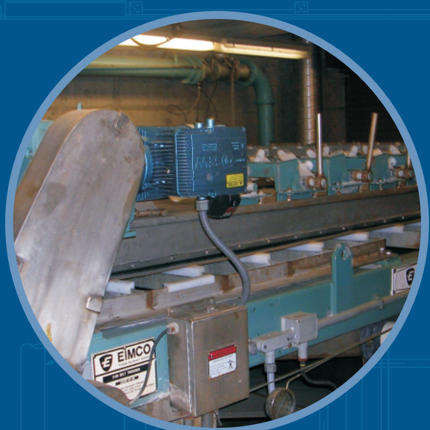
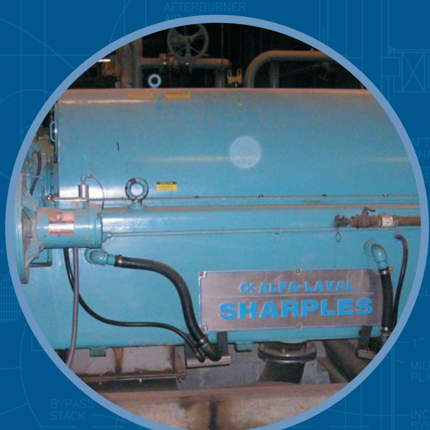
November 2010





City of Bellingham
Biosolids Plan

CDM

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November 29, 2010

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EXPIRES 3/26/2012

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Section 1 Introduction

To support the sustainable practices currently in place and those planned for the future, the City of Bellingham seeks a long term solution for the processing of their biosolids. With aging infrastructure, projected population growth, the increasing cost of energy, and new technologies available for biosolids processing, the City has recognized the need to evaluate its current biosolids handling system.

The City currently processes its biosolids at the Post Point Wastewater Treatment Plant (Post Point Plant) using two Multiple Hearth Furnaces (MHFs). This approach of sludge incineration has proven to be a reliable technology for the City of Bellingham over the years. However, the age of the existing equipment allows Bellingham an opportunity to examine other methods for processing the City's wastewater biosolids. It also provides the City with the opportunity to examine the potential of capturing heat and power from its biosolids handling system and transform the Post Point Plant into a waste to energy facility.

This plan compares the various biosolids alternatives available to the City while considering potential opportunities for renewable energy generation. For capital improvement planning purposes this evaluation assesses the condition of the existing biosolids handling equipment and the capacity constraints of the system into a 25 year time frame, effectively creating a planning period from 2010 to 2035. The comparison, based on economic, environmental, operational, and social objectives, will ultimately help the City of Bellingham gain insight into selecting a biosolids and energy path forward, a timeline for implementation of the selected approach, and a recommended action plan.

1.1 Categories and Evaluation Criteria

To establish a basis for comparison, the biosolids and energy alternatives will be evaluated against four overall objectives. The selected alternative should be:

- **Financial:** Capital, annual, and life cycle costs will be determined for each biosolids and energy alternative. To help the City plan for the biosolids and energy improvements, implementation timeframes will be developed to allow the City to better understand the budgetary and logistical impacts of the recommendations

- **Environmental:** Maintaining and increasing its sustainability is important to the City of Bellingham. Thus, each option will be evaluated based on its environmental impacts, which includes ease in which permits will be obtained, green energy production and utilization, energy demand for biosolids processing, and greenhouse gas emissions

- **Technical:** The handling, operations, and maintenance requirements for each alternative will be evaluated based on criteria outlined by the City. Considering the City's criteria for reliability, flexibility and redundancy will help select an alternative that meets the City's expectations with regards to operational ease and staffing requirements

- **Social:** Upgrades at wastewater treatment plants need to be conducted in a manner to maintain the way of life for the residents and the City wants to maintain it's good neighbor status in the surrounding community. Before proceeding with an implementation strategy, the evaluation will consider social criteria such as aesthetics, acoustics, and the potential for fugitive odor emissions

Section 2
Biosolids Production Projections

Projections of biosolids generation and loading rates at wastewater treatment plants are used to define the process conditions for biosolids handling systems. Specifically, biosolids projections are used to quantify the type of solids that will need to be processed, as well as the rate at which they must be processed. Without projections that are supported by a reasonable level of confidence, it is not possible to accurately evaluate, size, design, and phase upgrades to an existing biosolids handling system.

Biosolids projections for the Post Point Plant have been developed through the year 2035 for the different loading conditions as defined in **Table 2-1**.

Table 2-1. Different Loading Conditions

Acronym	Definition	Use and Notes
AA	Annual Average, the average daily solids generation rate over the course of a year	Used for annual operation and maintenance cost estimates
MM	Maximum Month, the 30 day period with the highest rolling average of solids generation over the course of a year	Used as a reference condition and for evaluation of operations and maintenance concerns
PW	Peak Week, the 7 day period with the highest rolling average of solids generation over the course of a year	Used for sizing some process equipment, such as a sludge incinerator
P3D	Peak 3 Day, the 3 day period with the highest rolling average of solids generation over the course of a year	Used for sizing some process equipment and storage points
PD	Peak Day, the day with the highest solids generation over the course of a year	Used for sizing some process equipment and storage points

The annual average condition is considered the baseline biosolids load and was used to estimate the peak loading conditions at the Post Point Plant. Carollo Engineers estimated the annual average load as part of their work on the liquid side of treatment. A model simulation of the Post Point Plant was performed to estimate the biosolids loads from 2007 to 2036. The simulation used historical loading (flow, TSS, BOD, etc.) and performance data (clarifier efficiency, wasting rates, growth yield, etc.) to estimate a normalized annual average and maximum month solids load for the year 2007. The sewered population projection as reported in the Sewer Master Plan was used to run a model simulation for the 2036 design condition and to estimate the annual average and maximum month load for that year. For the interim years from 2010 through 2035, a linear increase in biosolids loads was assumed.

With the annual average and maximum month biosolids load quantified, a peaking factor approach was employed to estimate the peak week, peak 3 day and peak day biosolids loading conditions that could be expected at the Post Point Plant. A peaking factor approach uses the historical ratio of the annual average load to the peak load to estimate the magnitude of future peaks. Historical peaking factors developed from the Post Point Plant's historical flow records are presented in **Table 2-2**.

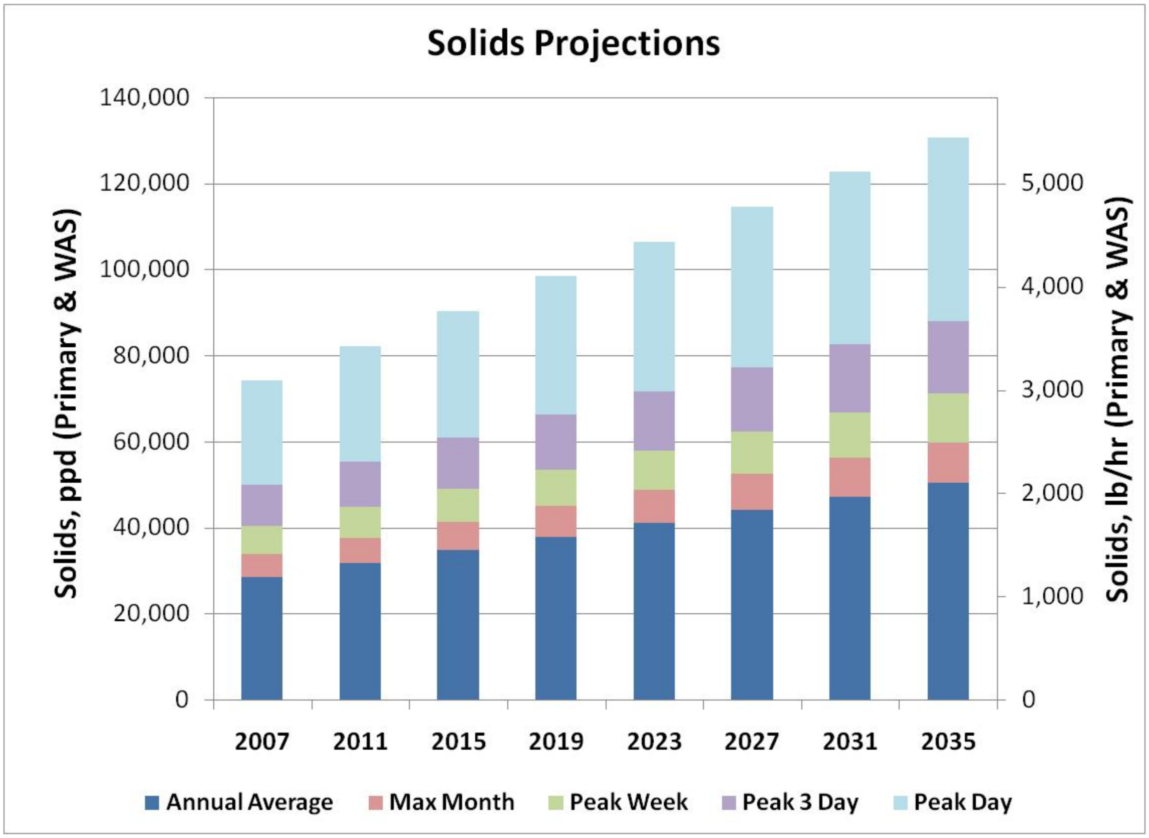
Table 2-2. Historical Peaking Factors

Load Parameter	1999	2000[1]	2001	2002	2003	2004[2]	2005	2006	2007	2008	Design (Avg.)
PW/AA	1.50	3.76	1.31	1.38	1.30	4.83	1.33	1.49	1.68	1.28	1.41
P3D/AA	2.07	4.60	1.86	1.79	1.51	5.95	1.74	1.65	1.88	1.46	1.74
PD/AA	3.40	6.10	3.00	2.28	2.03	8.68	2.96	2.63	2.91	2.09	2.66

[1, 2] Data from 2000 and 2004 were omitted in the design peaking factors. A metering error is suspected due to the extremely high values in the raw data.

With the annual average and peaking factors quantified, biosolids projections through the year 2035 were developed. A graphical representation of the anticipated biosolids in four year increments is shown in **Figure 2-1**.

Figure 2-1. Biosolids Projections at the Post Point Plant



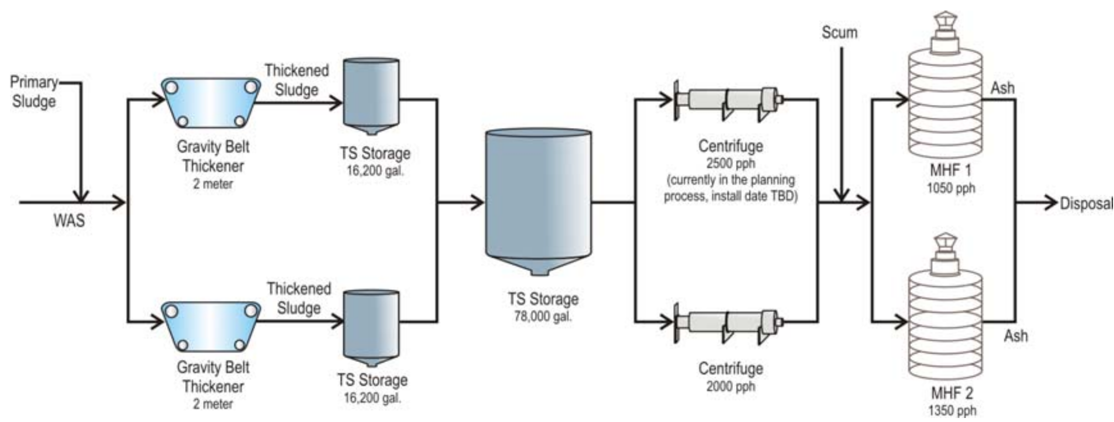
The left y-axis shows the biosolids projections in pounds per day (ppd) and the right y-axis shows the projections in pounds per hour (pph). The colored bands of each bar represent the different peaking conditions for that design year.

Section 3
Existing Biosolids Facilities

3.1 Background

The Post Point Plant uses a combination of technologies and equipment to handle, process, and dispose of its wastewater biosolids, see **Figure 3-1**. Primary and secondary solids are pumped from their respective unit processes into a common pipe and co-thickened on two gravity belt thickeners (GBTs). Thickened solids drop through a chute to two collection tanks located directly below and are then pumped to a large thickened sludge storage tank. The thickened sludge storage tank allows the Post Point Plant staff to operate downstream biosolids handling processes (solids dewatering and incineration) in shifts and on a five days per week operation schedule. Between shifts and during the weekends, thickened sludge is allowed to accumulate in the thickened sludge storage tank. When operating, the solids dewatering system is fed biosolids from the thickened sludge tank. Dewatered solids are pumped directly from the dewatering equipment to the incinerator.

Figure 3-1. Simplified Process Schematic, Existing Operations



The heart of the Post Point Plant's biosolids handling process are the sludge incinerators. The Post Point Plant has two multiple hearth furnace incinerators (MHFs). Both units have 7 hearths and an outside diameter of 14 ft - 3 inches. Presently, only one incinerator is operated at a time and both are operating fairly reliably.

The air permit for the incinerators requires that both units achieve 5 percent opacity on their stack emissions. This requirement essentially means that there can be no visible emissions from the incinerator stacks. To ensure compliance with the opacity requirement, the afterburners on each incinerator are continuously fired to achieve an afterburner exit temperature of 1200°F. Fuel usage in the afterburners is the majority of fuel used by the incinerators.

Biosolids handling at the Post Point Plant consists of the following key process areas: 1) sludge thickening, 2) thickened sludge storage 3) dewatering and 4) incineration. Post Point Plant staff have also expressed an interest in installing a fats, oils, and grease (FOG) receiving and handling process at the facility sometime in the future to coincide with a FOG collection program. An overview of each of the existing biosolids processes is described below.

3.2 Sludge Thickening

Presently two 2-meter Eimco gravity belt thickeners (GBTs), as shown in **Figure 3-2**, are installed at the Post Point Plant for thickening primary and waste activated sludge (WAS) prior to storage, dewatering, and incineration. Although originally designed to thicken WAS independently, plant staff modified the sludge feed for co-thickening operation. Operations staff have reported better performance through the biosolids handling system since this modification was incorporated. The GBTs are configured with a duty and standby unit; simultaneous operation is not possible. Thickening operates on a 24 hour a day, 7 day per week schedule. The existing units are 18 years old; typical life expectancies for GBTs are around 25 years.

Figure 3-2. One of Post Point Plant's Two Existing GBTs

The principal purpose of thickening is to remove excess water from sludge to make it more amenable for downstream storage and processing. Concentration of the biosolids results in a significant volume reduction, which limits the quantities to be processed and reduces the required equipment, piping and tank sizes downstream of thickening. Historically, the Post Point Plant has achieved exceptional thickening within their GBTs achieving a 6.8 percent solid. Waste activated and primary sludge are introduced to the GBT at a 0.8 and 3.2 percent solid respectively. Graphs of the projected hydraulic and biosolids loading rates to the GBTs have been developed to evaluate the existing thickening capacity. These graphs are shown in **Figures 3-3** and **3-4**.

Figure 3-3. Gravity Belt Thickeners Hydraulic Loading and Capacity

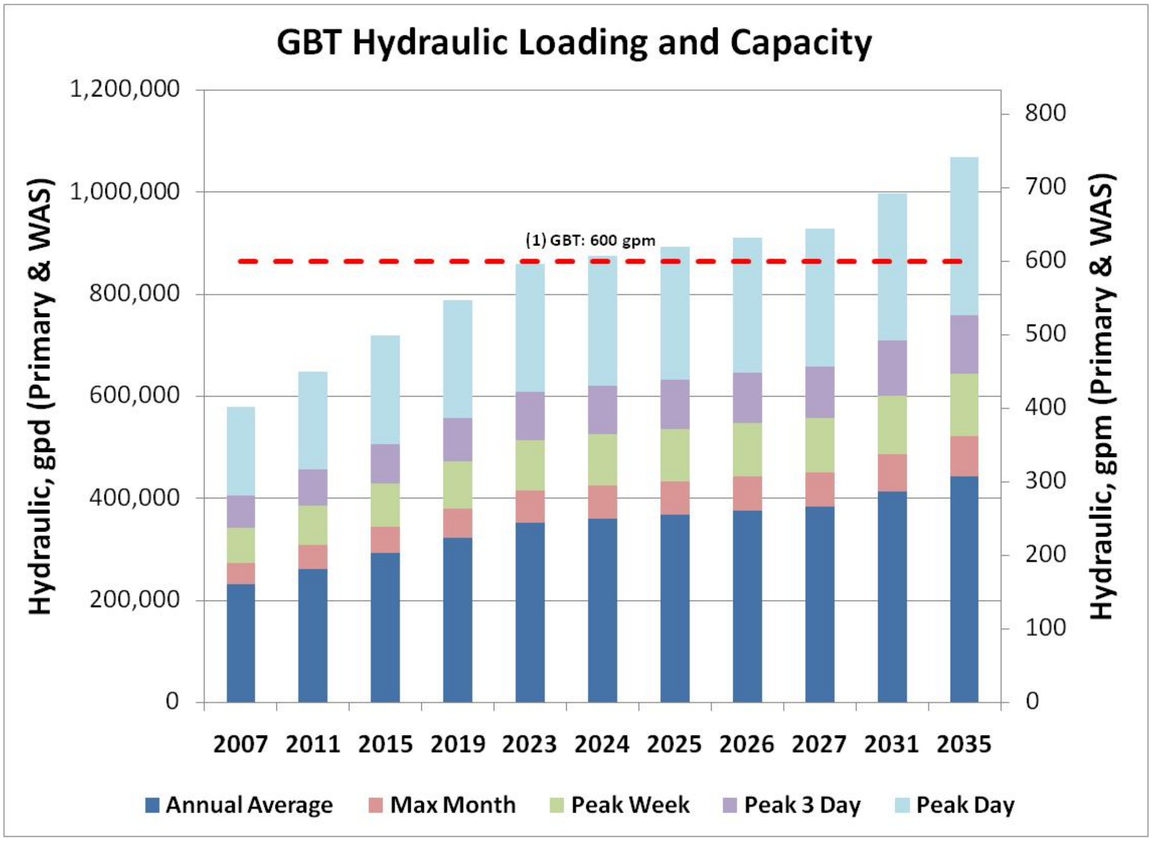
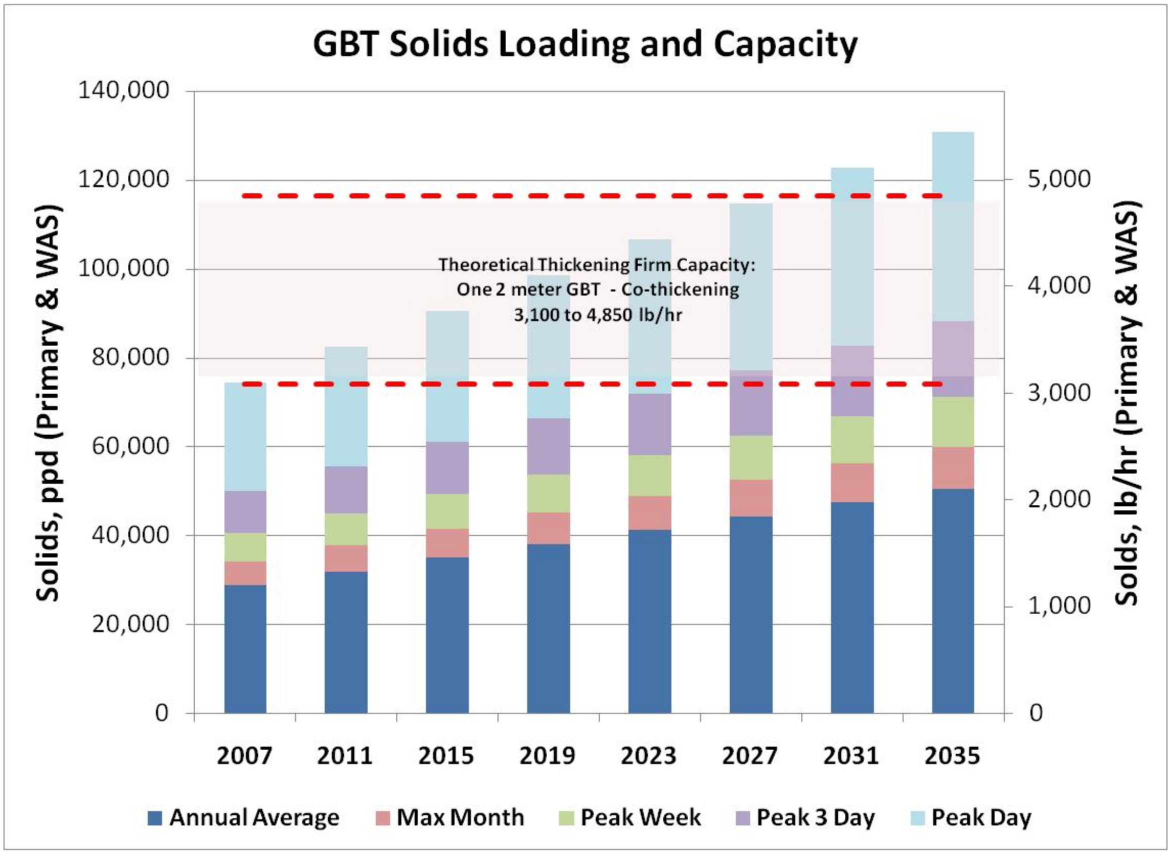


Figure 3-4. Gravity Belt Thickeners Solids Loading and Capacity



Theoretical hydraulic and biosolids capacities were used for this evaluation, as the actual capacities of the installed GBTs are unknown. With regards to hydraulic capacity the vendor estimated that the capacity is likely in excess of 300 gpm per effective meter. With regards to solids capacity the vendor estimated that the existing unit would met typical published values. Thus, Figure 7-4 was developed from the vendors recommendation whereas, **Figure 3-4** from the 2009 WEF Manual of Practice.

