fe^{2+}	1,896	kg/d

Primary Effluent		
Flow	184.6	MLD
Parameter	mg/L	kg/d
BOD	174	32,076
TSS	240	44,224
VSS	177	32,713

Secondary Effluent		
Flow	178	MLD
Parameter	mg/L	kg/d
BOD	7	1,187
TSS	15	2,672

Final Effluent		
Flow	178.1	MLD
Parameter	mg/L	kg/d
BOD	7	1,187
TSS	15	2,672

Centrate (Dewatering)		
Flow	2.43	MLD
Parameter	mg/L	kg/d
BOD	303	735
TSS	990	2,404
VSS	606	1,471

Centrate (Thickening)		
Flow	5.8	MLD
Parameter	mg/L	kg/d
BOD	124	726
TSS	405	2,369
VSS	284	1,660

TWAS		
Flow	0.63	MLD
Parameter	mg/L	kg/d
BOD	15,027	9,457
TSS	50,000	31,468
VSS	35,038	22,051

WAS		
Flow	6.47	MLD
Parameter	mg/L	kg/d
BOD	1,573	10,183
TSS	5,228	33,836
VSS	3,641	23,563

Horgan Residue		
Flow	0.10	MLD
TSS	430	kg/d

Primary Sludge		
Flow	2.00	MLD
Parameter	mg/L	kg/d
BOD	14,637	29,343
TSS	33,000	66,155
VSS	24,176	48,466

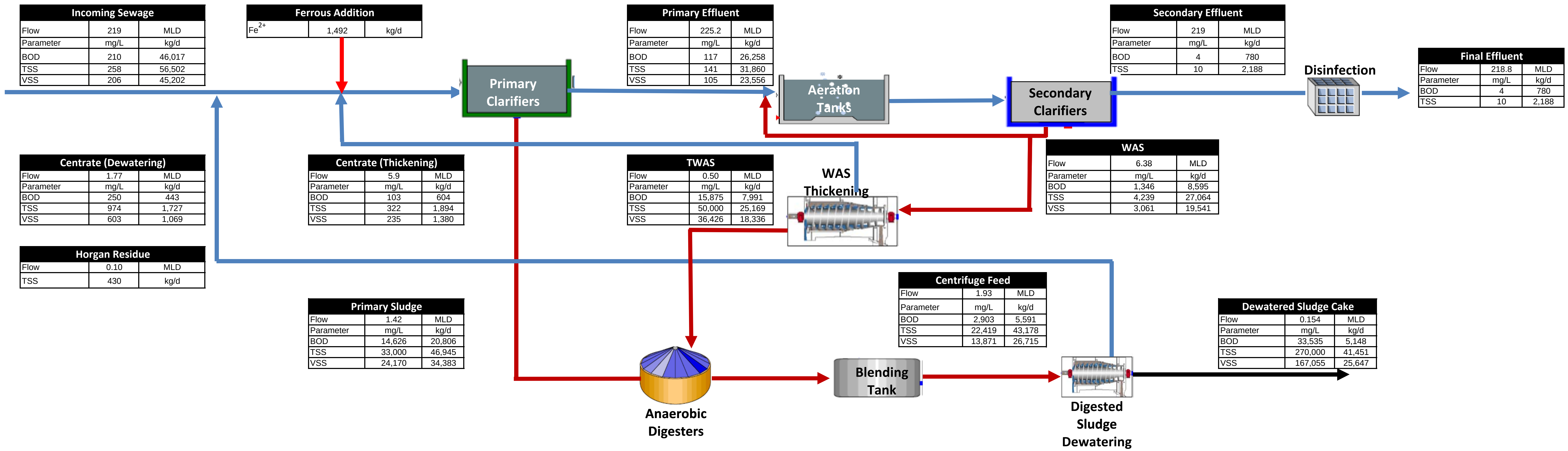
Centrifuge Feed		
Flow	2.63	MLD
Parameter	mg/L	kg/d
BOD	3,189	8,399
TSS	22,812	60,089
VSS	13,965	36,783

Dewatered Sludge Cake		
Flow	0.206	MLD
Parameter	mg/L	kg/d
BOD	37,199	7,664
TSS	280,000	57,686
VSS	171,400	35,312

Solids Balance for Rated Capacity (219 MLD) at the HCTP

Flowrate: 219 MLD

Loading: Annual Average



Incoming Sewage

Flow	219	MLD
Parameter	mg/L	kg/d
BOD	210	46,017
TSS	258	56,502
VSS	206	45,202

Ferrous Addition

Fe^{2+}	1,492	kg/d

Primary Effluent

Flow	225.2	MLD
Parameter	mg/L	kg/d
BOD	117	26,258
TSS	141	31,860
VSS	105	23,556

Secondary Effluent

Flow	219	MLD
Parameter	mg/L	kg/d
BOD	4	780
TSS	10	2,188

Final Effluent

Flow	218.8	MLD
Parameter	mg/L	kg/d
BOD	4	780
TSS	10	2,188

WAS

Flow	6.38	MLD
Parameter	mg/L	kg/d
BOD	1,346	8,595
TSS	4,239	27,064
VSS	3,061	19,541

