DISCUSSION PAPER

Capital Regional District
Core Area Wastewater Management Program

Macaulay/McLoughlin Point Wastewater Treatment Plant

Discussion Paper – Solids Process Alternatives Evaluation
034-DP-2

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Issued:	September 26, 2008
Previous Issue:	None

1 Objective

The Core Area Wastewater Management Program consists of four key elements: source control, distributed wastewater treatment, water reuse and resource recovery, and wet weather flow management. Distributed wastewater treatment will include a Macaulay/McLoughlin secondary wastewater treatment plant, two or more decentralized water reclamation plants within the wastewater collection system, and a wet weather flow management strategy that will see surplus wet weather flows managed on a more local basis. The objective of this discussion paper is to evaluate solids process alternatives for the Macaulay/McLoughlin wastewater treatment plant and develop a conceptual solids footprint requirement.

2 Design Flows and Loads

The maximum month design plant flow and corresponding loads for the Year 2065, in addition to the primary and secondary sludge from the distributed WWTPs and Clover Point, were used to size and evaluate the alternative solids treatment unit processes. These flows and loads were previously described in *Discussion Paper No. 1, Macaulay/McLoughlin Point WWTP Conceptual Planning, Liquid Process Alternatives Evaluation*. Table 2-1 shows the solids design flows and loads for the representative liquid process option carried forward: Lamella primary clarifiers with membrane bioreactors (MBR). As in the case of the liquid process alternatives evaluation, it was assumed that the solids loading from the Clover Point wet weather treatment facility, estimated to add an equivalent TSS concentration between 90 and 150 mg/L to the raw wastewater for the duration of the wet weather events for a ballasted flocculation process, would be intermittent and would not affect the solids process unit process sizing at the Macaulay/McLoughlin WWTP.

Table 2-1
Maximum Month Solids Design Flows and Loads

Parameter	Value
Primary sludge, m^3/d	2,400
Primary sludge concentration, mg/L	8,700
Secondary sludge, m^3/d	2,730
Secondary sludge concentration, mg/L	8,000

3 Description of Alternatives

Two solids processing alternatives were developed for the Macaulay/McLoughlin Point WWTP: Thickening, anaerobic digestion with biogas production, co-generation, and dewatering; and thickening, dewatering, and thermal oxidation with energy recovery. This section reviews the processes for these two treatment alternatives.

The alternatives described below are consistent with the short-listed biosolids management /organic organic residuals energy and resource recovery strategies presented in Discussion Paper 031-DP-4. Alternative 1 below aligns with the Maximum Beneficial Reuse strategy and the Separate Digestion and Balanced Energy Recovery / Beneficial Reuse strategy, with Alternative 2 aligning with the No Digestion and Balanced Energy Recovery / Beneficial Reuse strategy presented in 031-DP-4.

3.1 Alternative 1 - Anaerobic Digestion with Biogas Production

This alternative would blend primary sludge from the lamella primary clarifiers and secondary sludge from the secondary treatment process in a sludge blend tank prior to thickening on gravity belt thickeners (GBTs). Gravity belt thickening is a solids-liquid separation process that uses a moving fabric-mesh belt to drain free water from the sludge. As the material travels the length of the belt, plows mix and turn the sludge to enhance drainage characteristics. Polymer addition is required to achieve the desired coagulation and flocculation of solids. Typical final solids concentrations of co-thickened sludge are between 4 and 6 percent.

Following gravity belt thickening, the thickened sludge would be pumped to the anaerobic digesters. The purpose of anaerobic digestion is to reduce pathogens, reduce biomass quantity by partial destruction of volatile solids, and produce usable biogas, in the form of methane, as a byproduct. Stabilization by anaerobic digestion is measured by the amount of volatile solids destruction that occurs through the digester, with typical volatile solids destruction being between 40 to 65 percent. Anaerobic digesters must be sized to provide sufficient retention time to allow volatile solids destruction to occur (Water Environment Federation, 2003). In addition to retention time, temperature and pH are important in determining the rate of digestion and the rate of methane formation. Both temperature and pH need to be maintained at a stable operating level to avoid process upsets. For this alternative, the digesters would be operated in the thermophillic temperature range, at approximately 55 degrees Celsius. Mixing, heating, and feed-systems are necessary to minimize the potential for process upsets. The biogas generated would either be used on site to generate heat and power for in-facility use, or would be upgraded to biomethane and used off-site as an energy source.