Based on **Figures 3-3** and **3-4**, the existing biosolids thickening capacity may be limited in terms of firm capacity. However, the total processing capacity may be sufficient. Additionally the GBTs are old and future replacement may be required.

3.2.1 Thickened Sludge Storage

Thickened sludge is stored at the Post Point Plant in three locations. Two storage tanks are located beneath the GBTs in the east side of the Solids Handling Facility. These concrete, rectangular tanks have a working volume of 16,200 gallons each and were originally designed for storage of thickened waste activated sludge. One steel, circular tank located in the Solids Handling Facility, has a volume of 78,000 gallons and was originally designed for storage of primary sludge. The total volume available for thickened sludge storage is 110,400 gallons or 55,200 gallons per day of weekend storage. The circular tank was installed at the Post Point Plant in 1973 as a part of the original design.

While sludge storage provides a number of operational benefits to the Post Point Plant, including providing surplus capacity for peak and emergency events as well as operational flexibility, the storage of sludge over the weekend period is contributing to in-house generation of volatile fatty acids (VFAs). The

VFAs are released and recycled back to the secondary treatment processes during dewatering and significantly effect secondary treatment operation including increased biomass generation and oxygen demand.

3.2.1.1 Dewatering

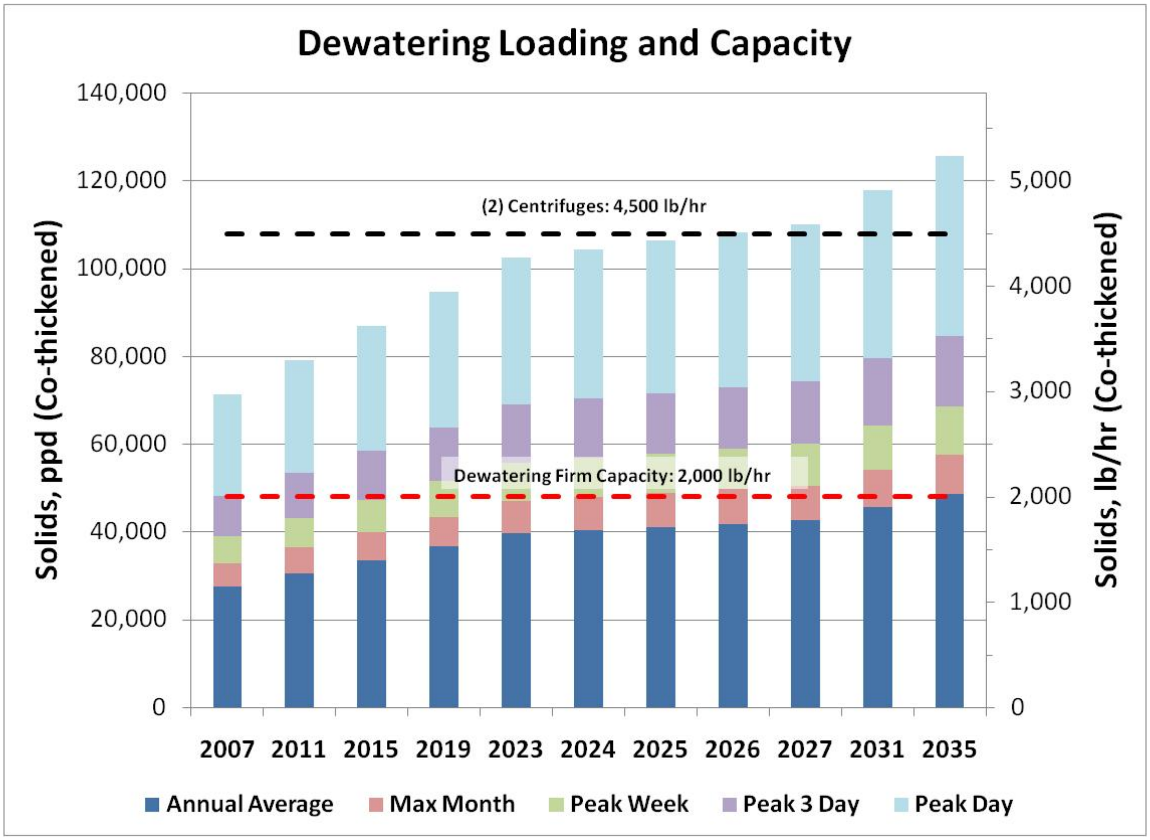
Until recently, dewatering of thickened sludge was accomplished using three centrifuges each designed for a biosolids loading of 2,000 lb/hr, operating 24 hours per day, 5 days per week. The centrifuges were manufactured by Sharples and were installed at the Post Point Plant in 1993. The life expectancy of a centrifuge is typically 25 years, although they have been known to operate effectively for longer periods with necessary mechanical component upgrades. Currently, no dewatered cake storage is located between the centrifuge and the incinerators to decouple the dewatering and incinerating activities. Additionally, two of the centrifuges were recently removed from service and a rotary press dewatering unit was piloted for several months. **Figure 3-5** shows the existing centrifuge at the Post Point Plant.

Figure 3-5. Existing Centrifuge at Post Point Plant

Centrifuge performance is satisfactory; historically producing a cake with a 27 percent solids concentration and operating with a solids recovery of approximately 97 percent. However, the centrifuge is expensive to operate and maintain due to its age, high polymer demand and high power draw. The centrifuge is 18 years old, requiring approximately 13 pounds of polymer per dry ton of solids processed, and has a 250 hp motor. Additionally, plant staff have expressed that it has been difficult to get spare parts for the existing MCC. Plant staff is currently upgrading the existing centrifuge with VFD technology to ensure sustained, reliable operation.

To reduce the dewatering operation and maintenance costs, the Post Point Plant intend to replace the two of the centrifuges already removed from service with a more energy efficient centrifuge. The dewatering equipment at the Post Point Plant will then include the following: (1) 2,000 lbs per hr centrifuge and (1) 2500 per hour centrifuge. This will give the facility a total dewatering capacity of 4,500 lbs per hour. A graph of the projected loading rates to the two centrifuges (once the 2500 lb per hour unit is installed within the next year) have been developed to evaluate the existing dewatering capacity.

Figure 3-6. Dewatering Loading and Capacity



The horizontal black lines show the total capacity of the planned dewatering equipment assuming 24 hour a day and seven day a week operation. The horizontal red line shows the firm capacity of the dewatering equipment. The firm capacity is the total processing capacity with the largest unit out of service. Based on this graph, it can be seen that the planned dewatering equipment is insufficient for peak loading and that no additional firm capacity will be available for average loading beginning in the year 2035.

The presence of thickened sludge storage upstream of the dewatering equipment provides some buffering capacity to attenuate peak loads, although it is estimated that peak loads could only be attenuated in this tank through about 2020. The thickened sludge storage tank is not large enough to completely address the insufficient firm capacity. A firm dewatering capacity of approximately 3,500 lbs/hr is necessary to attenuate peak biosolids at the Post Point Plant through 2035. Thickened sludge storage can be used to address the peak day loads that exceed this loading.

3.2.1.2 Incineration

The Post Point Plant has two multiple hearth furnaces (MHFs) that are used for incineration of the plant's biosolids. Both units have 7 hearths and an outside diameter of 14 ft - 3 inches. Incinerator 1, which is the older unit, was supplied by Envirotech, BSP Division, in 1973. The more recent unit, Incinerator 2, was supplied by Enviroquip in 1993. Incinerator 1 has been modified to include a top hearth afterburner. The dewatered solids are fed to Hearth 2 and the burners on Hearth 1 are used to maintain an exit flue gas temperature of 1200° F. Incinerator 2 has a separate, downflow afterburner chamber with a gas fired burner mounted on top of the chamber. Both incinerators have the same type of air pollution control systems, consisting of a venturi scrubber, followed by a tray scrubber and wet electrostatic precipitator (WESP). Downstream of each WESP is an induced draft (ID) fan which conveys the combustion gases through the system and maintains draft in the MHFs. Incinerator 2 has served as a standby unit that has insured incineration capability during maintenance periods or unexpected downtime of the operating unit.

MHFs were formerly the workhorses of the industry and there are approximately 200 of them still operating in the USA. MHFs consist of a series of stacked hearths. The biosolids are fed at the top of the furnace and move down the unit first drying on the upper hearths, followed by burning on the middle hearths and finally cooling of the resultant ash on the bottom hearths. The stacked hearth configuration is thermally efficient in that it allows the hot combustion gases to rise through the furnace and greatly assist in drying of the biosolids on the upper hearths. However, the upper drying hearths emit high levels of VOCs, CO, particulates and odors that are not acceptable to current air regulatory boards. Because of these pollutant emissions, most MHFs require the use of a fuel-fired afterburner to meet present day air emission standards.

The air permit for the incinerators does not require the afterburners on each unit to be fired. However, the air permit does require that both units achieve a 5 percent opacity on their stack emissions that essentially means that there can be no visible emissions from the incinerator stacks. To ensure compliance with the opacity requirement, the afterburners on each unit are continuously fired to achieve the 1200°F afterburner exit temperature. Fuel usage in the afterburners is the majority of fuel used by the incinerators.

The use of a fired afterburner made MHFs quite inefficient since a significant quantity of fuel is required to raise the flue gas temperature exiting the drying hearths to a minimum afterburner outlet temperature of 1200°F. At the Post Point Plant, the afterburners are used to ensure that the furnaces meet their opacity (visible emission) requirement.

Slag and clinker formation are two of the more frequently occurring operating problems that can restrict the performance of a MHF. Slag is the accumulation of molten or fused ash which sticks to the walls, rabble arms and center shaft of a MHF. Clinkers are hard or soft clumps of fused ash that can jam rabble arms or a unit's ash conveying system. Although both incinerators had some slagging and clinker problems in the past, modifications and improvements to the incinerators have reduced these problems to manageable levels. Adjustments were made on Incinerator 1 to the rabble arms and rabble pattern. On Incinerator 2 the drop holes were enlarged and the burners were modified to operate at very high combustion air levels with very low to zero fuel usage. Introducing a high air flow into the furnace provided better mixing of combustion gases and lowered hearth temperatures that reduced slag and clinker formation.

An annual summary of the incinerator operating records from 2006 through November 2008 is presented in **Table 3-1**. Presently, only one incinerator is operated at a time for approximately 5 days per week, 24 hours per day. During weekends the operating incinerator is kept on hot standby by firing natural gas in the furnace burners. Total annual quantity of biosolids burned in 2006 and 2007 was approximately 8.5 million dry lb/yr or 4,250 dry tons per year.

Table 3-1. Summary of Incineration Operating Records for 2006 – 2008

Year		Incinerator 1	Incinerator 2	Total
2006	Operating , Hrs[1]	2,200	3,645	5,845
	Sludge Burned			
	Dry lb/yr	3,088,028	5,285,953	8,373,981
	Dry tons/yr	1,544	2,643	4,187
	Avg Feed Rate, Dry lb/hr	1,404	1,450	
	Total Gas Usage, Cuft/yr	5,508,898	16,360,428	21,869,326
	Standby Gas Usage[2], Cuft/yr	1,391,720	5,836,792	7,228,512
	Standby Gas as % of Total Gas	25.3%	35.7%	33.1%
	Solids Processing Gas per Dry Ton[3], Cuft/ton	2,667	3,982	3,497
2007	Operating Hrs	4,622	1,273	5,895
	Sludge Burned			
	Dry lb/yr	6,657,415	1,923,927	8,581,342
	Dry tons/yr	3,329	962	4,291
	Avg Feed Rate, Dry lb/hr	1,440	1,511	
	Total Gas Usage, Cuft/yr	11,691,097	5,397,597	17,088,694
	Standby Gas Usage, Cuft/yr	2,974,027	2,012,894	4,986,921
	Standby Gas as % of Total Gas	25.4%	37.3%	29.2%
	Solids Processing Gas per Dry Ton, Cuft/ton	2,619	3,518	2,820
2008	Operating Hrs[4]	2,852	2,317	5,169
	Sludge Burned			
	Dry lb/yr	4,359,793	3,371,324	7,731,117
	Dry tons/yr	2,180	1,686	3,866
	Avg Feed Rate, Dry lb/hr	1,529	1,455	
	Total Gas Usage, Cuft/yr	3,994,917	7,323,535	11,318,452
	Standby Gas Usage, Cuft/yr	1,201,908	2,786,468	3,988,376
	Standby Gas as % of Total Gas	30.1%	38.0%	35.2%
	Solids Processing Gas per Dry Ton, Cuft/ton	1,281	2,691	1,896

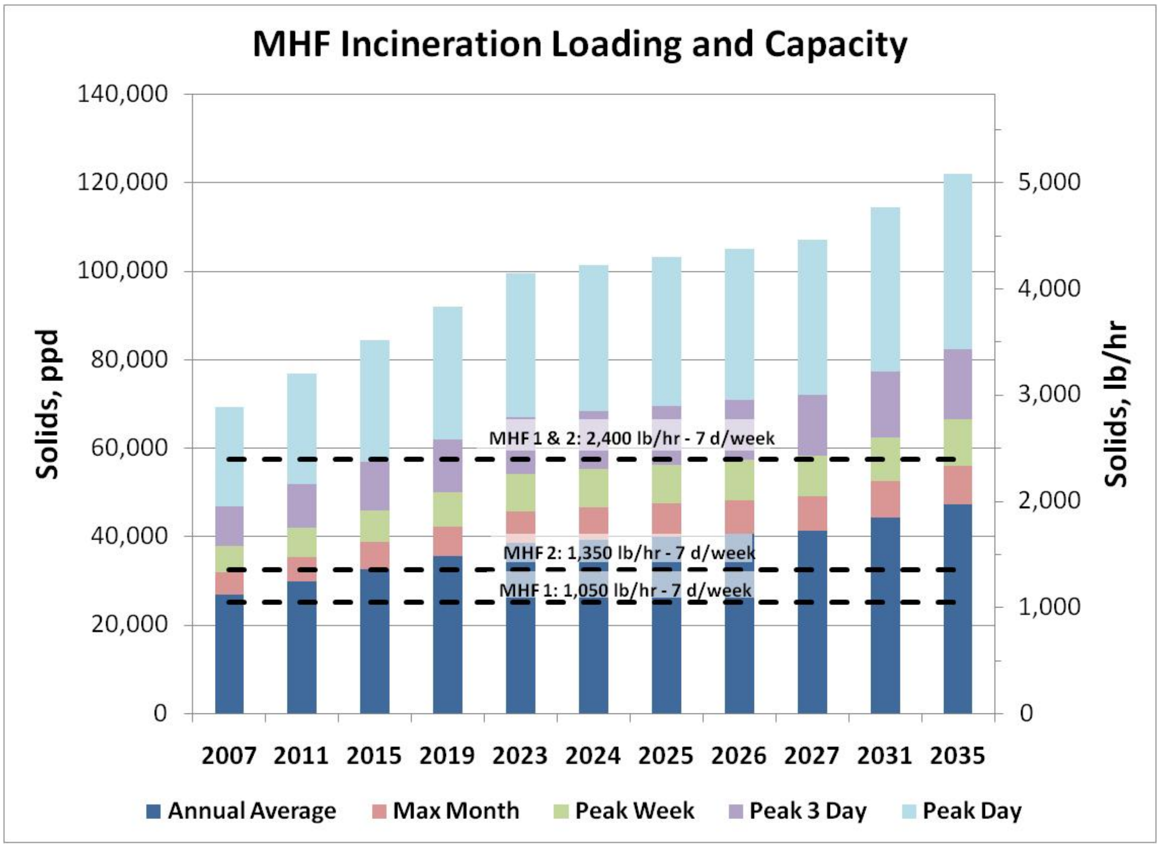
Notes

1. Operating hours are hours of sludge burning; standby hours are not included.
2. Standby gas usage is required to maintain incinerator in hot standby mode.
3. Solids processing gas per dry ton is the total gas minus the standby gas divided by the dry tons of sludge burned.
4. Operating hours for 2008 are January 1 through November 22, 2008.

The fuel usage to operate the MHFs is high mostly due to the high fuel requirement of the afterburners. The MHFs also require a significant amount of fuel (approximately 25% to 38% of the total fuel usage) to maintain a hot standby condition on weekends when the units are not burning biosolids. The annual fuel cost for the MHFs is approximately $160,000 per year.

Incineration is the primary means of biosolids disposal at the Post Point Plant and thus it must be capable of reliably handling the 2035 sludge loads. As indicated by the 2006 to 2008 data and illustrated in **Figure 3-7**, current average annual loads already exceed the capacity of a single MHF and peak loads exceed the capacity of the maximum design capacity of both MHFs. The Post Point Plant is only able to continue operating in this manner by operating the MHFs above their design rated capacity and utilizing the thickened sludge storage to attenuate peaks in sludge production. As sludge production increases in the future years, the Post Point Plant will increasingly need to operate both MHFs in excess of design capacity. By year 2025, the sludge production will exceed the attenuation capacity of the thickened sludge storage tank with 2 MHFs running simultaneously. Therefore to maintain operations beyond 2025, the Post Point Plant will need to rely on operating both MHFs in excess of their design capacity continuously for periods of one week straight.

Figure 3-7. Existing Incineration Loading and Capacity



The existing MHFs are becoming increasingly difficult and more costly to repair and maintain. Recently problems with the sand seal and center shaft bearings on Incinerator 1 resulted in 45 day repair period in which the MHF was not available for operation. It is expected that significant repairs to the refractories, hearths, and insulation and possibly reinforcing of the incinerator's steel shell will be required in the near future. It is noted that the PLC control system on both incinerators is a Texas Instruments processor which is 15 years old and parts for the PLC are no longer available from the original equipment manufacturer (OEM). Availability of parts for the PLC will be a problem in the future. Given the age of the MHFs it is expected that maintaining the units will be a continuous and increasingly difficult task for the plant maintenance staff.

Incinerator 1 is 37 years old and Incinerator 2 is 17 years old. By the end of the 25 year planning period in 2035, Incinerators 1 and 2 will be 62 and 42 years old, respectively. A typical life expectancy of a MHF is approximately 25 years. If neither unit is replaced, both incinerators will be well beyond their life expectancy by the end of the planning period. As an incinerator gets older, replacement of major components becomes necessary. Typical maintenance on an old MHF would include replacement of the furnace firebrick and hearths, replacement of the wet scrubbing system due to erosion and corrosion, and replacement of the center shaft drive mechanism. From a maintenance standpoint as well as the difficulty obtaining replacement parts, it is recommended that the existing MHFs be replaced with a new incinerator.

In conclusion, due to the above deficiencies, namely high fuel usage, insufficient incineration capacity, high maintenance costs, and limited additional life expectancy, it is recommended that the existing MHFs not be relied upon as the primary means of biosolids disposal in the future.