Centrate (Dewatering)

Flow	1.77	MLD
Parameter	mg/L	kg/d
BOD	250	443
TSS	974	1,727
VSS	603	1,069

Centrate (Thickening)

Flow	5.9	MLD
Parameter	mg/L	kg/d
BOD	103	604
TSS	322	1,894
VSS	235	1,380

TWAS

Flow	0.50	MLD
Parameter	mg/L	kg/d
BOD	15,875	7,991
TSS	50,000	25,169
VSS	36,426	18,336

Horgan Residue

Flow	0.10	MLD
TSS	430	kg/d

Primary Sludge

Flow	1.42	MLD
Parameter	mg/L	kg/d
BOD	14,626	20,806
TSS	33,000	46,945
VSS	24,170	34,383

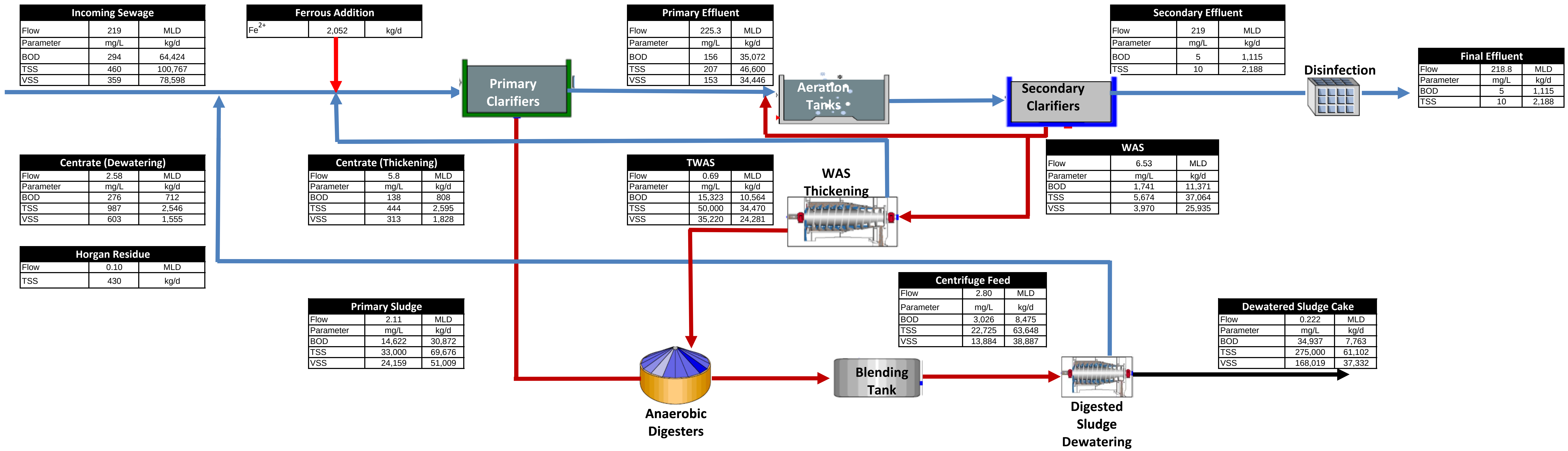
Centrifuge Feed

Flow	1.93	MLD
Parameter	mg/L	kg/d
BOD	2,903	5,591
TSS	22,419	43,178
VSS	13,871	26,715

Dewatered Sludge Cake

Flow	0.154	MLD
Parameter	mg/L	kg/d
BOD	33,535	5,148
TSS	270,000	41,451
VSS	167,055	25,647

Solids Balance for Rated Capacity (219 MLD) at the HCTP
Flowrate: 219 MLD
Loading: Maximum Month



Incoming Sewage		
Flow	219	MLD
Parameter	mg/L	kg/d
BOD	294	64,424
TSS	460	100,767
VSS	359	78,598

Ferrous Addition		
Fe^{2+}	2,052	kg/d

Primary Effluent		
Flow	225.3	MLD
Parameter	mg/L	kg/d
BOD	156	35,072
TSS	207	46,600
VSS	153	34,446

Secondary Effluent		
Flow	219	MLD
Parameter	mg/L	kg/d
BOD	5	1,115
TSS	10	2,188

Final Effluent		
Flow	218.8	MLD
Parameter	mg/L	kg/d
BOD	5	1,115
TSS	10	2,188

Centrate (Dewatering)		
Flow	2.58	MLD
Parameter	mg/L	kg/d
BOD	276	712
TSS	987	2,546
VSS	603	1,555

Centrate (Thickening)		
Flow	5.8	MLD
Parameter	mg/L	kg/d
BOD	138	808
TSS	444	2,595
VSS	313	1,828

TWAS		
Flow	0.69	MLD
Parameter	mg/L	kg/d
BOD	15,323	10,564
TSS	50,000	34,470
VSS	35,220	24,281

WAS		
Flow	6.53	MLD
Parameter	mg/L	kg/d
BOD	1,741	11,371
TSS	5,674	37,064
VSS	3,970	25,935