After digestion, the solids would be dewatered to approximately 25 percent using centrifuges. Centrifuges revolve at high speeds and impart centrifugal forces of about 3,000 G to the sludge. The equipment consists of a cylindrical “bowl” that terminates at one end with a concentric weir and at the other end with a tapered section that acts as a “beach”. A screw conveyor rotates at a slightly slower speed than the bowl. The scroll collects and conveys dewatered solids to the beach, where they are discharged. The biosolids product would be hauled away for ultimate reuse or disposal. For this alternative, biosolids could either be transported offsite by truck or loaded onto barges and shipped to their final destination. The preferred transportation method will be dependant on the truck and barge accessibility at the Macaulay/McLoughlin WWTP and biosolids reuse or disposal sites.

3.2 Alternative 2 - Thermal Oxidation with Energy Recovery

Alternative 2 would also blend sludge from the primary and secondary treatment processes in a sludge blend tank. Polymer would be added to the mixture and the sludge then thickened on a gravity belt thickener. After thickening, the sludge would be dewatered by centrifuges to approximately 27 percent solids concentration.

Following the centrifuges, the dewatered sludge would be pumped to a fluidized bed incinerator (FBI). Thermal oxidation uses high temperatures and pressures to break and oxidize cellular material, releasing bound water. It oxidizes all the organic compounds in the wastewater and release large amounts of energy as heat. This heat can be used to sustain the thermal oxidation process. With sufficient dewatering, thermal oxidation is generally self-sustaining, or autogenous, and can produce a significant amount of usable heat or energy. The FBI process reduces the volume of solids to an inert residue ash consisting of about 5 to 15 percent of the original volume, and it eliminates some potential environmental problems by destroying pathogens and degrading many toxic organic chemicals. Metals are not degraded but are concentrated in the ash and in particulate matter entrained in the exhaust gases generated by the process. Pollution control devices are needed to prevent degradation of air quality. The ash would be transported offsite by truck to the final disposal site, possibly the Hartland Landfill.

The advantages and disadvantages of each unit process in the above two alternatives are summarized in Table 3-1.

Table 3-1
Solids Process Advantages and Disadvantages

Process	Advantages	Disadvantages
Gravity Belt Thickening	• Low energy demands • Low equipment costs • High thickened sludge solids concentrations • Consistent thickened solids concentration achievable with appropriate operator attention • Machine are quiet	• Operator must control many variables to optimize sludge thickening • High operator attention • Requires polymer to achieve reasonable solids capture and thickened sludge concentrations • Requires periodic cleaning • High odour potential • Requires large amounts of belt washwater
Centrifuge Dewatering	• Achieves high solids cake concentration • Small footprint requirements • Provides sludge containment • Highly reliable process • Flexible process	• High capital costs • High power consumption • Machines spin at high rpms, therefore there are on-going maintenance requirements • Machines are noisy • Requires substantial overhead space for centrifuge disassembly
Anaerobic Digestion	• Valuable end-product, methane, that is combustible and can be used to produce heat for the digestion process and other uses • Relatively low operating costs • Biosolids suitable for application on land as a soil conditioner • Mass of solids reduced • Commonly used and well understood process	• Methane-producing bacteria are slow growing and prone to process upset • Digesters have high capital costs • Relatively complex operation • Potential risk if methane gas leaks • Gas cleaning required
Thermal Oxidation	• Maximum solids reduction • Energy recovery • Pathogens eliminated • Stable, odorless ash • Easily dewaterable ash	• High capital costs • High O& M costs • High maintenance requirements • Ash may be hazardous due to metal leachability • Air pollution control required • Potential negative public perception