Section 4
Limitations of Existing Biosolids Handling System

While effective for ultimate sludge disposal, the existing equipment and operational schedule of the biosolids handling system is both energy and labor intensive, is causing substantial operational difficulties on the liquid side of treatment, and has limited excess capacity for peak events and growth. A summary of key deficiencies with the existing system are highlighted below:

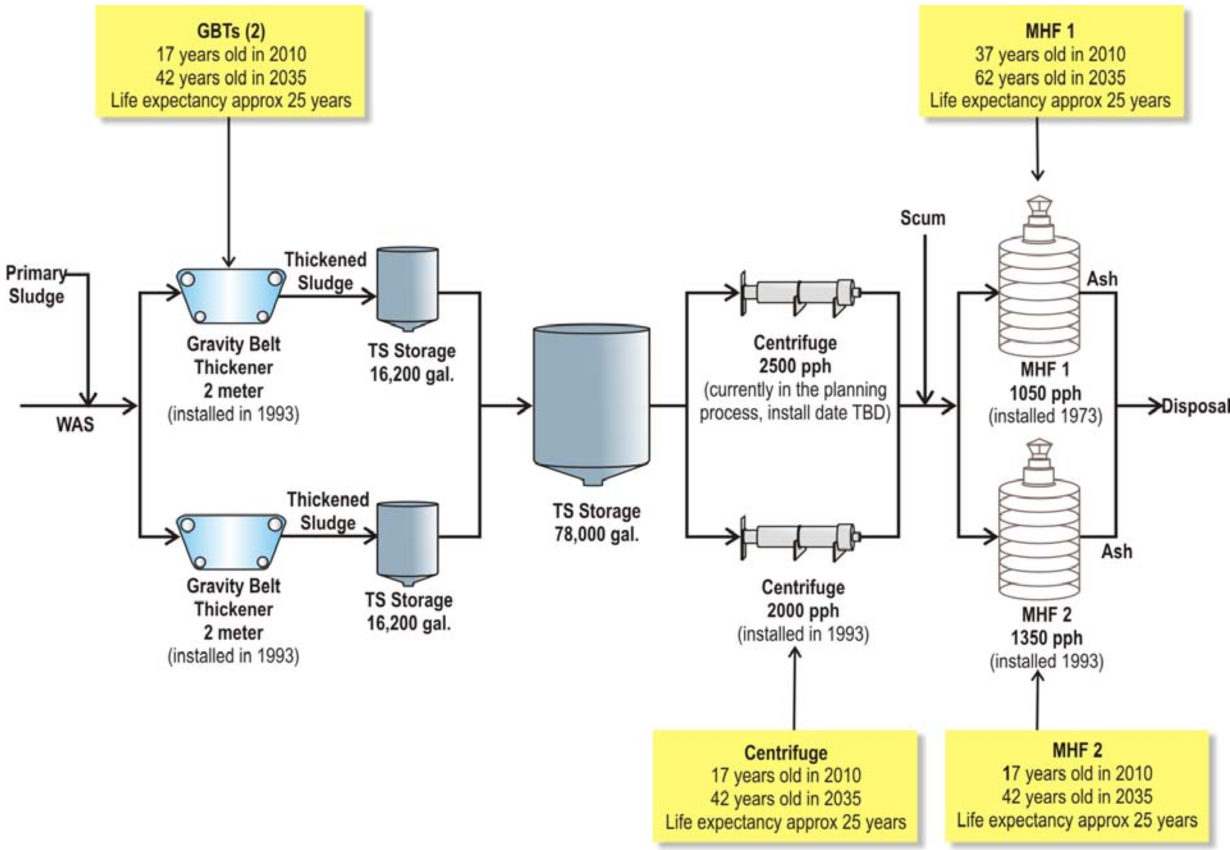
- **Energy**
  - MHF operations use an average of 465 therms of natural gas per day
  - Approximately 1/3 of the natural gas demand is for standby operation to maintain the MHF temperature during weekend shutdowns
  - Approximately 1/2 of natural gas usage is for operation of the afterburner, which is required to meet the 5 percent opacity requirement of the air permit
  - Incinerator 2, the newer incinerator, has unsteady performance and can require twice the natural gas as Incinerator 1 to maintain temperatures and incineration activities
  - There is no energy recovery on either MHF
- **Labor**
  - Dewatering and MHF incineration operation require 33 percent of the Post Point Plant operations staff; 3 out of 9 operators. The remaining 6 operators are responsible for the liquid side treatment, 50 or more pump stations, and the City water treatment plant via a SCADA system. The remaining 6 operators are also responsible for the sludge thickening portion of the biosolids operation
- **Liquid Side Impact**
  - The use of sludge storage over the weekend period generates volatile fatty acids (VFAs), which are returned to the liquid side in the dewatering centrate. This self generated source of VFAs account for 43 percent of total VFA loading to the liquid side
  - The centrate VFA loading causes various challenges to the liquid side including:
    - Depleting dissolved oxygen levels in the aeration basins
    - Requiring increased oxygen generation
    - Increasing activated sludge generation and wasting rates

    - Overloading the secondary clarifier with a deep sludge blanket
    - Requiring increased operator attention to maintain treatment

- **Capacity**
  - When operated as single units, the existing MHFs are operating between 110 and 140 percent of their design capacities during 5 day/week operations
  - There is no surplus capacity in the thickened sludge tanks to accommodate growth or peak events during weekend storage
  - The VFA loading from the centrate has pushed the liquid side treatment to its capacity, especially during summer months when the dissolved oxygen levels in the water decrease due to the increased ambient temperature
- **Age of Biosolids Handling Equipment**
  - MHF incinerator 1 was installed in 1973 and MHF incinerator 2 was installed in 1993. Thus, the incinerators are presently 37 years old and 17 years old respectively.
  - The Post Point Plant staff has confirmed that replacement parts for the MHFs are becoming difficult and expensive to procure since MHF incineration is an outdated technology
  - The PLC control system for both incinerators is currently a TI processor and is over 15 years old. The parts are no longer supported by the original equipment manufacturer
  - The GBTs were both installed in 1993 and are presently 17 years old
  - The remaining centrifuge was installed in 1993 and is also presently 17 years old. Parts are also becoming difficult and expensive to procure for the centrifuge, particularly outdated electrical components
  - If kept in service without replacement, by the end of the planning period in 2035:
    - Incinerator 1 will be 62 years old
    - Incinerator 2 will be 42 years old
    - The GBTs will be 42 years old
    - The existing centrifuge will be 42 years old

Figure 4-1 demonstrates the present age and life expectancy of the Post Point Plant's existing biosolids handling equipment.

Figure 4-1. Age and Life Expectancy of Existing Biosolids Handling Equipment



Section 5
Potential Biosolids Handling and Energy Alternatives

As previously stated, sludge incineration has proven to be a reliable biosolids handling approach for the City of Bellingham over the years. However, the age of the existing equipment and its capacity limitations allows the City to examine other potential methods for handling wastewater biosolids. It also presents an opportunity to examine ways to capture energy, in the forms of heat and power, from its biosolids process. Among the possible biosolids handling alternatives for the Post Point Plant to consider include:

- Incineration with Heat Recovery and Power Production
- Anaerobic Digestion
- Sludge Drying
- Gasification
- Sludge to Fertilizer
- Sludge to Fuel

5.1 Biosolids Handling Alternatives

5.1.1 Incineration with Heat Recovery and Power Production

The Post Point Plant has been incinerating its wastewater biosolids for the past 37 years and the process has proven itself to be reliable. A new incineration facility would likely utilize fluidized bed technology in lieu of the current multiple hearth technology which is inefficient and outdated.

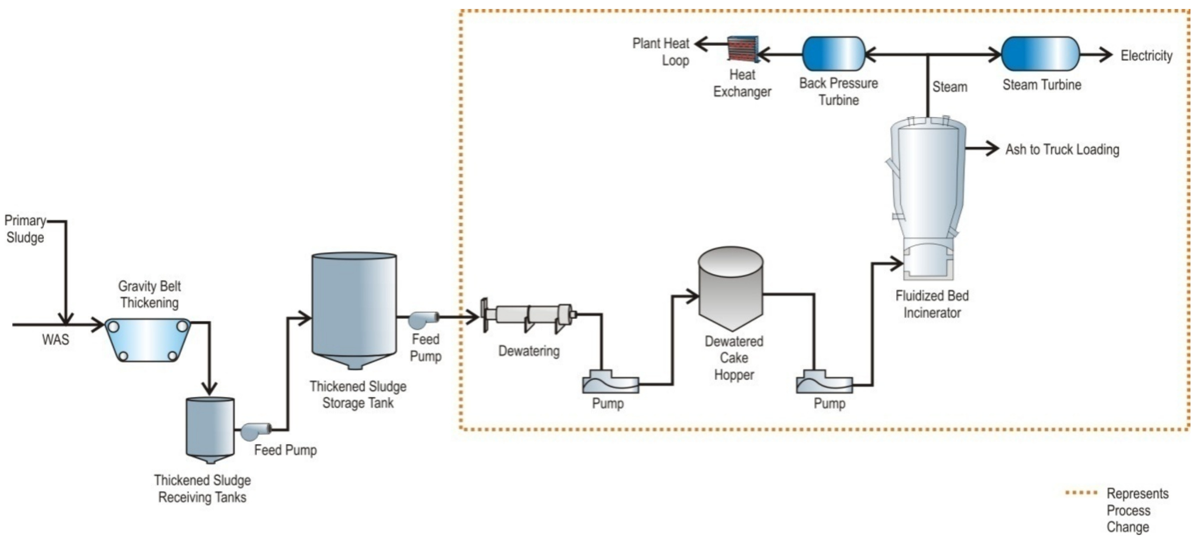
A Fluidized Bed Incinerator (FBI) can be thought of as a completely mixed process in which drying and combustion take place concurrently and very rapidly. The combustion related components of a FBI system consist of the following items: the reactor, combustion air heat exchanger or preheater, and the fluidizing air blower. Preheated combustion air supplied by the fluidizing air blower is blown into a windbox and distributed through nozzles or tuyeres to the bottom of the bed. The combustion air fluidizes a sand bed. Then fuel (natural gas or fuel oil) and dewatered biosolids are pumped directly into the sand bed to create a hot, turbulent suspension of sand, gases, and burning biosolids. In the 1400°F to 1500°F suspension, the water in the biosolids is evaporated and the combustible matter oxidized in a matter of seconds.

FBIs are thermally efficient, as the reactor flue gas is routed to the combustion air preheater to heat the combustion air to 1200°F, while cooling the flue gas to 1000°F. The combustion air preheater makes it possible to burn biosolids with low solids content or low heating value with a minimal use of auxillary fuel. FBIs typically use one-third less natural gas to operate than a MHF.

Following the air preheater, the flue gas can be sent to steam boiler to generate steam. The steam would be primarily used to run a condensing steam turbine and/or a backpressure steam turbine and generate electricity. With the use of a backpressure steam turbine, the steam can also be captured for use for plant heating needs or for periodic pipe cleaning.

Similar to the current MHF incineration system, an FBI system would require sludge thickening and dewatering. In addition, sludge storage would be required. Utilization of the existing thickened sludge storage would be beneficial and dewatered cake storage would also increase system flexibility. A schematic diagram of a basic FBI system is provided in **Figure 5-1**.

Figure 5-1. Incineration with Heat Recovery and Power Production Process Schematic



An FBI incineration process would have many of the same benefits as the existing MHFs, including elimination of over 80 percent of the wastewater biosolids and producing a product that is acceptable to landfill. The process is proven at many installations throughout North America and permitting of the process is expected to be easier considering the Post Point Plant's incineration experience. In addition, a new FBI would be capable of producing electrical power and reducing plant building heating requirements.

The expected cost of a new FBI incinerator, with dewatered cake storage, power generation, and building heat auxiliaries, is $32 million. This cost is based on CDM's recent project experience scaled up to meet the conditions for Bellingham and does not include plant modifications that may be necessary in sludge thickening, dewatering, or other auxiliary processes.

A new FBI would be expected to require annual fuel inputs of 30,000 gallons of fuel oil or 44,000 therms of natural gas. Space heating demands for the Post Point Plant will require an additional natural gas input of 30,000 therms per year. Electrical demand for the system will be about 2.4 million kWh per year;

however, if it is equipped with power generation and waste heat recovery, the system could produce approximately 1.7 million kWh per year. Disposal of the ash product at the local land fill is projected to require 8,200 gallons of diesel fuel per year to run the ash hauling trucks and freight trains. Overall, a new incinerator would emit 700 tons of fossil fuel-based carbon emissions per year.

A new FBI incinerator would be expected to have a space footprint of 1,900 ft2. Other equipment, including hotwell pumps, a surface condenser, turbine generator, waste heat boiler, condensate tank, pumps, deaerator, and boiler feed water pumps, would require an additional 1600 ft^2. Some of the existing facilities could be used and CDM estimates that the solids handling facility and maintenance facility combined has more than enough room to accommodate the FBI and accompanying equipment. Carollo Engineers is currently working with the City to relocate the existing maintenance building. While the re-siting is still in the planning stages, a proposed location for a new maintenance building has been situated on the Homeport property, located adjacent to the Post Point Plant.

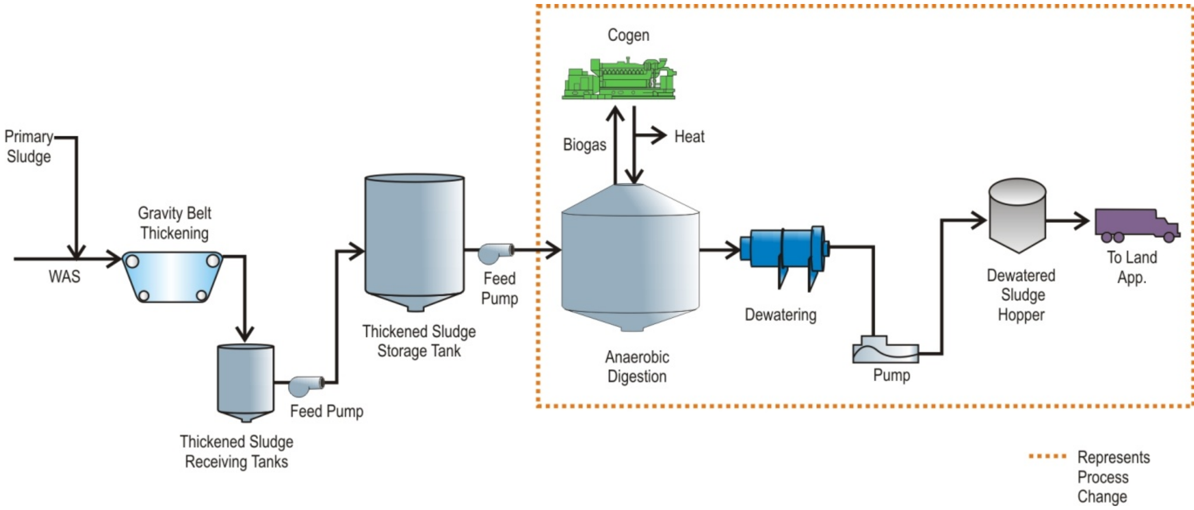
5.1.2 Anaerobic Digestion

Anaerobic digestion is the most common method to stabilize wastewater biosolids. Anaerobic digestion relies on anaerobic organisms to digest the wastewater biosolids and biodegrade the solid compounds. The byproducts of anaerobic digestion are CH_4 and CO_2. The CH_4 is often used to produce electrical power and hot water. The hot water is used to heat the sludge fed to the anaerobic digester and to maintain the digester temperature. Excess heat can be used for building heating.

Anaerobic digestion is typically carried out in large diameter tanks. For the Post Point Plant, CDM estimates that 2.4 Mgal of tankage would be required, plus another 0.8 Mgal tank for sludge storage prior to dewatering. CDM also estimates that 600 kW of power could be produced by year 2020 from a cogeneration system that utilizes the CH_4 byproduct of the digestion process.

Anaerobic digestion would be installed just downstream of the existing gravity belt thickeners and upstream of sludge dewatering. In addition to the digestion facilities themselves the process would require a support building to house the pumps and piping associated with the process and a new wet cake load out facility adjacent to dewatering. Due to space constraints around the existing dewatering facility, relocation of dewatering may be needed to provide a better approach for wet cake haul trucks. Schematically, the facilities required for a new anaerobic digestion system are shown in **Figure 5-2**.

Figure 5-2. Digestion Process Schematic



Anaerobic digestion will typically convert about half of the wastewater biosolids into biogas, leaving a significant portion of the biosolids to be hauled out of the wastewater treatment plant. The remaining biosolids contain about 75 to 80 percent water and can be applied to agricultural land (with certain application restrictions) and forest land as a soil amendment. They can also be composted and converted to topsoil.

The cost of a new anaerobic digestion facility with cogeneration is expected to be approximately $32 million. This cost is based on similar projects and does not include site specific considerations that may increase or decrease the facility cost. Further, the cost does not include any modifications to sludge thickening or dewatering that may be required at the Post Point Plant. Due to space constraints around the existing sludge handling building, it is likely that the new digester facilities would be located remotely. This in turn may predicate moving either sludge thickening and/or dewatering to a location adjacent to the new digester facilities. The cost of this relocation is not included in the above costs. Including an allowance of $5 million dollars to relocate dewatering and construct a new truckload out facility, the cost of this alternative increases to $32 million.

A new anaerobic digestion facility with cogeneration would require an estimated 20,000 therms of natural gas per year to heat the digester. The facility would be a net producer of electricity, generating an estimated 4.5 million kWh per year. However, an estimated 112,000 gallons of diesel fuel per year would be required to haul the dewatered biosolids to land application sites. The estimate of diesel fuel is based on application of 60 percent of the biosolids on agricultural land in Eastern Washington, 30 percent of the biosolids in the North Cascade forests, and the remaining 10 percent composted in Western Washington. Fugitive methane emissions from the digester would be equivalent to emitting approximately 350 tons of carbon dioxide per year. Overall, a new anaerobic digestion process would offset approximately 1,500 tons of carbon dioxide emissions per year (corrected for fugitive methane emissions).

New anaerobic digesters would require an additional 22,000 ft^2 on the Post Point Plant site.

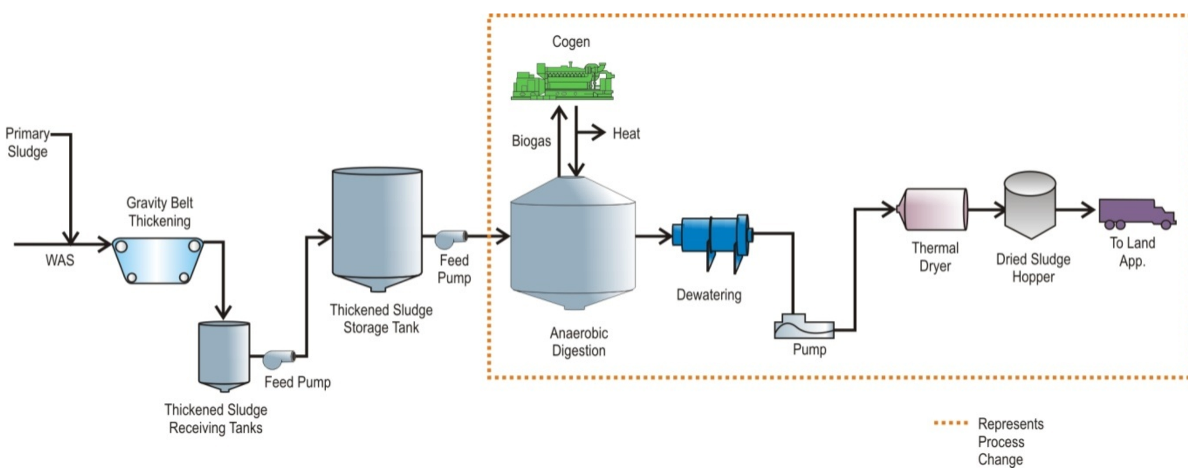
5.1.3 Sludge Drying

Sludge drying is used to remove the water from wastewater biosolids. Typical wastewater sludges in the wastewater processes are 97 percent water. Sludge drying utilizes thickening and dewatering to mechanically remove a significant portion of the water, leaving an intermediate product with only 75 to 80 percent water to be fed into the sludge dryer. The majority of sludge drying processes also incorporate anaerobic digestion between the thickening and dewatering. Anaerobic digestion removes a substantial amount of organic material by converting it to CH_4 and CO_2. The reduction in organic matter makes the dried product more stable and significantly reduces the probability of spontaneous combustion and fire hazards from the product. There is a growing trend of coupling digestion and drying processes with cogeneration. There is at least one United States facility and more than five European facilities that couple the processes. By coupling the processes, the biogas from the digester can be used to fuel the cogeneration facility and dryer. Exhaust from the cogeneration facility can be captured and used as a heat input into the dryer. Waste heat from the engine jacket water can be captured into a hot water loop and used to heat the digester and any space heating needs.