Horgan Residue		
Flow	0.10	MLD
TSS	430	kg/d

Centrifuge Feed		
Flow	2.80	MLD
Parameter	mg/L	kg/d
BOD	3,026	8,475
TSS	22,725	63,648
VSS	13,884	38,887

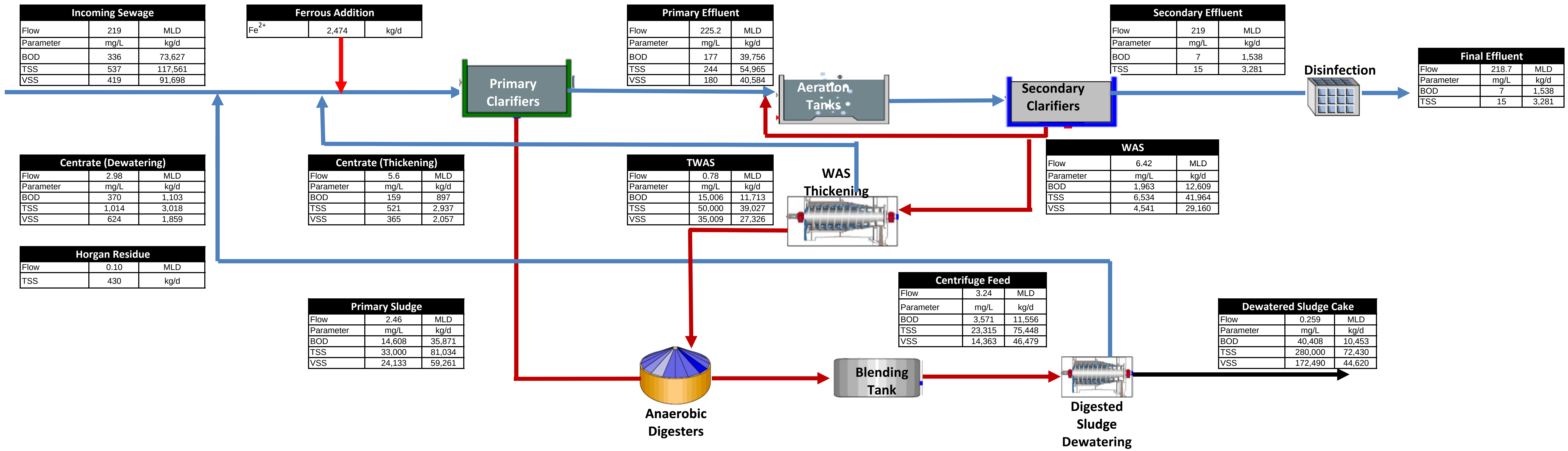
Primary Sludge		
Flow	2.11	MLD
Parameter	mg/L	kg/d
BOD	14,622	30,872
TSS	33,000	69,676
VSS	24,159	51,009

Dewatered Sludge Cake		
Flow	0.222	MLD
Parameter	mg/L	kg/d
BOD	34,937	7,763
TSS	275,000	61,102
VSS	168,019	37,332

Solids Balance for Rated Capacity (219 MLD) at the HCTP

Flowrate: 219 MLD

Loading: Maximum Week



Incoming Sewage		
Flow	219	MLD
Parameter	mg/L	kg/d
BOD	336	73,627
TSS	537	117,561
VSS	419	91,698

Ferrous Addition		
Fe^{2+}	2,474	kg/d

Primary Effluent		
Flow	225.2	MLD
Parameter	mg/L	kg/d
BOD	177	39,756
TSS	244	54,965
VSS	180	40,584

Secondary Effluent		
Flow	219	MLD
Parameter	mg/L	kg/d
BOD	7	1,538
TSS	15	3,281

Final Effluent		
Flow	218.7	MLD
Parameter	mg/L	kg/d
BOD	7	1,538
TSS	15	3,281

Centrate (Dewatering)		
Flow	2.98	MLD
Parameter	mg/L	kg/d
BOD	370	1,103
TSS	1,014	3,018
VSS	624	1,859

Centrate (Thickening)		
Flow	5.6	MLD
Parameter	mg/L	kg/d
BOD	159	897
TSS	521	2,937
VSS	365	2,057

TWAS		
Flow	0.78	MLD
Parameter	mg/L	kg/d
BOD	15,006	11,713
TSS	50,000	39,027
VSS	35,009	27,326

WAS		
Flow	6.42	MLD
Parameter	mg/L	kg/d
BOD	1,963	12,609
TSS	6,534	41,964
VSS	4,541	29,160

Horgan Residue		
Flow	0.10	MLD
TSS	430	kg/d

Centrifuge Feed		
Flow	3.24	MLD
Parameter	mg/L	kg/d
BOD	3,571	11,556
TSS	23,315	75,448
VSS	14,363	46,479

Primary Sludge		
Flow	2.46	MLD
Parameter	mg/L	kg/d
BOD	14,608	35,871
TSS	33,000	81,034
VSS	24,133	59,261

Dewatered Sludge Cake		
Flow	0.259	MLD
Parameter	mg/L	kg/d
BOD	40,408	10,453
TSS	280,000	72,430
VSS	172,490	44,620