4 Alternative Design Development

Unit process sizing, design criteria, and a process flow diagram were developed for each of the two solids processing alternatives. Process modelling using CH2M HILL's Pro2D version 9.03 was performed to calculate the anticipated sludge production from each liquid treatment alternative. Pro2D is a steady state simulator that has been developed by CH2M HILL to perform wastewater treatment plant simulations and calculate full-plant mass balances. The modelled sludge production values were used to develop process unit sizes.

4.1 Alternative 1 – Anaerobic Digestion with Biogas Production

Figure 4-1 shows the solids process flow diagrams for this alternative assuming MBR secondary treatment. Table 4-1 provides the conceptual design criteria and process unit sizes for this representative treatment alternative. The digesters have been sized to provide 15 days of hydraulic retention time at the 2065 design flows and loads with one unit out of service. This will provide 100 percent standby for the entire life of the project.

Table 4-1
Alternative 1 – Anaerobic Digestion with Biogas Production

Process	Parameter	Value
Sludge Blend Tank	HRT, h	2
	No. of Units	2
	Volume, m^3	215
	Diameter, m	6
	Side Water Depth, m	7.6
Gravity Belt Thickeners	Solids Loading Rate, kg/m/h	300
	No. of Units	3+1
	Belt width, m	3
Dewatering Feed Tank	No. Units	2
	Diameter, m	6
	Side Water Depth, m	8
Anaerobic Digesters	No. Units	2
	HRT (1 unit off line)	15
	Volume per unit, m^3	12,500
	Diameter, m	25
	Side Water Depth, m	24
Centrifuges	Hydraulic Loading Rate, m^3/d	40
	No. Units	1+1

4.2 Alternative 2 – Thermal Oxidation with Energy Recovery

Figure 4-2 shows the solids process flow diagrams for the thermal oxidation alternative with MBR secondary treatment. Table 4-2 provides the conceptual design criteria, process unit sizes and energy diagrams for this representative treatment alternative. The FBI has been sized so that each of the lines the capacity for 75 percent of the projected 2065 flows and loads. This will provide 100 percent standby in the early years of the project for times when one of the lines is taken out of service with routine maintenance (3-4 weeks per year). In later years of the project, when sludge quantities exceed 75 percent of the design values, the excess sludge will have to be stabilized at the Central Saanich WWTP lime stabilization facility to provide system redundancy.