The dried biosolids product produced from the dryer facility would be classified as a Class A biosolids product. This classification would allow land application of the product on a larger variety of sources. It would also allow local citizens to purchase the product and apply to their home lawns.

For the City of Bellingham, a sludge drying alternative would be similar to an anaerobic digestion alternative. Anaerobic digestion would be installed between the thickening and dewatering. Truck loadout and biosolids pellet bagging facilities would be incorporated into the sludge dryer footprint. A schematic representation of a sludge drying process is shown in **Figure 5-3**.

Figure 5-3. Digestion with Drying Process Schematic



Based on previous sludge drying projects, a planning level cost for a sludge dryer would be $38 million. This cost would include new anaerobic digestion facilities, cogeneration equipment, and the sludge drying facility. Costs to upgrade and modify or relocate existing thickening and dewatering are not included in this planning level estimate.

A new sludge drying facility with anaerobic digestion and cogeneration will be a net producer of electricity, yielding 3.2 million kWh per year. The facility would require a natural gas input of 300,000 therms per year for the dryer, 90,000 therms per year for the digester, and 100,000 therms per year for space heating demands. Assuming that 100 percent of the dried product could be distributed locally, the diesel fuel usage for transportation to land application sites would be 7,400 gallons. Fugitive methane emissions from the digester would be equivalent to emitting approximately 350 tons of carbon dioxide per year. CDM estimates that an anaerobic digestion process with drying would emit approximately 650 tons of carbon dioxide per year (corrected for fugitive methane emissions).

The total footprint of a new sludge drying facility, including anaerobic digestion facilities, is 24,000 ft^2.

5.1.4 Sludge Gasification

Gasification involves the reaction of dried biosolids with one or more of several gases (e.g., air, oxygen, steam, carbon dioxide) at elevated temperatures to produce a combustible synthesis gas, or syngas. The syngas is composed primarily of H_2, CO and CH_4. The syngas is burned in a thermal oxidizer to heat a thermal fluid. The thermal fluid is usually oil, but may also be steam, air, or other gases. The hot thermal fluid can be used for electricity generation, space heating, and/or feedstock drying. In most cases, there is enough net energy produced from gasification to dry the incoming feedstock from around 25 percent solids to 90 percent solids, and very little usable heat is left over. Electricity generation from biosolids gasification processes is not currently being performed anywhere in the world. However, the vendors of the equipment believe that the process will work and are prepared to couple the processes. Without any facilities in the world coupling biosolids gasification and power generation, CDM does not consider the marriage proven and thus will not perform any detailed analyses on a combination of the processes.

The only full-scale implementation of sewage sludge gasification in North America is at the Sanford, Florida WWTP. The gasification facility was installed in 2009 and was designed to supplement Sanford's biosolids dryer. The system is designed to process 60 tons of dried biosolids per day; however, the Sanford WWTP only produces about half that amount. Therefore, the gasification facility will operate intermittently throughout the week until additional feedstock can be provided from surrounding cities or until population growth increases sludge production at the WWTP.

At the Sanford, Florida WWTP, undigested and digested (from neighboring treatment plants) biosolids are dried in the Solids Handling Building and are subsequently conveyed from a storage silo to the gasifier using a pneumatic pipe system. The biosolids are then gasified, which reduces the volume of dried material by about 75 percent, and the residual ash is disposed at a local landfill. The thermal energy produced from combustion of the syngas (approximately 7 MMBTU/hr) is captured in a hot oil system for use in Sanford's biosolids dryer to reduce natural gas demand. The reduction in natural gas demand is expected to save the City of Sanford more than $8 million over a 20-year time period. However, because the Sanford gasification facility began operation in 2009, an adequate track record of successful operation has not been demonstrated and a comprehensive evaluation of the plant's operation and success cannot be performed.

In contrast to incineration and other combustion processes, gasification processes operate at substoichiometric oxygen levels, which prevents complete oxidation of carbon in the biosolids. Oxygen in the gasification chamber reacts with carbon and hydrogen in the biomass to produce heat. If the biosolids feed is dried properly, the heat produced in the gasification chamber is sufficient to maintain a relatively autogenous gasification reaction. Supplemental fuel, approximately 3 MMBTU per hour for 40 hours, is required to preheat the chamber, and an additional 0.25 MMBTU per hour is used during operation for pilots in the syngas burners. The estimated electrical demand to the gasification equipment and dryer is 500 kW. A photograph of sludge gasification system equipment is shown in **Figure 5-4**.

Figure 5-4. Sludge Gasification System

Gasification will typically convert 80 percent of the wastewater biosolids into syngas. The residual ash contains some heavy metals and is primarily inorganic. Therefore, the gasifier ash has little fertilizer value and typically has hauling and disposal requirements similar to incinerator ash. Current sludge gasification technologies utilize the syngas as a fuel for the sludge drying process. Vendors are currently researching methods to utilize syngas to power cogeneration such that electrical energy can be produced with the waste heat being used for the sludge drying. Therefore, it may be possible in the future to recover both heat and power from the syngas.

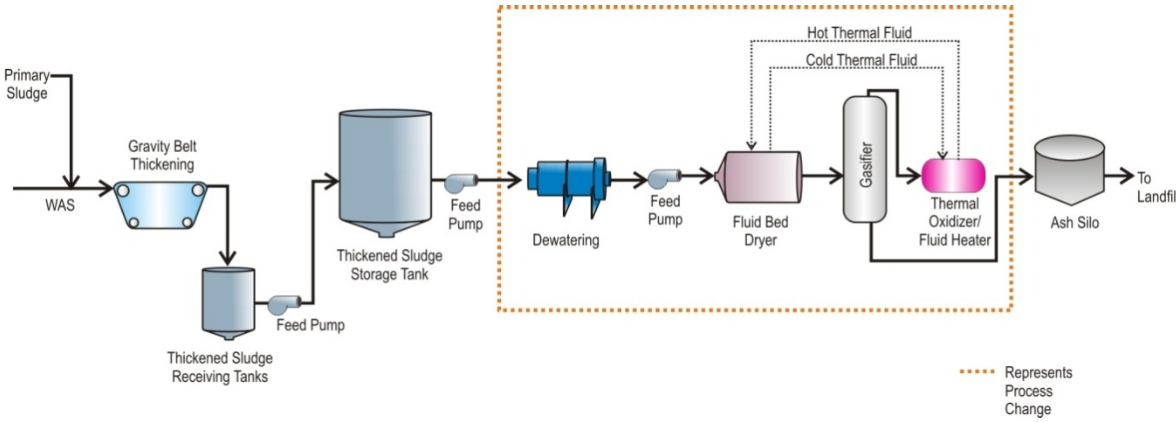
Ideally, gasification chambers are operated continuously and with a constant solids loading. The gasification chamber is refractory-lined and temperature cycling will result in increased maintenance costs. Gasification vendors purport that raw undigested sludge is a suitable product for gasification. However, due to the infancy of this process, the problems of using an undigested product are not fully understood. Since it involves sludge drying implementation without anaerobic digestion could increase the risk of a fire. In order to examine sludge gasification under the best possible circumstances, CDM has assumed that sludge gasification could be implemented without anaerobic digestion; however, if the process is selected for implementation, CDM recommends that the issue be more fully explored during the pre-design stage.

For the Post Point Plant, CDM estimates that a 10-foot diameter gasification chamber will be required. The gasifier will operate continuously for most of the year, with an estimated 3 or 4 maintenance periods requiring the gasifier to be taken offline for service. For this reason, CDM recommends that a biosolids storage hopper be installed to store dewatered cake. At a minimum, the storage hopper should be 50,000 gallons.

The gasification unit would be installed downstream of a biomass dryer, although some manufacturers include drying equipment in their turnkey gasification packages. If drying equipment is included in the gasifier package, the gasification process would be located downstream of dewatering.

A schematic representation of a drying-gasification process is shown in **Figure 5-5**.

Figure 5-5. Drying-Digestion-Gasification Process Schematic



The cost of a new gasification facility with dryer is expected to be approximately $36 million at the Post Point Plant. This cost does not include site specific considerations that may increase or decrease the facility cost. Further, the cost does not include any modifications to sludge thickening or dewatering that may be required at the Post Point Plant.

A gasification facility with cogeneration would be a net consumer of electricity; using an estimated 4.2 million kWh per year. An estimated 5,400 gallons of diesel fuel would be required to haul the ash to a certified landfill (haul distances as determined for the incinerator ash, above). The total fossil fuel emissions are estimated to be 2,100 tons CO_2 equivalents per year.

A new gasification system would require an additional 5,600 ft^2 on the Post Point Plant site.

5.1.5 Sludge to Fertilizer

Sludge to Fertilizer is a newer process that is developing. One process is called VitAG and it is based on the addition of nitrogen and phosphorus to wastewater sludge. The chemicals added not only add fertilizer value to the sludge, but they also cause an exothermic reaction that increases the temperature of the sludge product and evaporates some of the water. With addition of a conventional sludge dryer the VitAG process produces a high value fertilizer product and a lower energy demand than traditional drying.

The VitAG vendor, VitAG Corp., traditionally likes to enter into a turnkey project where they are responsible for the construction and operation of the facilities, including the chemical mixing, and are paid by the biosolids generator for the ultimate disposals of the biosolids. VitAG typically sells the enhanced biosolids as a high value fertilizer. Because of the economics associated with construction and operation of the facilities, as well as the cost of developing a market for the fertilizer, VitAG is currently only looking at agencies that produce at least 100 tons per day of wet solids. Since the Post Point Plant residuals production is only 58 wet tons per day, and will only reach 100 wet tons per day by year 2035, VitAG is not a viable option for the Post Point Plant.

5.1.6 Sludge to Fuel

Wastewater sludge can be converted to a fuel very similar to pulverized coal. This process is completed through a technology called SlurryCarb. SlurryCarb pressurizes the sludge through the addition of high pressure steam. The high pressures prevent evaporation of the water and cause the cell structure of the sludge to rupture and release CO_2. The particles in the sludge are reduced in size and take on a more uniform structure. The end product is hydrophobic and can be easily dewatered to biosolids concentrations in excess of 50 percent. This dewatered product is then dried yielding a fuel product that is high in carbon with only approximately 10 percent moisture. Because the water has been mechanically removed, the energy required for evaporation is significantly reduced. The resultant product contains over 7,000 BTU per lb.

SlurryCarb is still under development. The technology recently started up the first facility to process biosolids in Rialto, CA. Based on initial observations of the facility's operation, the overall intent of the process was being satisfied for a period of about half a year. However, they were not able to sustain biosolids processing at the design loading rates and needed to divert sludge for off-site disposal. Recently, the process violated its discharge permit due to issues with biosolids separation and removed the facility from operation. The manufacturer continues to support the process and believes that the problems can be worked out. However, the process is still a developing technology and is not recommended for the Post Point Plant.

5.2. Biosolids Handling Alternatives Summary

Of the alternatives outlined above, four main biosolids handling approaches remain as viable options for the Post Point Plant:

- Incineration with Heat Recovery and Power Production
- Digestion with Combined Heat and Power
- Digestion and Drying with Combined Heat and Power
- Gasification

A summary of the specifics for each biosolids handling alternatives are presented in **Table 5-1**.

Table 5-1. Biosolids Handling and Energy Alternatives Summary

Alternative	Projected Capital Cost	Projected Total O&M Cost	Carbon Dioxide Footprint (tons CO_2e/yr)	Space Footprint (ft^2)
Incineration with Power/Heat Recovery	$32,000,000	$1,090,000	700	3,500
Digestion/CHP	$32,000,000	$1,130,000	-1,500	22,000
Digestion/Drying/CHP	$38,000,000	$1,300,000	650	24,000
Gasification	$36,000,000	$1,300,000	2,100	5,600

5.2.1 Financial

The four biosolids handling alternatives all have similar levels of costs. Incineration and digestion with combined heat and power are projected to have both construction and operations and maintenance cost savings relative to the drying and gasification option. The cost differences between incineration and digestion with CHP are not expected to be different.

5.2.2 Environmental

Based on the fossil fuel analysis, the only alternative that has a negative carbon footprint is the digestion alternative. This alternative maximizes power production, offsets space heating demands, and has low input fuel requirements. Drying and incineration have similar carbon footprints with the drying alternative producing more electrical power but requiring a greater input fuel requirement. Gasification has the highest carbon footprint.

Incineration air permits can often be difficult to obtain. However, a new incinerator at the Post Point Plant shouldn't be difficult due to the past experience with incineration and because the proposed incinerator would be a fluidized bed type with lower emissions than the existing MHFs. Digestion with combined heat and power projects are standard for many agencies and the required permit to complete this alternative is not expected to be difficult. The sludge drier alternative would likely be slightly more complex in permitting than a digestion facility but is not expected to be difficult. Gasification is a new process and thus is unknown with regards to permitting.

From a land use perspective the incineration and gasification alternatives have significant advantages over the two alternatives that involve digestion. Digestion options can be located on site and coordination with liquid stream land use requirements have been conducted. An approximate space footprint of this option is shown in **Figure 5-6**.

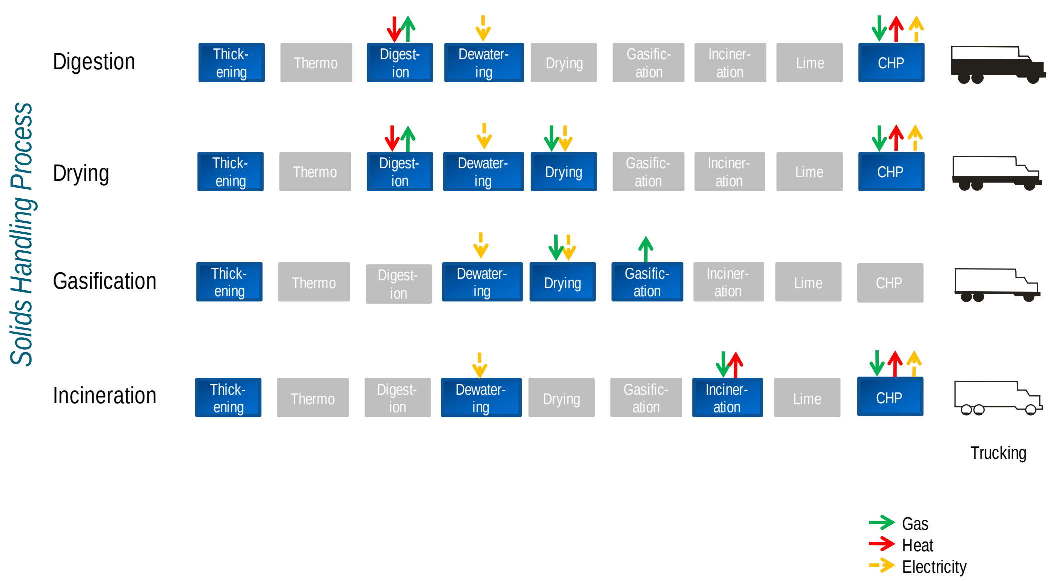
Figure 5-6. Approximate Space Footprint of Digestion/CHP Alternative

5.2.3 Technical

The incineration alternative offers a high degree of operator familiarity, minimal ash haul volume, and ash disposal flexibility. Because the Post Point Plant has been incinerating its biosolids cake for over 30 years, it has proven itself as an effective technology and very little training would be required for a new FBI. Many facilities operate anaerobic digesters. Overall anaerobic digestion is not a mechanically intense or difficult process to control from an operational standpoint. Operators would likely need to learn new laboratory and sampling techniques but overall would transition with minimal problems. Adding the drier to the digester alternative increases the mechanical complexity. Further, operators would need to be cognizant and control the environment around dried sludge pellets to prevent spontaneous combustion of the pellets and a fire from starting. The gasification alternative is the most mechanically complex of the four and would likely require the most support.

In addition to daily operators and maintenance another factor that impacts operations is the ability to handle and dispose the residual byproduct. Bellingham is geographically situated with an international border to the North and the Puget Sound to the West. South of the city lies significant urban and suburban lands that would limit the ability to accept large volumes of wet cake sludge for land application. This would leave Bellingham reliant on wet cake land application programs in Eastern Washington. Access to Eastern Washington is somewhat limited again due to geography and the likelihood of road closures during winter snowstorms in the Cascade Mountains. Therefore the digestion alternative without a drying facility would be severely limited and external storage of wet cake may need to be considered. The other three alternatives significantly reduce the volume of residual needed for storage and thus provide greater flexibility compared to the digestion alternative. Furthermore, Bellingham's experience with incineration has resulted in an efficient and flexible biosolids handling and disposal system via rail car to Vancouver, WA. **Figure 5-7** demonstrates the simplicity of process, the trucking volumes and energy characteristics of the main biosolids handling alternatives. Incineration is a straightforward biosolids handling approach and requires a minimal amount of biosolids handling processes.

Figure 5-7. Biosolids Handling and Energy Alternatives Processes



5.2.4 Social

Residents and business owners located near wastewater treatment plants are typically concerned about four factors – odors, noise, aesthetics, and truck traffic. Incineration and gasification have significant advantages compared to an anaerobic digestion wet cake program. Dried pellet programs can also increase traffic on local roads if the product is sold directly at the treatment plant as is done in many municipalities. From an odors perspective the incineration alternative likely has the least impact as odorous compounds would be combusted. Odor potential from the two alternatives with anaerobic digestion would likely be greater than the other alternatives due to fugitive emissions. Anaerobic digesters will be large tanks around 30 ft tall and 70 ft diameter. These large structures may not be welcomed by local neighbors. Noise emissions could be controlled for all alternatives with acoustical enclosures and treatment.

5.2.5 Conclusions

On a cost basis the four alternatives are similar. However, continued incineration offers many advantages that are not possible from the three alternatives – smaller footprint, ease of operation, flexibility in handling residual byproducts, low odors, low truck traffic, and minimal visual impacts. Anaerobic digestion with wet cake has similar costs to incineration and a lower carbon footprint, but the large land requirements, as well as, potential problems with wet cake disposal during winter storms present significant issues. Additionally, nearby neighbors that are not used to the potential for fugitive odor emissions or the increased truck presence in the streets may prevent it from gathering public support.

Section 6
Biosolids Handling Process—Discussion and Recommended Improvements

To provide capacity and reliability to each biosolids handling processes, CDM has developed recommendations to meet the City's overall objectives while enhancing the plant operations by providing flexibility, reliability, and redundancy. The recommended improvements are outlined in the following order: 1) Operations schedule, 2) Sludge thickening, 3) Dewatering), 4) Incineration, 5) Sludge storage and 6) Fats, oils and grease (FOG) receiving.

6.1 Operations Schedule Improvements

The transition to a 7 days per week operating schedule for the entire treatment plant including the sludge dewatering and incineration activities has been identified as an immediate need for the Post Point Plant. If the Post Point Plant were to add two incinerator operators, the plant could provide 24 hours per day, 7 days per week operations for biosolids handling which would allow for 12 hour shifts for solids handling operations. Dewatering and incinerating on a 7 days per week schedule would require hiring two additional operators at the Post Point Plant. This would provide many benefits including: greater operational flexibility, opportunities for operator development and training, reduced natural gas demand for incineration activities by limiting standby operation, minimization of the liquid stream impacts associated with sludge storage, and increased treatment capacity with the existing equipment installed at the Post Point Plant.

6.1.1 Additional Staffing

As described above, hiring additional operators is a necessary feature of the 7 day per week operations. The additional operators are needed to provide the labor to extend the dewatering and incineration activities beyond the 120 hours per week (24 hours per day x 5 day per week) currently employed.

6.1.2 Staffing Flexibility and Development

In addition to addressing an operational need on the solids side of treatment, the hiring of additional incinerator operators and the transition to a 20 to 24 hours per day operation would also help to address some of the operations needs for the entire drinking water and wastewater division. Current operations use a minimal staff for the operation of the liquid side of treatment, sludge thickening, 50 or more pump stations and the drinking water treatment plant via a SCADA system. During weekend shifts, the entire plant is stationed by a single operator. This staffing arrangement provides little relief to operators during holiday and vacation periods and can make the plant vulnerable during emergency situations.

One potential solution that would minimize the risks associated with the current staffing breakdown would be to eliminate the distinction between incinerator operators and plant operators. By eliminating the distinction and maintaining a staff of operators capable of both positions, the Post Point Plant would be afforded greater flexibility in work assignments and facilitate increased collaboration between plant operators. While one operator would be required to monitor the incinerator when it was in operation, the operators could rotate and suspend incineration as needed to address emergency equipment and staffing related issues. Teaming operators would have the added benefit of facilitating knowledge and experience transfer. An operator with a Class 3 certification could be teamed with an operator with a Class 1 certification as the latter works towards their Class 3 certification. This staffing configuration would help to ensure a well educated and certified operations staff for the Post Point Plant facility.

6.1.3 Natural Gas Usage

Transitioning to a 7 day per week operation will greatly influence when and how natural gas is used for the incinerators. Currently, approximately 1/3 of the natural gas demand is used for hot standby, defined as the time when the incinerator heat is maintained over the weekend when it is not being fueled with sludge. Based on an average day demand of 465 therms, this equates to approximately 56,500 therms of natural gas per year (365 days per year x 465 therms per day x 1/3). While a large portion of this will be recovered by transitioning to a 7 day per week operation, there will be an additional natural gas demand for the actual operation of the incinerator, including the afterburner. Based on historical operating data, the average natural gas demand for the incinerator operations is 14 therms per hour. Thus, by increasing the operations between 20 and 48 hours a week, the yearly operations demand will increase between 14,500 and 39,000 therms. The net natural gas savings is the difference between the natural gas avoided from eliminating standby operation and the natural gas incurred by increased operation, or between 21,500 and 42,000 therms per year. Based on a cost of $0.85 per therm, the prevailing rate for the Post Point Plant natural gas at the time of writing, this represents a savings between $18,275 and $35,700 per year from transitioning to a 7 days per week schedule.

In addition to the economic savings related to the reduced natural gas demand, emissions associated with the incineration process would also be lessened. This includes the criteria pollutants (SOx, NOx, CO, PM2.5, PM10), as well greenhouse gas emissions. Preliminary estimations indicate that reducing natural gas demands between 21,500 and 42,000 therms per year would reduce carbon dioxide emissions between 130 and 250 tons per year, which is the equivalent of removing between 22 and 42 cars off of the road.

6.1.4 Liquid Stream Impacts

One of the key features of transitioning to a 7 days per week operating schedule is that it addresses a key operational problem on the liquid side of treatment: high VFA loading to the aeration basins as a result of storing thickened sludge over the weekend. Storing sludge for an extended period of time, typically more than 8 hours, can cause the sludge to ferment and increases the generation of VFAs. By eliminating sludge storage as the default operation, sludge fermentation and the subsequent VFA loading to the aeration basin will be eliminated. This will reduce VFA loading to the aeration basins by approximately 43 percent according to recent VFA testing performed by Carollo Engineers.

The reduced VFA loading will decrease the oxygen demand in the aeration basins, reduce sludge generation and wasting rates, and reduce loading to the secondary clarifier. This will greatly improve the operations of the liquid side of treatment, which have been near capacity as a result of the high VFA loading.

For further details regarding how the VFAs impacted the liquid side of treatment, see Technical Memorandum No. 14 - VFA Testing Report (April 2010) by Carollo Engineers.

6.1.5 Discussion and Recommendation

Transitioning to a 7 days per week operations schedule is recommended to address the immediate capacity limitations with the sludge incinerators, which have been operating in excess of their design capacity. A 7 days per week operations schedule will also address the operational problems caused to the liquid side of treatment by storing sludge over the weekend period. While the transition to 7 days per week schedule will require hiring an additional operator to cover the extended operating schedule, the added cost of an additional operator is offset by the operational and environmental benefits associated with extended operation. Extending operation will achieve the following at the Post Point Plant:

- Energy
  - Reducing natural gas demands between 21,500 and 42,000 therms per year
  - Reducing greenhouse gas emissions associated with natural gas combustion between 130 and 250 tons per year
  - Reducing the power demands associated with pure oxygen generation and excess sludge pumping
- Labor
  - Providing a more flexible operation of the incinerators by having standby capacity built into each day
  - Providing an additional staff member to round out an operations team capable of breaking up into groups of two for operational flexibility
  - Reducing the operational attention required on the liquid side of treatment as a result of high VFA loading
- Liquid Side Impact
  - Eliminating the VFA loading to the aeration basins thereby reducing:
    - Dissolved oxygen demand
    - Sludge generation
    - Secondary clarifier loading
    - Required operator attention

- Capacity
  - Increasing the operational capacity of the incineration system by extending their operating schedule
- Restoring surplus capacity to the aeration basins and secondary clarifiers by reducing VFA loading
- Eliminating the concern for limited thickened sludge storage during weekend periods by eliminating thickened sludge storage as the de facto operation

CDM therefore recommends the Post Point Plant transition to a 7 days per week operations schedule as soon as possible to address the limitations and operational problems outlined above.

6.2 Sludge Thickening

Although the GBTs have been in operation for 18 years, they have not been under continuous loading. Thus, their state of repair may allow them to operate for longer than the 25 year life expectancy, provided the manufacturer still maintains a supply of parts. Because GBT operations have changed, this time allows Post Point Plant staff to confirm thickening capacity in the near future and to optimize design requirements when it comes time for replacement.

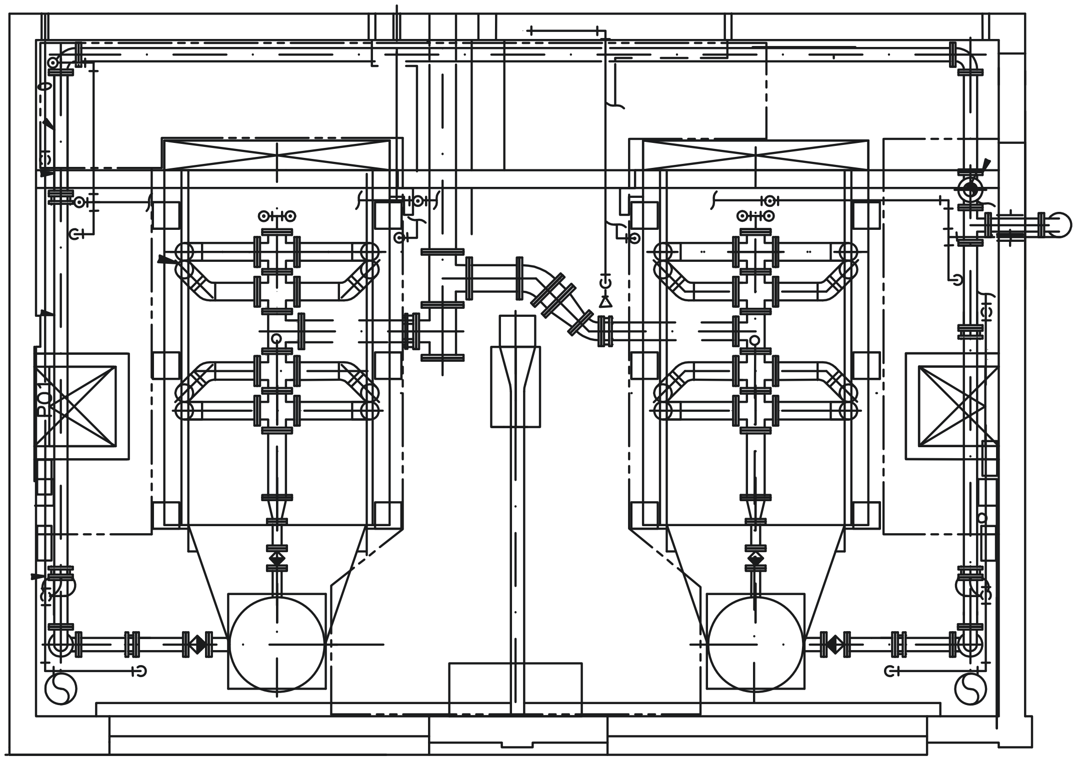
To further define the actual installed capacities of the GBTs, a stress test of the units is recommended. A stress test would involve pushing the units to and beyond their hydraulic and solids capacity to determine their actual installed capacity. A stress test would quantify how performance is impacted at higher loading rates. This information would help the Post Point Plant determine how to best respond to peak conditions with existing equipment. Because the GBTs are not configured for simultaneous operation, the Post Point Plant will need to address these peak hydraulic conditions via another means. This could have the following impacts at the Post Point Plant:

- During peak events, the GBT could be operated in excess of its hydraulic capacity reducing equipment performance. This could increase polymer demand and reduce biosolids capture and thickened solids concentration
- Upgrades to the thickening system could be necessary before the useful life of the existing GBTs is fully realized. Upgrades could include new equipment with higher hydraulic capacities and a piping modification to allow simultaneous operation
- Additional contingency operations may be required to reduce the loading to an individual GBT. Contingency operations could include a primary sludge bypass or a reduced wasting rate for WAS. A primary sludge bypasses could cause an inconsistent feed and performance of the dewatering equipment. Reduced wasting rates could impact the liquid stream treatment

6.2.1 Thickening Beyond the Useful Life of the GBTs

Gravity Belt thickener stress testing may show that the the Post Point Plant will require new thickening equipment with higher throughput capacities to replace the existing GBTs. Ideally, thickening equipment with a firm hydraulic capacity of around 700 gpm and a firm solids capacity of 5,400 lbs/hr would be installed to handle the peak day condition in 2035. However, the existing thickening room at the Post Point Plant is space limited as shown in **Figure 6-1**. Given this, it is recommended that the Post Point Plant install the thickening units with the largest throughput capacity available that can fit within the existing space. The units should be installed in parallel for simultaneous operation during peak events and a contingency operational plan should be developed for the rare circumstance when a peak event occurs when a unit is unavailable. The potential contingencies are discussed above.

Figure 6-1. Space Constraints of Existing Thickening Room



Based on a review of the drawings and discussions with equipment manufacturers, it appears that two 2.2 meter GBTs could be installed in place of the existing units. This would augment the Post Point Plant's existing thickening capacity by 10 percent. Connecting the equipment in parallel would provide sufficient capacity for the peak conditions through the year 2035. While other thickening technologies including dissolved air flotation thickeners (DAFT) and thickening centrifuges were considered, continued reliance on GBTs has numerous benefits for the Post Point Plant for the following reasons:

- DAFTs require a substantial footprint that exceeds the space available in the existing room and site. Preliminary estimates suggest a new DAFT sized for the peak week 2035 load would require a minimum of 1500 square feet. Additionally, DAFTs have high power demand
- Thickening centrifuges are high wear items with high power consumption
- GBTs are familiar to the operators at the Post Point Plant
- GBTs have an excellent performance history at the Post Point Plant
- The installation of new GBTs would require minimal modifications to the existing room, piping, and equipment

6.2.2 Discussion and Recommendation

To provide the Post Point Plant with the requisite thickening capacity in the near term and the short term, CDM recommends continued reliance on the GBT technology. In the short term, the existing units, which are 18 years old, should be monitored to track their performance and their condition. The units are potentially near the end of their useful life and solids projections are increasing such that they may be limited in capacity in the future. The existing units should be stress tested to determine their actual installed capacity so that the Post Point Plant has the means and information to address near term peak conditions.

In anticipation of replacing the existing GBTs, the Post Point Plant should consider installing the largest GBTs that can fit within the existing thickening room. The new GBTs should be installed in parallel to allow for simultaneous operation. Simultaneous operation will enable the Post Point Plant to handle the peak loads through the year 2035. For the rare circumstances when a GBT is out of service during a peak event, a contingency operational plan should be followed. Contingency operations could include bypassing primary sludge directly to the thickened sludge storage tank, or reducing the wasting rate from the secondaries. Investigating the feasibility of installing larger GBTs should be begun by the City within the next five years.

6.3 Dewatering Improvements

Based on the biosolids projections completed earlier, Post Point Plant will require over 5,000 dry lb per hour of dewatering capacity. Centrifuges spin at high speeds and thus require significant maintenance and can experience extended periods of downtime. In order to avoid the cost of a redundant centrifuge, some facilities have purchased an extra centrifuge scroll. This type of solution may be difficult for Post Point as the facility will maintain two different types of centrifuge units. As noted earlier, Post Point could potentially operate through year 2020 with the existing firm capacity (existing centrifuge and the planned 2,500 pound per hour centrifuge). However, this type of operation would require that solids are stored in the thickened sludge tank whenever either the existing or the planned centrifuge is out of service. Since peak week solids production exceeds the firm capacity, some components of the solids would be being stored for in excess of 1 week. Thus, VFA production would be significant during this event.

Due to Post Point staff concerns about VFA production and the impacts that VFAs have on liquids stream treatment, CDM recommends increasing the firm capacity by adding a third centrifuge with capacity for 2,500 pounds per hour. This would increase firm capacity to 4,500 dry pounds per hour and allow fully redundant centrifuge operation through year 2026. By year 2026, the existing centrifuge would be 33 years old and would likely need to be replaced due to its age. Replacing it at that time with another 2,500 pound per hour machine would provide firm capacity through nearly the entire planning period. Centrifuges have proven performance at the Post Point Plant, yet unfortunately their power demands are high. In order to meet the firm capacity requirements the Post Point Plant would require a total of 3 centrifuges in 2035. Due to their capacities there is little opportunity for phasing in centrifuges. The benefits of centrifuge dewatering are as follows:

- Proven performance of centrifuges at the Post Point Plant
- Familiar technology for operators
- Consistent and reliable high solids content of dewatered cake

6.3.1 Discussion and Recommendation

Post Point could potentially operate with two centrifuges, the existing machine and the planned new 2,500 pound per hour machine through year 2020. However, operation with only two centrifuges risks the potential that thickened sludge will need to be stored for periods lasting 1 week in the event one centrifuge is out of service, which will create VFA problems. Thus, CDM recommends installing a third centrifuge with a capacity of 2,500 dry lb per hour. The Post Point Plant should also assess the condition of the existing centrifuge. This centrifuge may be suitable to operate as a redundant unit if parts continue to be available for it. The cost of a new 2,500 lb per hour centrifuge is likely to be between $1 million and $2 million (in 2010 dollars).

6.4 Incineration Improvements

The existing multiple hearth furnace incinerators are undersized, consume significant amounts of natural gas, are operating beyond their typical service life, and as a result are increasingly suffering from mechanical problems making them unreliable. The multiple hearth incinerators need to be replaced with new equipment. Continued incineration is recommended over a change in processes, as Bellingham staff are familiar with incineration operations and the incinerators provide better residual biosolids disposal flexibility compared with anaerobic digestion technology. Continued incineration is also anticipated to be less costly compared to digestion and drying and have a lower carbon footprint compared to sludge gasification.

6.4.1 Incineration Alternatives for the Post Point Plant

Based on the initial screening of biosolids alternatives presented in Section 7.3, incineration was selected as the recommended biosolids processing alternative. In this subsection various types of incineration and energy recovery alternatives were considered. Specifically, the following incineration/energy recovery alternatives were evaluated:

1. Installing a new MHF
2. Installing a new Fluidized Bed Incinerator (FBI) with heat recovery
3. Install new a Fluidized Bed Incinerator (FBI) with heat recovery and power production

6.4.1.1 Installing a New MHF

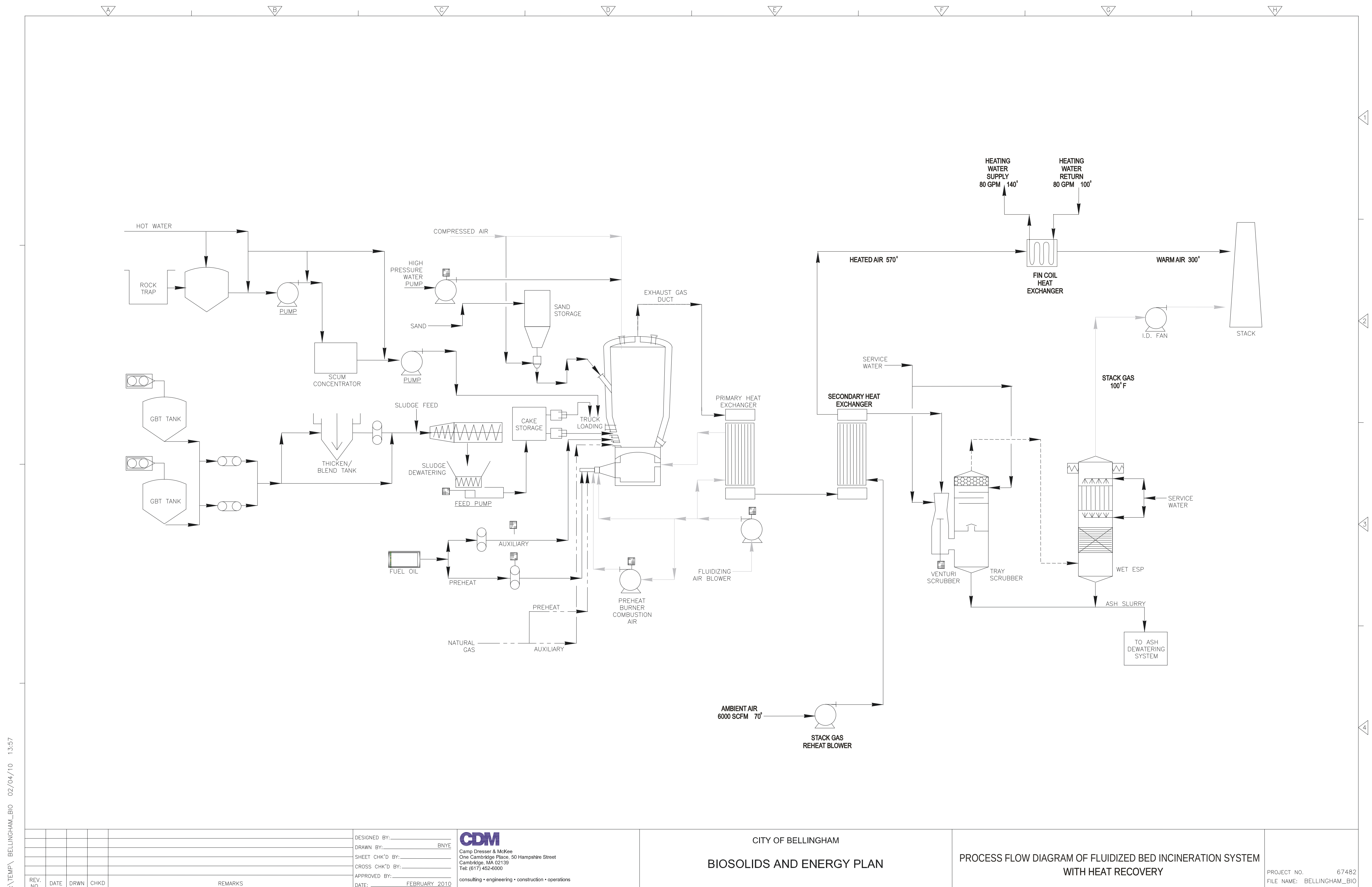
This alternative considers installing a new MHF to meet the future biosolids loading quantities. Although MHFs were extensively used for sludge incineration in the past, there has not been a new MHF sludge incinerator installed in the USA for over 20 years. In addition, all the suppliers of MHFs have gone out of business. The reason for this is that a MHF needs an afterburner to control emissions of the following pollutants, hydrocarbons, carbon monoxide (CO), and odors to meet present–day air pollution control standards. Finally, the EPA is currently developing new air emissions rules related to sludge incineration. These rules, if adopted as proposed, will put equivalent air emissions criteria on MHFs and FBIs. Since MHFs have a more difficult time meeting these limits, new MHFs and potentially existing MHFs may find themselves unable to meet future air emission control requirements.

Due to the high fuel usage resulting from a fired afterburner, MHFs are at a significant disadvantage in comparison with FBIs, which can achieve very low emissions of hydrocarbons, CO and odors while using less fuel. In the past 20 to 30 years FBIs have been the technology of choice for sludge incineration. Therefore, due to the limitations and unavailability of MHFs, installation of a new MHF is not recommended.

6.4.1.2 Installing a New FBI with Heat Recovery

This alternative evaluates installation of a new FBI with a moderate amount of heat recovery. The heat recovery system is designed to recover enough heat in the form of hot water to displace the fuel usage in the hot water heaters in the basement of the Solids Handling Building. The hot water heaters are gas fired and supply hot water for space heating of the Administration/Laboratory Building, Maintenance Building, and Solids Handling Building. A process flow diagram of the proposed system is shown in **Figure 6-2**.