Table 4.2
Alternative 2 – Thermal Oxidation with Energy Recovery

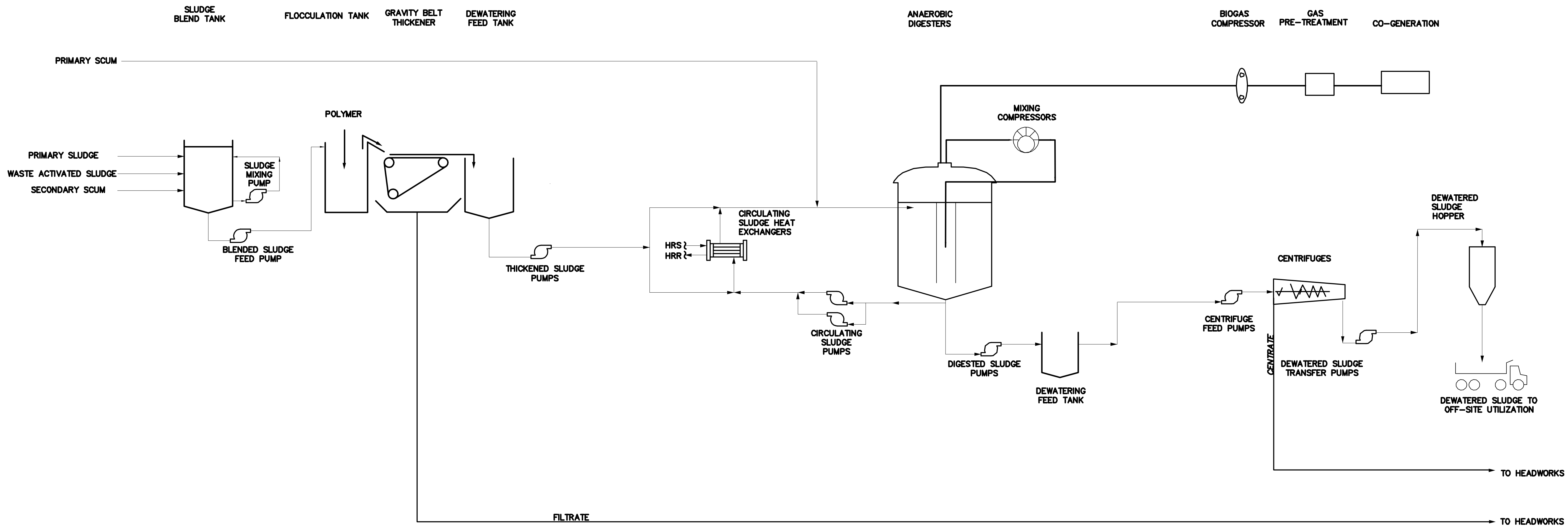
Process	Parameter	Value
Sludge Blend Tank	HRT, h	2
	No. of Units	2
	Volume, m^3	215
	Diameter, m	6
	Side Water Depth, m	7.6
Gravity Belt Thickeners	Solids Loading Rate, kg/ m h	300
	No. of Units	3+1
	Belt width, m	3
Dewatering Feed Tank	No. of Units	2
	Diameter, m	6
	Side Water Depth, m	8
Centrifuges	Hydraulic Loading Rate, m^3/d	40
	No. of Units	1+1
Fluidize Bed Incinerator	Primary Sludge Dry Solids, kg/d	19,000
	Secondary Sludge Dry Solids, kg/d	23,300
	No. of Lines	2
	Operation capture, %	75
	Diameter, m	6.4
Waste Heat Boiler	No. of Units	2
	Diameter, m	2.2

5 Summary

The representative solids processing alternative that will be used to develop a preliminary plant layout for the Macaulay/McLoughlin Point WWTP is thickening, anaerobic digestion with biogas production, co-generation, and dewatering. A solids layout assuming anaerobic digestion is more conservative in determining land requirements and does not preclude thermal oxidation from being selected in the future since the footprint for thermal oxidation is smaller. This provides a robust alternative for the plant siting analysis.

References

Water Environment Federation. 2003. Wastewater Treatment Plant Design. Water Environment Federation.



DESIGN FLOWS

ADWF: 110 ML/d
MMF: 125 ML/d
PWWF: 364 ML/d
STC: 220 ML/d

DESIGN LOADS

PRIMARY SLUDGE:
MMF 2,400 m^3/d @ 8,700 mg/l
SECONDARY SLUDGE:
MMF 2,730 m^3/d @ 8,000 mg/l

ABBREVIATIONS

HRR: HEAT RELEASE RATE
ADWF: AVERAGE DRY WEATHER FLOW
MMWF: MAX MONTH WEATHER FLOW
PWWF: PEAK WET WEATHER FLOW
STC: SECONDARY TREATMENT CAPACITY