Figure 6-2. Process Flow Diagram of FBI with Heat Recovery



6.4.1.2.1 Process Description

The incinerator would be a hot windbox FBI which would receive 1200° F preheated combustion air from the primary heat exchanger. Flue gas at 1550° F flows from the incinerator through the primary heat exchanger and is cooled to 1000° F. The heat recovery system would consist of a secondary heat exchanger and a fin coil heat exchanger. The secondary heat exchanger would receive the 1000° F flue gas from the primary heat exchanger and cool the flue gas to approximately 700° F while heating approximately 6000 scfm of ambient air from 70° F to 570° F. The 570° F ambient air would proceed through the fin coil heat exchanger where it would heat up approximately 80 gallon per minute of return water from 100° F to 140° F, thereby transferring 1.6 million Btu per hour (MM Btu/hr) of energy to the plant hot water heating system. The hot water is pumped through the plant hot water heating system which services the manned buildings at the Post Point Plant.

The 700° F flue gas from the secondary heat exchanger is sent to the air pollution control (APC) system. The APC system consists of venturi and impingement tray scrubbers for removal of particulate matter, metals and acid gases and a wet electrostatic precipitator (WESP) for additional removal of fine particulate matter. The exhaust from the WESP is drawn by an induced draft (ID) fan which discharges the cleansed gas to the stack. The stack gas is reheated to 220° F by the addition of the exhaust air from the fin coil heat exchanger. Reheating the stack gas is aesthetically desirable because it eliminates any water vapor plume from the stack. At this time it appears likely that the existing WESPs and ID fan are adequately sized to handle the flue gas flow from the new FBI. However, a thorough inspection of the WESP and ID fan will have to be made (during the subsequent design phase) before a final determination on the suitability of these components can be made.

Unlike a MHF, all the ash from a FBI is carried out of the incinerator in the flue gas and is removed as a liquid slurry in the venturi scrubber water. The ash-laden scrubber water from the venturi scrubber will be sent to an ash thickener which will concentrate the ash to a 10 percent to 15 percent solids slurry which will then be pumped to a one-meter belt filter press for dewatering. The dewatered ash cake at 30 percent to 35 percent solids would then be discharged to an ash hauling truck.

6.4.1.2.2 Capacity

New FBI incinerators are typically sized between the maximum week and maximum month condition of the design year. In order to ensure adequate footprint for the components are available and to keep the analysis conservative in nature, CDM has sized the incinerator for peak week conditions at 2,770 dry lb/hr. CDM recommends that this size be revisited in the preliminary design stage to optimize project costs with processing capacity.

Because the FBI is not being sized for maximum day conditions, the facility will require sludge storage upstream of the FBI. Sludge storage is discussed in a subsequent sections of this document.

6.4.1.2.3 Location of the New FBI

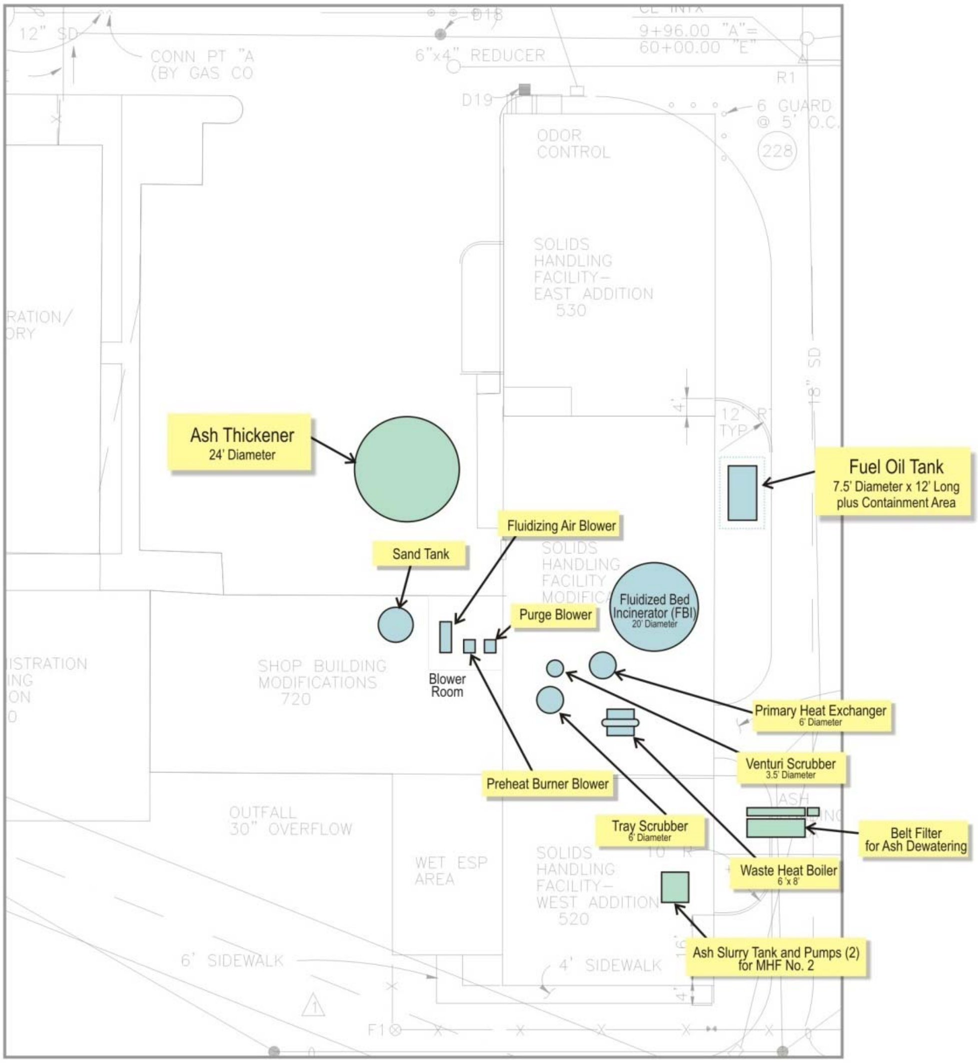
The size of a 2,770 dry lb/hr FBI and its accompanying heat exchangers and APC equipment presented some challenges in locating space for the new FBI system. A 2,770 dry lb/hr FBI will have a freeboard diameter of approximately 20 feet and an overall height of approximately 41 feet. The following alternative locations for the FBI were considered:

1. Remove Incinerator 2 and install FBI in its place
2. Remove Incinerator 1 and install FBI in its place
3. Relocate Maintenance Shop Building and install FBI in its place

The building space required for the FBI has to be free of any building columns over a minimum 20 ft by 20 ft area. Given the space required by the new FBI and its auxiliary components, the building space occupied by Incinerator 2 is not sufficient. In addition the height of the Solids Handling Building would have to extend over the FBI and the primary heat exchanger.

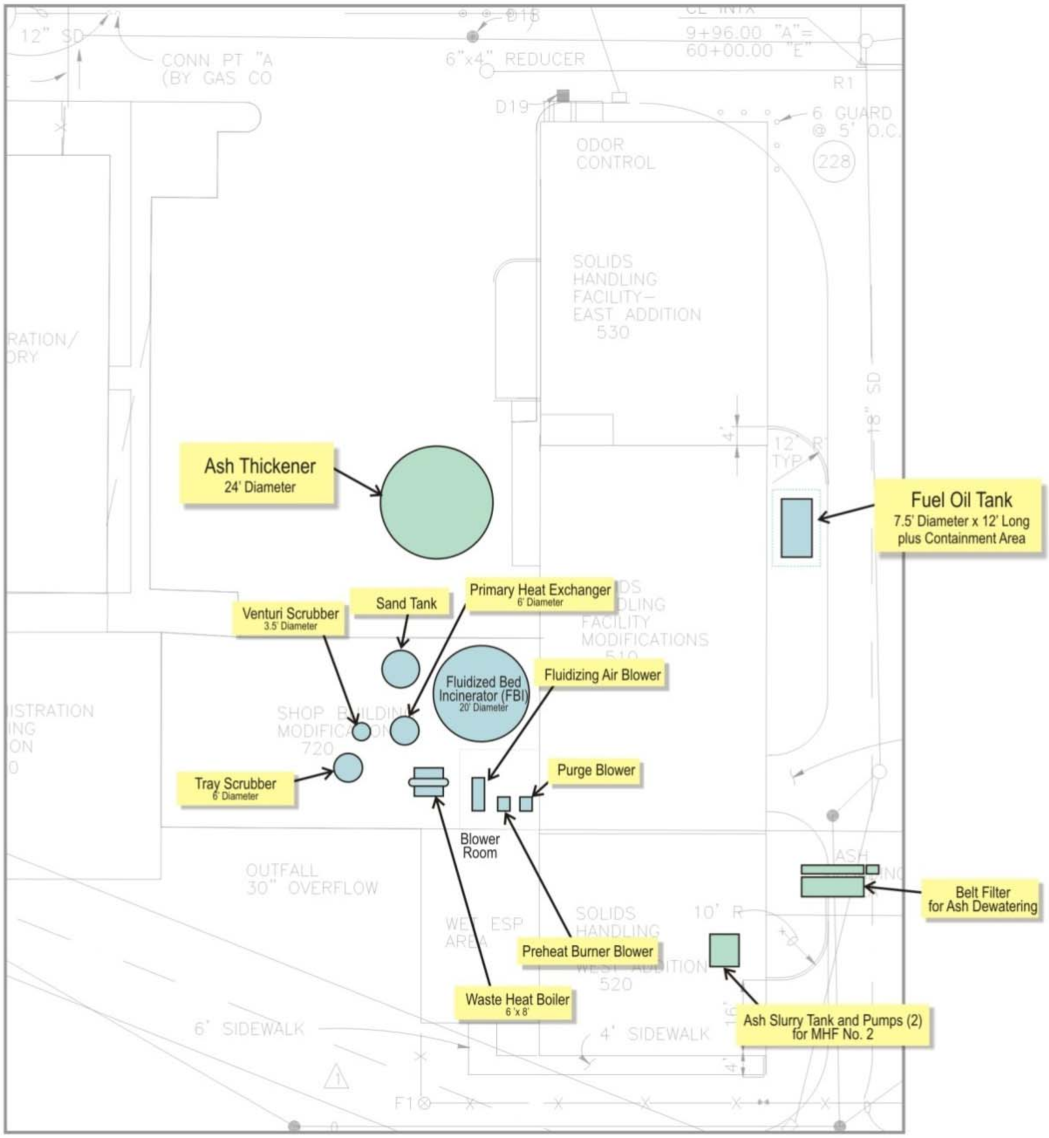
The building space occupied by Incinerator 1 has been determined to be adequate. However, major structural modifications of the building would be required and the building height around the incinerator would have to be raised. In addition, some of the space in the Maintenance Shop Building would be required to house some of the FBI's auxiliary components such as the fluidizing air blower, purge blower and preheat blower. Another disadvantage of this alternative is that it would require demolishing the incinerator (Incinerator 1) which possessed the better operating characteristics of the two MHFs, namely less fuel usage and less clinker formation. The plant staff has indicated that they would much prefer to demolish Incinerator 2 than Incinerator 1, even though Incinerator 2 is considerably younger than Incinerator 1. A plan view of the FBI location in place of Incinerator 1 in the existing Solids Handling Building with a portion of the necessary equipment located in the Maintenance Shop Building is shown in **Figure 6-3**.

Figure 6-3. FBI Sited in Place of MHF Incinerator 1



The third alternative location for the FBI, the Maintenance Shop Building, has ample space for the FBI and its heat exchangers and APC system. In addition, neither of the existing MHFs would have to be demolished. The City could decide if and when either of these units would be removed. Thus, the City could use either unit as a standby unit for the new FBI. An additional benefit of siting the FBI in the Maintenance Shop Building is that there is adequate space to add power production equipment should it be desired in the future. A plan view of the FBI located in place of the existing Maintenance Shop Building is shown in **Figure 6-4**.

Figure 6-4. FBI Sited in Place of Existing Maintenance Shop Building



Note that the existing Maintenance Shop Building would have to be essentially demolished and a new steel frame building erected in its place to house the new FBI system. Relocation of the Maintenance Shop Building has already been included as an option in the ongoing plans for liquid stream upgrades at the Post Point Plant. Given the advantages of using the Maintenance Shop Building space, this location is the recommended one for the new FBI.

6.4.1.2.4 Energy Savings

The heat recovery system proposed for this would extract heat from the exhaust and transfer the heat to the Heating Water Supply/Heating Water Return (HWS/HWR) system in a fin coil heat exchanger. This fin coil heat exchanger would be sized such that whenever the FBI would run, the HWS/HWR boilers could be shutdown. This would reduce the natural gas requirements for the Post Point Plant. Based on data provided by Post Point Plant staff approximately $125,000 in natural gas could be saved annually. It should be noted that the Post Point Plant data appears to have a high natural gas demand for space heating. It is recommended that these values are confirmed during preliminary design to assure that the heat recovery system is properly sized and that the actual savings are achievable.

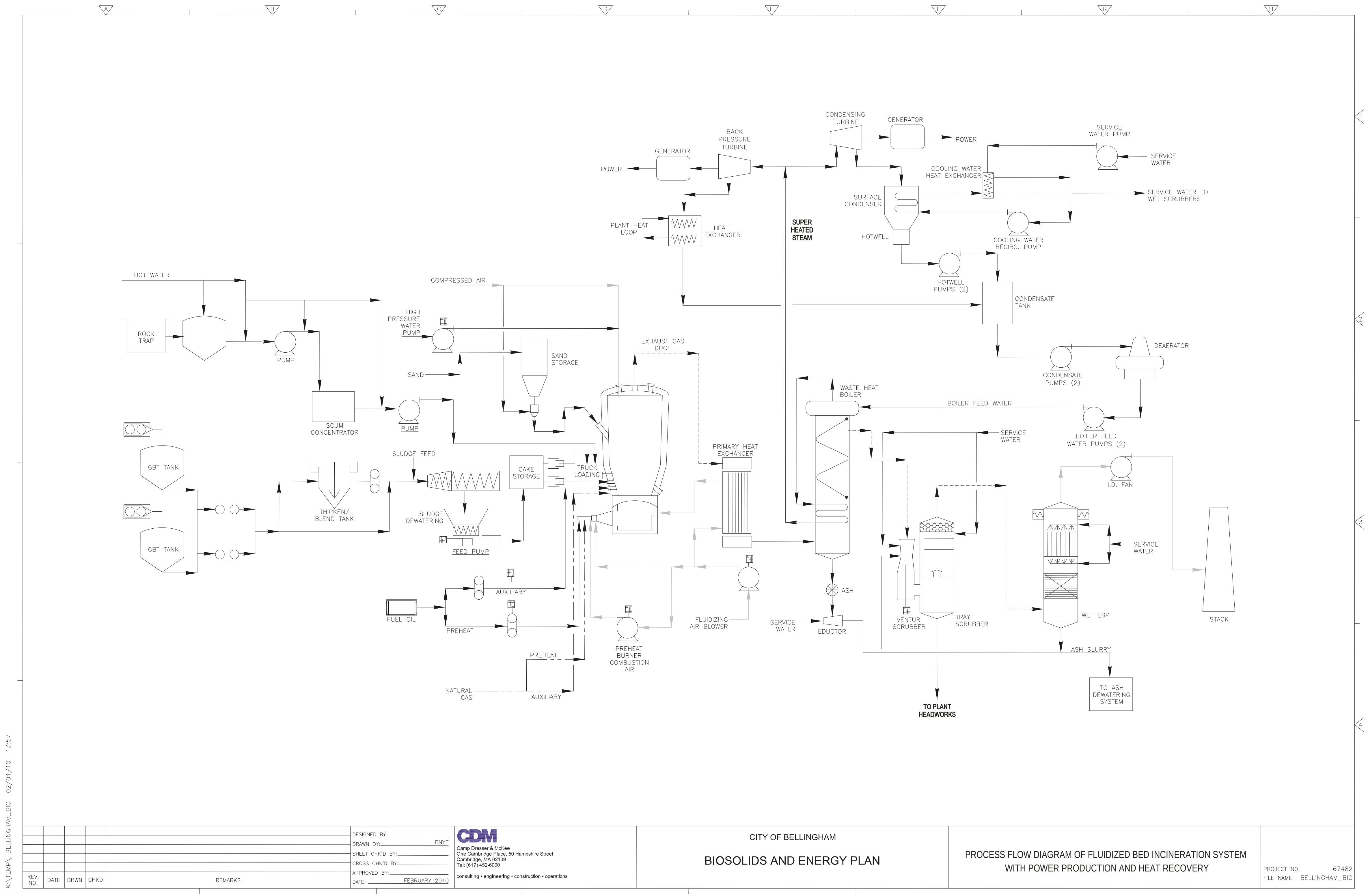
6.4.1.3 Install New FBI With Heat Recovery and Power Production

This alternative evaluates installation of a new FBI with power production. Conceptually, this alternative is similar to the previous alternative except that the energy in the incineration flue gas would be recovered as steam which would then be converted to electrical power. The electrical power would be used to displace the purchased power at the treatment plant.

There are several methods for achieving both heat recovery and power production from the incinerator flue gas. CDM believes that the most cost effective solution would be to use the incinerator flue gas in a steam boiler. The steam boiler would produce super heated steam. Super heated steam would then be used in two different steam turbines. A base load sized to meet the average annual plant heat demand would be diverted to a back pressure turbine. In the back pressure turbine, the pressure of the steam is dropped in the process of producing electrical power of approximately 35 kW, however, leaving a low pressure steam exiting the turbine. This low pressure steam would then be sent to a steam to water heat exchanger where it would be used to heat the plant heat loop and the space heating needs of the Solids Handling Building. Steam load to the back pressure turbine would be controlled such that the steam to water heat exchanger converts all steam to condensate and no additional waste heat system.

Steam not used by the back pressure turbine and steam to water heat exchanger would be passed through a condensing turbine. The condensing turbine is more efficient at producing electrical power compared to the backpressure turbine, but also fully consumes the steam and thus leaves a liquid condensate that cannot effectively be used for space heating. The condensing turbine is estimated to be 160 kW. A process flow diagram of the proposed FBI system with power production is shown in **Figure 6-5**.

Figure 6-5. Process Flow Diagram of FBI with Power Production and Heat Recovery



6.4.1.3.1 Process Description

The incinerator system would consist of a 2,770 dry lb/hr hot windbox FBI with a primary heat exchanger. The primary heat exchanger would preheat the combustion air to 1200° F and thereby maintain essentially autogenous (without fuel use) combustion in the FBI. The flue gas exiting the primary heat exchanger at 10000 F would then enter a waste heat boiler (WHB) which would produce approximately 5,450 lb/hr of superheated steam at 400 psia and 600° F. The flue gas would exit the WHB at 430° F and then enter the APC system consisting of a venturi scrubber, impingement tray scrubber and WESP. An ID fan downstream of the WESP would convey the flue gas through the system and maintain a negative pressure in the WHB. The superheated steam would be sent to a steam turbine with 400 kilowatt generator for electrical power production. The expanded steam from the turbine would be discharged to a surface condenser which would use cooling water to condense the steam to liquid water (i.e. condensate). The cooling water would be circulated in a closed loop through a heat exchanger which would transfer the heat gained from the condensed steam to the plant service water. The plant service water would exit the heat exchanger at approximately 105° F and be used in the wet scrubber systems. The condensate from the surface condenser would be pumped to a deaerator which would preheat the water and remove dissolved oxygen. Lastly, the preheated water would be pumped by the boiler feed water pumps to the WHB.

The ash slurry from the Venturi scrubber and WESP would be sent to the ash dewatering system consisting of an ash thickener and belt filter press. The dry ash that falls out of the WHB would be slurried with water and sent to the ash thickener.

6.4.1.3.2 Capacity

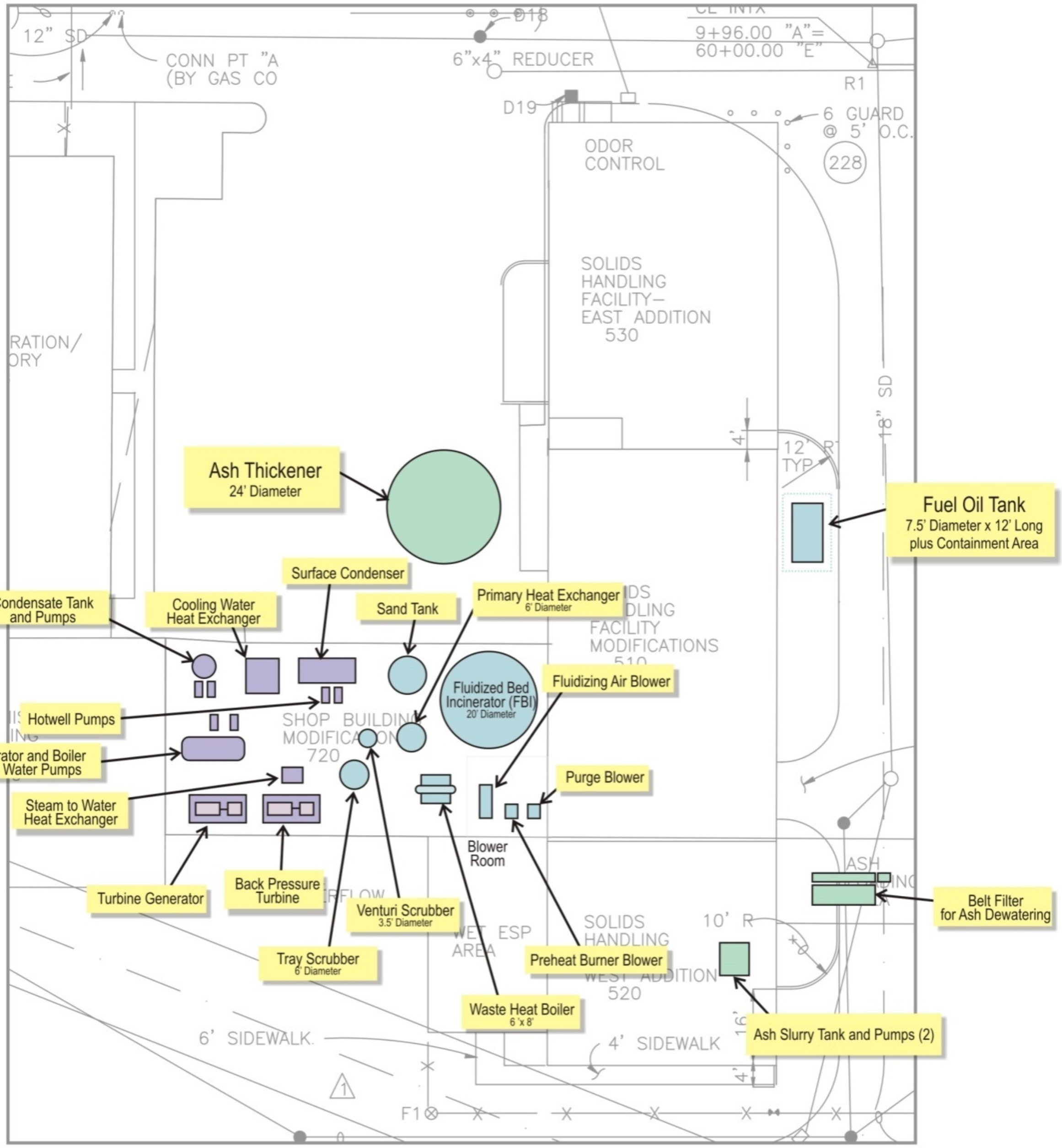
New FBI incinerators are typically sized between the maximum week and maximum month condition of the design year. In order to ensure adequate footprint for the components are available and to keep the analysis conservative in nature, CDM has based this report on the maximum week condition in 2035 of 2,770 dry lb/hr. CDM recommends that this size be revisited in the preliminary design stage to optimize project costs with processing capacity.

Because the FBI is not being sized for maximum day conditions, the facility will require sludge storage upstream of the FBI. Sludge storage is discussed in a subsequent sections of this document.

6.4.1.3.3 Location of the FBI and Power Production System

For this alternative the entire Maintenance Building area would have to be utilized since the FBI with power production equipment will not fit in the existing Solids Handling Building. The proposed layout of the FBI and power production system is shown in **Figure 6-6.**

Figure 6-6. FBI and Power Production Equipment Sited in Existing Maintenance Shop Building Area



6.4.1.3.4 Energy Savings

The power production between both the back pressure turbine and the condensing turbine is approximately 200kW and has the potential to reduce $93,000 in electrical costs annually. The heat recovery system would allow the HWS/HWR boilers to be taken off-line whenever the incinerator is in use and thus could reduce natural gas space heating costs by $125,000 annually. I t should be noted that the Post Point Plant data appears to have a high natural gas demand for space heating. It is recommended that these values are confirmed during preliminary design to assure that the heat recovery system is properly sized and that the actual savings are achievable.

6.4.2 Discussion and Recommendation

Power production for an incineration system is advantageous from both an energy perspective and from a greenhouse gas perspective. However, the cost of power production in sludge incinerators is very high. For Bellingham, the cost of the power production component is around $8 million. The cost of a power production component will likely not be paid back during the operation of the FBI, however, in a community such as Bellingham where an importance on renewable energy and maintaining a sustainable process are important power production may be considered.

6.5 Storage Improvements

Sludge storage capacity is required in nearly all biosolids handling processes. Storage provides the ability to decouple continuously running processes and optimize operations of each. Storage is also used to reduce the costs of certain equipment, effectively allowing equipment to be sized for loadings less than the peak day and using the storage to attenuate loadings that exceed the peak conditions. A final reason for storage is to provide redundancy for equipment that is expensive and whose cost cannot be justified to sit idle for most of its design life.

6.5.1 Thickened Sludge Storage

Sludge dewatering equipment is costly to purchase, install, and operate. Sludge storage upstream of dewatering is often provided to reduce the costs of the equipment and to allow the equipment to be operated at a relatively steady capacity in order to optimize performance and reduce operating costs. The Post Point Plant has three tanks for storing thickened sludge upstream of dewatering. Two of the tanks, each with a volume of about 16,000 gallons, sit directly below the gravity belt thickeners and receive the thickened sludge. The third tank is just downstream of the other two and has a capacity of 78,000 gallons. The smaller tanks can hold between 8,000 and 9,000 lbs of dry solids, each, and the larger tank can hold between 39,000 and 44,000 lbs of dry solids.

Removing any of the thickened sludge storage equipment would reduce operational flexibility and impact the plants ability to respond to emergency situations. Under normal operation, CDM would recommend that all thickened sludge tanks are operated at a minimum liquid level. This would reduce the residence time of thickened sludge in the tank and inhibit VFA formation. The tanks are currently essential as there is currently only one operating centrifuge and thus, the tanks could be used to store thickened solids in the event of an unplanned removal of this centrifuge. Even in the future, when three centrifuges are available, the tank provides an additional level of security to handle unplanned and emergency situations.

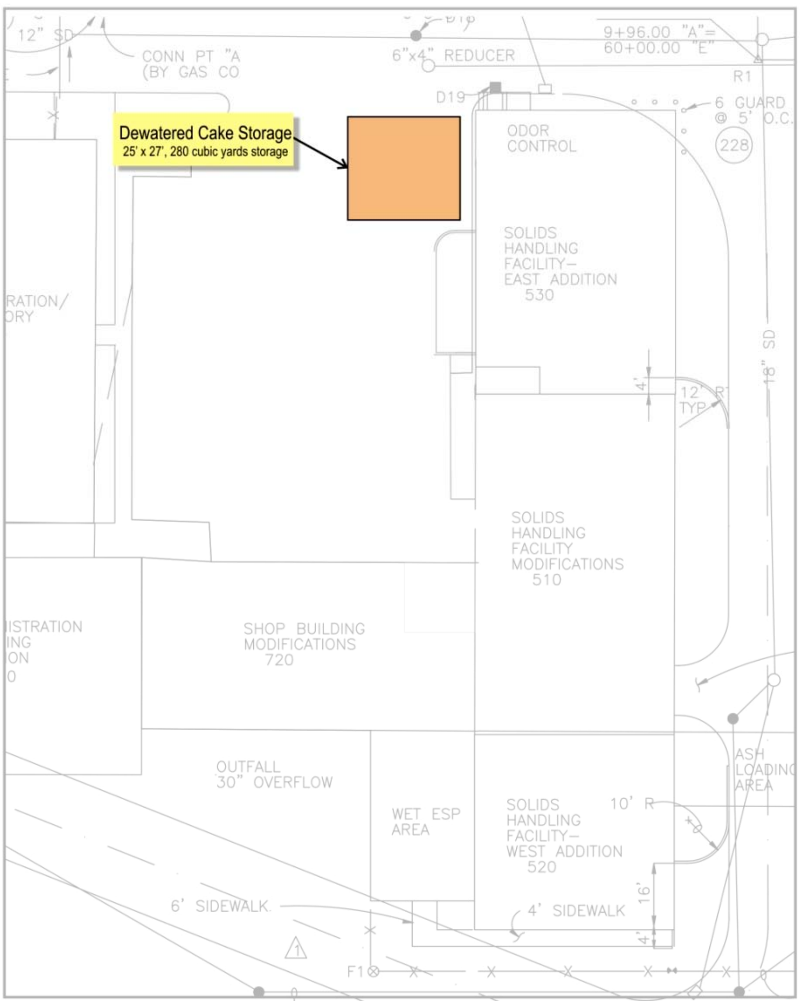
6.5.2 Dewatered Cake Storage

In order to limit the expected costs of the new incineration facility, CDM has recommended that the new fluidized bed incinerator be sized to handle the 2035 peak week loading condition of 2,770 lbs per hour. Further, the cost of the new incinerator equipment does not justify adding a fully redundant incineration unit.

The peak biosolids production during the planning period is 5,080 lbs per hour, whereas the maximum capacity of the proposed incinerator is only 2,770 lbs per hour. In order for the facility to accommodate peak day loads, the plant needs nearly 55,000 lbs of dry solids storage. Since incinerator redundancy would not be provided in the proposed facility, CDM recommends that a total of 1 to 2 days of storage capacity is provided prior to incineration. This capacity would allow the Post Point Plant staff to repair any equipment that fails during operation or, in the event of a maintenance issue with an extended repair time, find an acceptable alternate method of sludge disposal.

The most cost effective means of sludge storage is gained by adding dewatered cake storage after the dewatering process. Dewatered cake storage could be located immediately north of the existing Solids Handling Building as shown on **Figure 6-7**. This location allows the installation of approximately 280 yd^3 of dewatered cake storage, 118,000 lbs of dry solids, enough capacity for 50 hours of sludge storage in the 2035 peak month event and 23 hours in the 2035 peak day event.

Figure 6-7. Dewatered Cake Storage Location

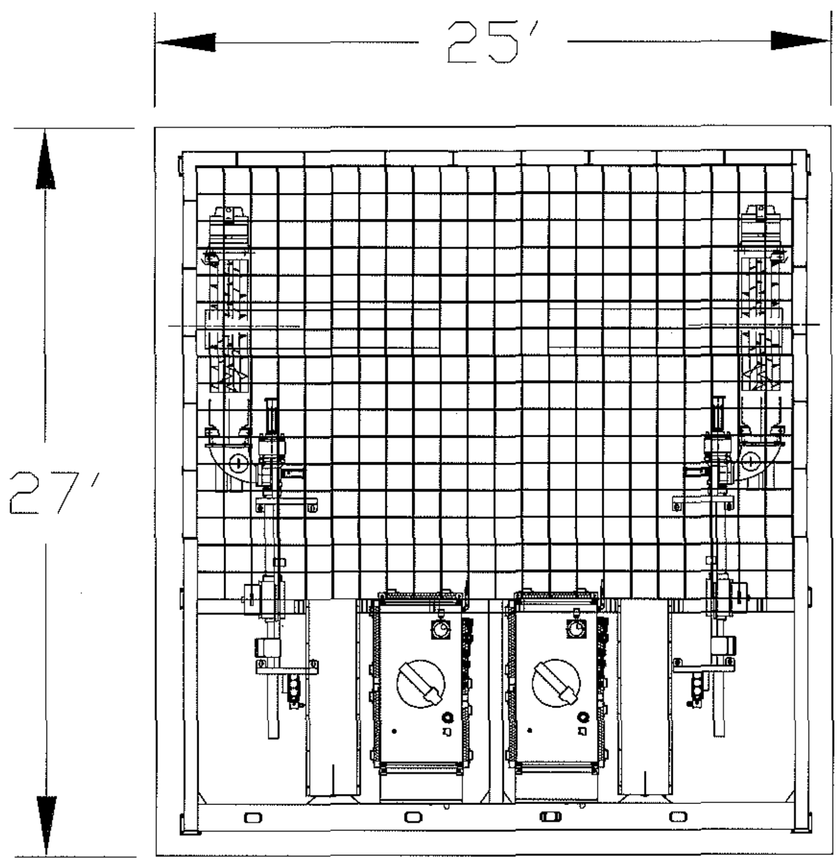


CDM recommends the Post Point Plant install a dewatered cake storage bunker similar to the one shown in **Figure 6-8**. The bunker is a carbon steel push floor, live bottom bin with a storage capacity of 280 yd^3.

Provided in the dewatered storage equipment package are two extraction screw conveyors and knife gates, one push floor hydraulic power unit with control panel, two twin screw feeders, two incinerator feed piston pumps, two sludge flow measuring systems, two hydraulic power units, and two feed pump control panels. The bunker is equipped with two hydraulic cylinders that operate a push floor inside the bunker. The push floor reciprocates across the bunker floor, preventing bridging and allowing uniform drawdown of biosolids on a first-in, first-out basis. Twin screw feeders receive the biosolids from the extraction screw conveyors and pressurize the feed into the incinerator feed pumps. The dewatered storage bunker is also capable of offloading cake to a haul truck if needed (i.e., if solids loading exceeds the incinerator capacity and the cake must be disposed offsite). All serviceable components are located external to the bunker for easy maintenance.

The cost of the storage bunker equipment is approximately $1 million. Smaller dewatered cake storage could also be provided, however the cost savings are not significant. CDM contacted the manufacturer and learned that a 120 yd^3 silo unit, while taking less space footprint, would save only around 25 percent of the equipment cost price. Further, the 280 yd3 dewatered cake storage provides all the recommended storage without requiring any storage in the existing sludge holding tanks.

Figure 6-8. Dewatered Cake Storage Equipment, Plan View



6.5.3 Discussion and Recommendation

Sludge storage provides the ability to decouple continuously running processes and can provide redundancy for equipment that is expensive and whose cost cannot be justified to sit idle for most of its design life. Sludge storage can also reduce the costs of certain equipment, effectively allowing equipment to be sized for loadings less than the peak day. In this case, the storage is used to attenuate loadings that exceed the peak conditions.

CDM recommends the Post Point Plant retain the existing thickened sludge storage tank. The tank is needed in the short term to handle peak solid loads, and can be used as an emergency storage tank in the future in the event that dewatering equipment is off-line. The thickened sludge storage tank has the capacity to attenuate over 39,000 pounds of dry solids.

CDM recommends the Post Point Plant install a dewatered storage bunker to provide a total of 1 to 2 days of storage capacity prior to incineration. This capacity would allow the Post Point Plant staff to repair any equipment that fails during operation or, in the event of a maintenance issue with an extended repair time, find an acceptable alternate method of sludge disposal.

6.6 Adding Fats, Oils and Grease (FOG) Receiving

Fats, oils, and greases (FOG) are generated at residential, commercial, and industrial establishments. FOG presents difficulties for municipalities. In the sewers the FOG can build up and line the conveyance system, thus reducing its capacity. At the treatment plant the FOG is difficult to remove and tends to float in treatment processes in the form of scum. The floating scum can be a nuisance and a source of odors. Also, when the FOG enters the secondary treatment system, it adds to the aeration demand and can also decrease the quality of the treated effluent.

FOG is typically characterized in two forms. Yellow grease is typically found from producers using deep fat fryers and has the potential to be converted to biodiesel. Brown grease is a mixture of fats, oils, and greases and has the potential to be processed through Post Point Plant's biosolids handling system as a recoverable energy source.

Many agencies have begun FOG control programs to reduce the problems outlined above. These programs typically contain the installation of FOG separators at key points in the sewer system, more stringent regulation on commercial and industrial generators of FOG, including mandatory grease trap record collection, grease trap inspections, or a municipal provided grease trap cleaning program. These programs can successfully reduce the FOG entering the sewers and the treatment plant, resulting in positive benefits for the municipality. However, the programs generate large quantities of brown grease, which must be disposed of properly. The most common method of large quantities of brown grease disposal is in a landfill.

Many treatment plants are now finding that brown grease, when handled separately can be a benefit to the plant. For the Post Point Plant, the brown grease contains a high energy content and could be used to offset fuel requirements for the incinerator. Further, a brown grease acceptance program can provide an additional source of revenue for the Post Point Plant as it would offer a more economical alternative for disposal compared to landfills.

6.6.1 FOG Alternatives

All FOG receiving operations at the Post Point Plant require the following:

- A FOG receiving tank with upstream rock box or screening equipment. The FOG receiving tank needs to be in excess of 3,000 gallons to handle a typical tanker truck volume. The rock box is required as haulers will haul other items besides FOG. They may pick up rocks and debris from other facilities, which could be discharged to the Post Point Plant. The rock box or screening equipment protects the FOG system. A rock box would need to be located to allow vactor truck access, whereas screening equipment would need to allow truck pick up of screenings material.

- Installation of a new FOG concentrator. Grease trap waste contains significant quantities of water. A dilute grease will no longer be beneficial to the incinerator as the energy required for evaporation of the water would be greater than the fuel value in the FOG. The existing scum concentrator is old and needs to be replaced. A new scum concentrator could be replaced in the existing location

- FOG pumping equipment. FOG pumping will be required between the new FOG receiving tank and the new FOG concentrator. FOG pumping would ideally be a positive displacement pump to allow a controlled loading to the FOG concentrator

- Odor control. FOG receiving and holding has a potential to be a source of odors, particularly on warm summer days. Tying the FOG receiving tank into an odor control system will alleviate concerns for odors

- Hot water or steam for periodic cleaning. FOG receiving facilities will periodically require cleaning. Hot water or steam should be routed to the FOG receiving facilities to facilitate periodic cleaning

The Post Point Plant has several locations that could be used to site a FOG receiving facility. The locations that have the highest potential for use are as follows:

- Existing primary scum box

- Existing GBT thickened sludge receiving tank

- Existing tank underneath ash loadout

- New scum receiving facility adjacent to the plant's influent screens

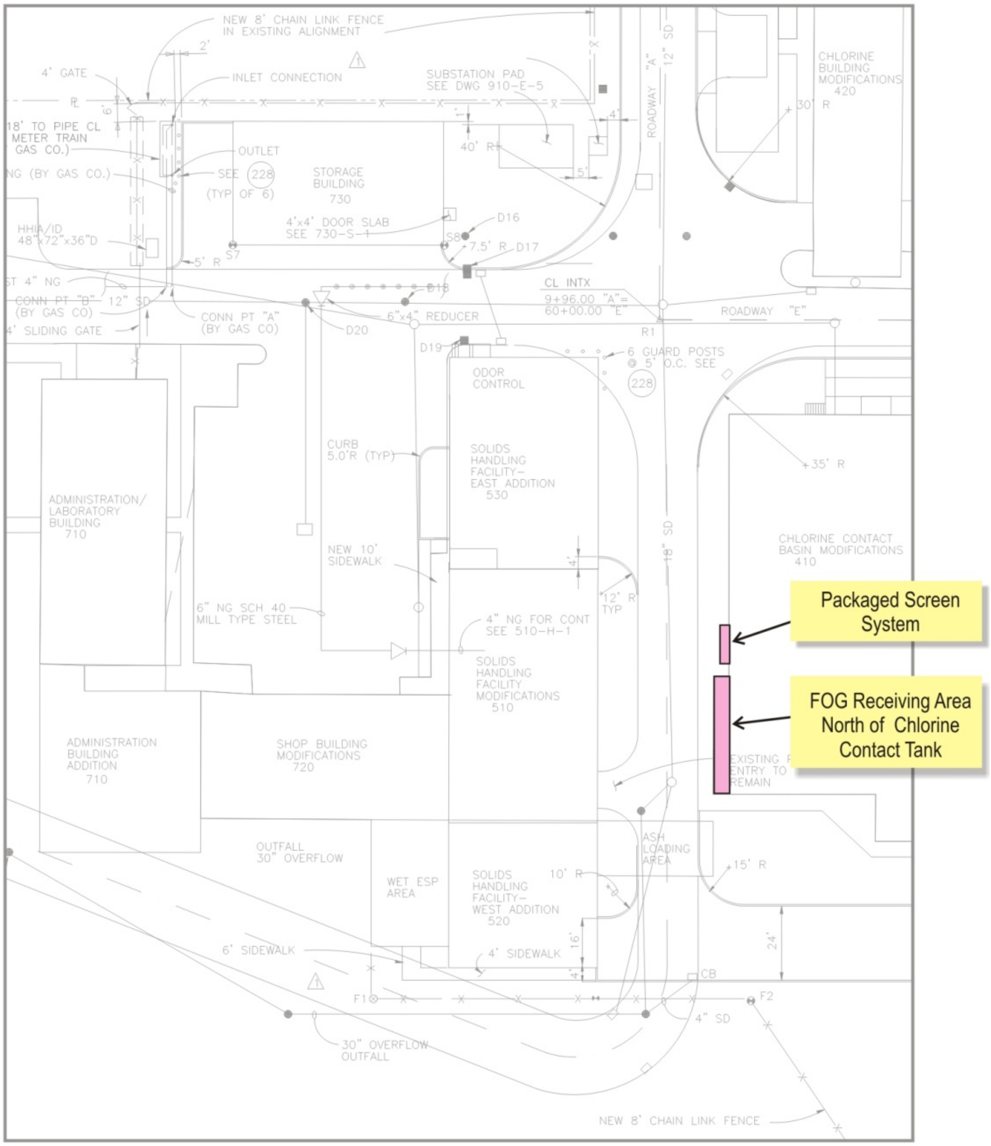
- New scum receiving facility adjacent to the solids building

- Existing scum box

6.6.1.1 Existing Primary Scum Box

FOG could be received at the existing scum box located north of the chlorine contact tank as shown on **Figure 6-9**. This tank was originally used for primary scum handling and has a pump and pipe that discharges to the existing scum concentrator. The tanks bottom is about 5 feet below grade and is connected to the existing scum transfer pipe. The walls of the tank extend to approximately 6 ft above grade.