SLUDGE BLENDING TANKS

- 2 TANKS
- 215 m^3
- 6 m DIA.
- 7.6 m SWD
- PUMPED MIXING

GRAVITY BELT THICKENERS

- 4 UNITS (3 DUTY/ 1 STANDBY)
- 3 m BELT WIDE
- 300 kg/ m h

DEWATERING FEED TANK

- 2 TANK
- 175 m^3
- 6 m DIA.
- 8 m SWD

ANAEROBIC DIGESTERS

- 2 UNITS (1 DUTY/ 1 STANDBY)
- MESOPHILLIC
- 25 m DIAMETER
- 24 m SWD

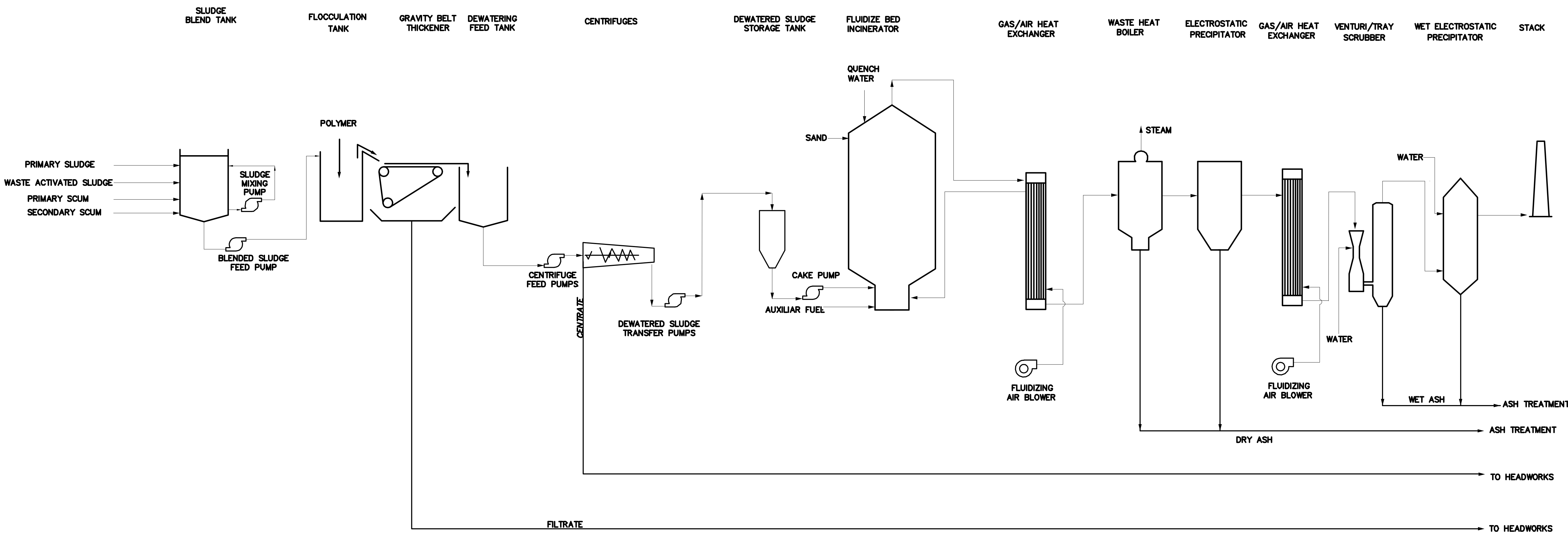
CENTRIFUGES

- 2 UNITS (1 DUTY/ 1 STANDBY)
- 40 m^3/h

FIGURE 4-1
MCLAUGHLIN POINT
SOLIDS PROCESS FLOW DIAGRAM
ANAREOBIC DIGESTION W/ BIOGAS PRODUCTION
LAMELLA-MBR

CH2MHILL

9/12/08



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- 6 M DIA.
- 8 M SWD

CENTRIFUGES

- 2 UNITS (1 DUTY/ 1 STANDBY)
- 40 m^3/h

FLUIDIZE BED INCINERATOR

- 2 LINES
- 75% OPERATION CAPTURE
- 6.4 m DIA

WASTE HEAT BOILER

- 2 UNITS
- 2.2 M DIA

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FIGURE 4-2
MCLAUGHLIN POINT
SOLIDS PROCESS FLOW DIAGRAM
THERMAL OXIDATION
W/ ENERGY RECOVERY
LAMELLA-MBR

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