Figure 6-9. FOG Receiving Location North of Chlorine Contact Tank



The advantages of this option include minimal capital and construction costs, a limited FOG pumping distance due to the proximity to the solids building, and the intangible benefit of utilizing a currently abandoned asset. This location, however, may not have ready access to steam or hot water for maintenance. FOG would likely need to be screened as opposed to discharged into a rock box. A packaged screen with washer compactor made for above grade applications could be sited adjacent to the scum box. Screened FOG would gravity drain directly into the scum box. Because of the gravity drain, only the lower portion of the existing tank could be utilized for handling. The below grade volume of this existing tank is about 2,500 gallons. The packaged screen system would also have a small reservoir that could temporarily handle the excess volume in a typical 3,000 gallon truck. Packaged screens are effective at removing debris from FOG, however, they are not designed for grit and sand that may get into trucks which these trucks may pick up under other contracts. Grit and sand can potentially damage the screenings equipment.

Hot water and process water would need to be routed to the truck offloading screen to accommodate screenings washing and for general maintenance. The location of this scum box, less than 100' from a popular public walking path would dictate that odor control be provided. A simple stand alone odor control system that includes covers for the existing scum box and screen system, an odor control fan to maintain negative pressures in the scum box and the screen system, and an activated carbon canister could be used. FOG vapors can present unique problems with activated carbon units, thus CDM recommends that a demister with a high pressure hot water tap be installed nearby for maintenance.

6.6.1.2 Existing GBT Thickened Sludge Receiving Tank

Sludge thickened from the GBTs drops into two receiving tanks. Each tank has a volume of 16,000 gallons with each dedicated to the GBT located directly above the tank. There is currently no ability to drop sludge from one GBT into the tank underneath the adjacent GBT.

Although one of the tanks could be isolated from the GBTs and retrofitted to receive FOG from an adjacent rock trap, located just outside the Solids Handling Building, the both tanks are required to meet thickened sludge storage needs upstream of dewatering. Therefore, they are not recommended to receive FOG.

6.6.1.3 Existing Tank Underneath Ash Loadout

An existing 41,000 gallon tank located underneath ash loadout. The tank is irregular in shape with a flat bottom and access into the tank is limited to a single manway. The volume of the tank is significantly larger than required since the volume of a single FOG truck would only discharge about 9 inches of liquid into the tank. The tank is also located in a congested area adjacent to multiple hearth 2 and the ash conveyor. There is limited room for siting FOG pumping equipment and routing the odor control ducting. This location is not recommended for FOG receiving.

6.6.1.4 New FOG Receiving Adjacent to the Influent Screenings Facility

A new FOG receiving facility could be sited adjacent to the Influent Screenings Facility. The facility would require a rock box and a 4,500-gallon heated storage tank. The rock box would be installed below grade with a weir overflow to the adjacent storage tank. Warm FOG could be continually pumped through a glass-lined circulation loop between the screenings facility and the FOG concentrator in the Solids Handling Building. The benefits of FOG receiving at the Screenings Facility include limited odor issues because of the closed process loop and discharge (low odors), limited stratification due to constant mixing in the process loop, easy utilization of incinerator heat to maintain a high FOG temperature and low viscosity, increased use of the screenings facility receiving station, and prevention of increased truck traffic to other parts of the plant.

The drawbacks of this option are that a heated storage tank, pumping appurtenances, and over 100 feet of glass-lined pipe would need to be installed to store and convey the FOG.

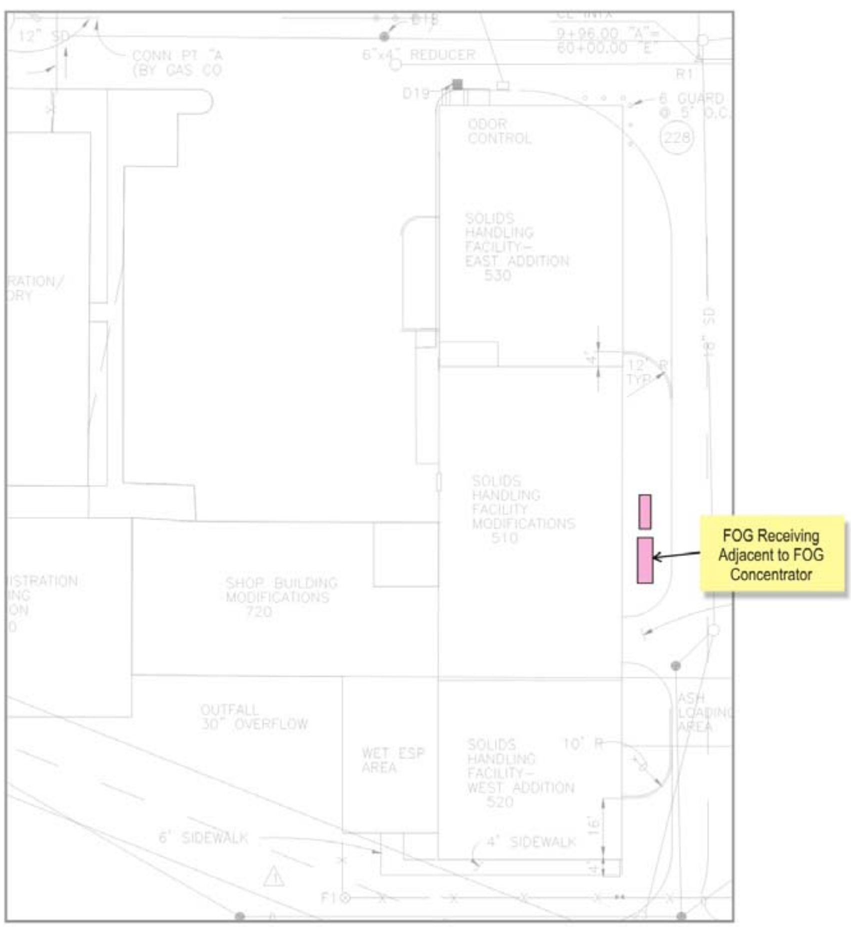
6.6.1.5 New FOG Receiving Adjacent to the FOG Concentrator

New settling and storage tanks could be installed on the south side of the Solids Handling Building, East addition. The rock box would be located below grade and have a weir overflow to the adjacent storage tank. Due to the location, it would be relatively easy to route hot water to this location. Additionally, odor control of the tank and the rock box could be tied into the existing odor control system that connects to the large thickened sludge storage tank. No additional changes are anticipated for the existing odor control system. A new positive displacement pump could be located adjacent to the FOG concentrator and would draw from the new storage tank and feed the FOG concentrator.

The primary advantages of this option include easy access and egress to the FOG receiving tank, minimal pumping distances due to the close proximity to the scum concentrator, easy access to hot water or steam for maintenance, access to odor control ducting, and tanks and piping dedicated exclusively to handling FOG. The facility would also be located adjacent to an existing truck path providing easy unloading for the drivers.

The new rock box would be approximately 9 ft by 3.5 ft with a depth of 8 ft. The rock box would be covered with checker plate and have a connection for the FOG hauling truck. A gravity overflow pipe from the surface of the rock box would flow to an adjacent 4,500 gallon below grade, FOG storage tank. Both the rock box and storage tank could be constructed of precast polymer concrete to provide superior corrosion resistance compared to lined tanks. These new facilities would be sited between the solids building and the ash loadout driveway. The location and anticipated footprint for this alternative is shown on **Figure 6-10**.

Figure 6-10. FOG Receiving Location Adjacent to FOG Concentrator



6.6.2 Discussion and Recommendation

There are several existing tanks that could be applicable to FOG receiving, however only the existing scum box north of the chlorine contact basis is truly a feasible alternative. For the other two existing tanks that are not applicable for FOG receiving, either their size or their locations relative to the important features of a receiving system make them impractical for use in FOG receiving facilities. New tanks could be located in one of two locations – adjacent to the influent screens or adjacent to the Solids Handling Building and the FOG concentrator. The anticipated costs of both options are expected to be similar, with the location adjacent to the Solids Handling Building requiring less disturbance at the plant as only a single location is undergoing construction. Post Point Plant staff has stated that they prefer using the existing scum tank and utilizing existing assets.

Section 7
Conclusion and Recommendations

From a condition standpoint, the current biosolids handling system at the Post Point Plant is nearing the end of its useful life. CDM estimates that several components of the existing biosolids handling equipment, particularly the incineration and dewatering equipment, need attention within the near term and the City should plan for upgrades soon. It is possible that the equipment can operate successfully for approximately another 5 years, although with every year that passes beyond 2015, the risks of capacity constraints and/or major equipment failure will rise proportionately. These risks increase greatly after 10 years and, beyond 2020, the risks to the Post Point Plant become substantial if upgrades are not done to address the capacity and equipment condition issues at the plant.

Additionally, the current 5 days per week incineration operations schedule is causing significant liquid stream impacts at the plant. The 5 day schedule is contributing to high VFA loading to the aeration basins as a result of storing thickened sludge over the weekend. Storing sludge for an extended period of time can cause the sludge to ferment and increases the generation of VFAs. By transitioning to a 7 days per week schedule, storing sludge over the weekend would no longer be the default operation and the sludge fermentation and subsequent VFA loading issues would be eliminated.

In order to address the issues associated with the current equipment and operational practices, CDM recommends the following modifications to the existing biosolids handling process at the Post Point Plant:

1. Transition to a 7 days per week operations schedule
2. Stress test the existing GBTs to determine their actual installed capacity
3. Investigate the feasibility of installing larger GBTs
4. Increase dewatering capacity
5. Begin planning for installation of a new Fluidized Bed Incinerator
6. Retain the existing sludge storage tank
7. Provide dewatered cake storage
8. Replace existing FOG concentrator and install a FOG receiving station
9. Begin planning of the FOG program

7.1 Anticipated Construction Costs

The above recommendations range from operational changes with limited actual construction costs to costly projects such as installing a new fluidized bed incinerator. Further, some of the projects are still undefined as more investigation is required including stress testing operations. CDM has developed detailed construction costs for the major components that are clearly defined at this time including installation of the new fluidized bed incinerator, installation of wet cake storage, and installation of a FOG receiving system. Construction costs for these major components are anticipated to be $42.9 million in 2010 dollars as shown in **Table 7-1**.

Table 7-1. Estimated Construction Costs (2010 Dollars) for Installation of a New FBI with Power Generation, 290 yd^3 of wet cake storage, and FOG receiving

Description	Line Item Total
Work Plan/ Submittals/ Permits	$100,000
Mobilization/Demobilization	$100,000
TESC	$100,000
Fluidized Bed Incinerator System	$18,400,000
Power Generation	$5,100,000
FOG System	$300,000
Cake Storage/Pumping	$1,400,000
Sitework Allowance	$500,000
Safety	$100,000
General Conditions	$1,400,000
Subtotal	**$27,500,000**
General Liability Insurance	$200,000
Builder's All Risk Insurance	$200,000
Subcontractor Bond	$300,000
Performance & Payment Bond	$500,000
B&O Tax	$100,000
Subtotal	**$28,800,000**
Overhead	$1,600,000
GC Fee	$1,300,000
Total Construction (Excluding Taxes)	**$31,700,000**
Sales Tax (2010 Taxes)	$2,700,000
Subtotal	**$34,400,000**
Contingency	$8,500,000
Total Anticipated Construction Cost (Includes Taxes and Contingency)	**$42,900,000**

The costs in **Table 7-1** are construction costs only and do not included engineering and construction management services. Engineering and construction management services can be estimated at about 25 percent of the project total or around $10 million.

In addition to these defined costs, the Post Point Plant is proceeding with the installation of at least one new 2,500 pound per hour centrifuge. An additional, third, centrifuge will also be needed in the near term and will require an additional $1 million to $2 million in dewatering capacity upgrades. Stress testing of the thickener improvements are also recommended and depending on the results of this testing another $1 million in thickening upgrades may be required.

7.2 Comparison of Detailed Construction Costs versus Alternative Analysis Cost Estimates

The detailed construction costs revealed that construction costs for FBI incineration alternative were higher than anticipated during the alternative analyses of Section 7.6. In part the increase is due to the addition of several components that were not part of the incinerator alternative of Section 7.6, including FOG receiving and Wet Cake Storage. Excluding these costs, the detailed construction cost for the FBI system including heat and power generation reduces to approximately $39.9 million in 2010 dollars.

A second difference between the cost estimates is that the detailed construction cost was developed from Bellingham drawings and anticipated layouts. Alternative analyses estimates were developed by using construction cost curves and recent project experiences. Cost curves and recent project experiences draw from projects that were completed all across North America and thus are based on different labor rates, power costs, and other information. It is anticipated that other alternatives would increase in cost if a detailed construction cost were developed on each of them.

7.3 Elimination of Power Generation for Cost Reduction

The payback period for power generation is likely beyond the life expectancy of the new FBI. Therefore, Post Point Plant staff may consider eliminating this component of the project. The estimated additional costs associated with power generation are around $8 million in construction and another $2 million in engineering and construction management. Eliminating power generation would increase operations costs by approximately $100,000 and increase fossil fuel based green house gas emissions by 1,600 tons per year.

7.4 Implementation Plan

Timing for the proposed upgrades depends on the age of equipment, capacity requirements, and on-going or future testing requirements. To assist in planning the upgrades CDM recommends implementation in accordance to the schedule in **Table 7-2**.

Table 7-2. Implementation Schedule

Activity	Timeframe
Increase Dewatering Capacity	In progress
GBT Stress Testing	2010 to 2011
Thickening Assessment	2011 to 2015
Preliminary Design Analysis for the New FBI, Dewatered Cake, and FOG receiving	2014
Installation of Dewatered Cake Storage	Prior to 2020
Transition to 7 day a week operation	Prior to 2011
FOG Program Development	2011
Installation of new FBI and FOG Receiving	Prior to 2020

The above schedule is based on a number of factors. Timeframes for implementation may need to be altered if future conditions change. Some of the changes that may drive earlier implementation are as follows:

- Population growth occurs at a different rate.
- Regulatory changes occur. Most notably, the EPA is developing new air emission rules related to sludge incineration. The exact outcome of these changes are unclear as of this writing, although the regulations are expected to be more stringent than current requirements. These changes, if adopted, may force expensive modifications to the existing MHF incinerators. These rules are expected to be finalized within the next one to two years. If adopted, the Post Point Plant may find that accelerating the installation of the FBI incinerator is more economical than modifying the existing MHF incinerators.
- Failure or increased maintenance of existing aged equipment.

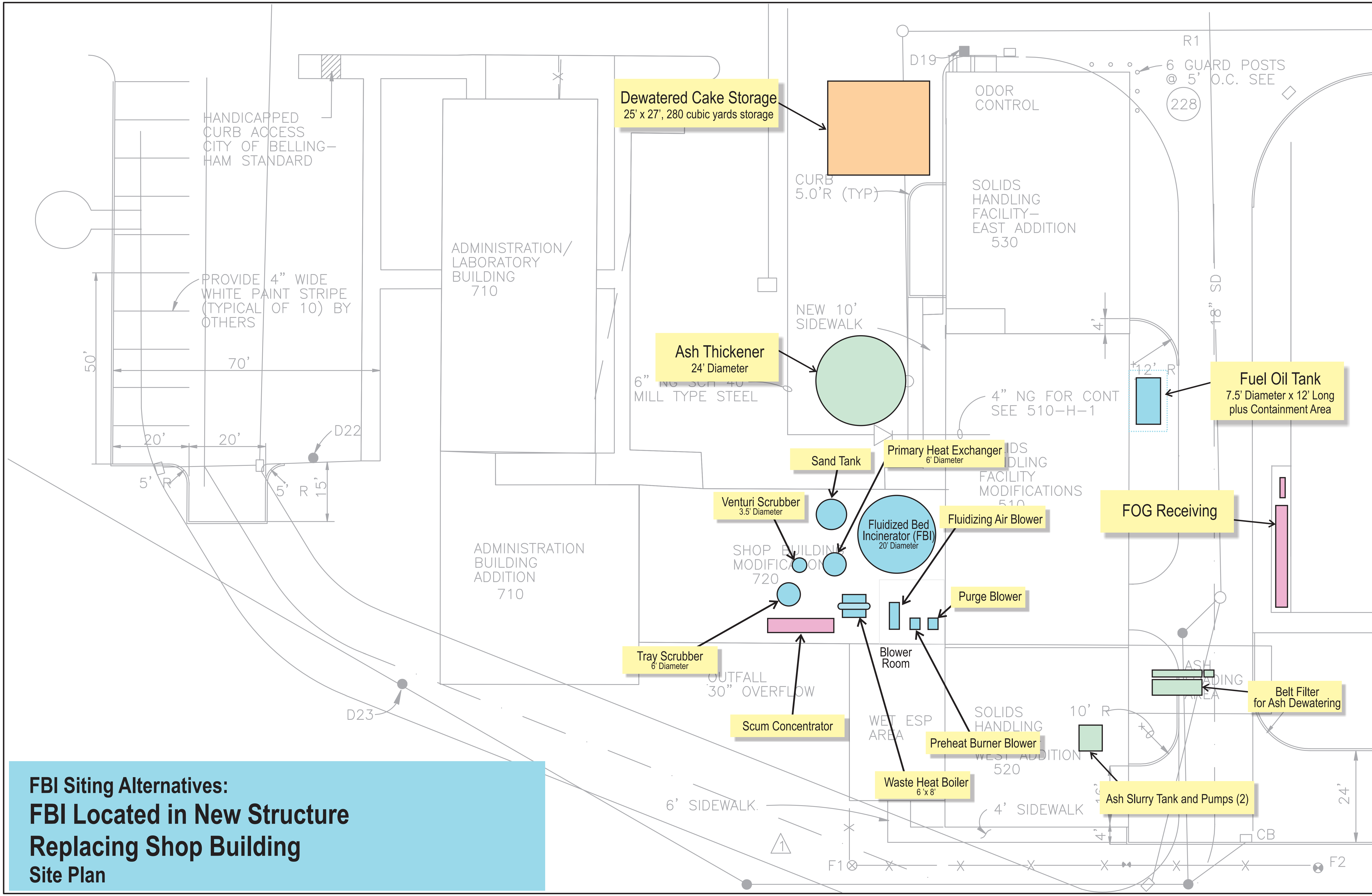
CDM recommends that Post Point Plant complete all on-going improvements to dewatering capacity and to commence GBT stress testing. Subsequent analyses of thickening should be conducted to clarify any additional upgrades to these systems that may be required. Installation of a third centrifuge could be postponed until as late as 2020, however, Post Point Plant would likely be operating under risk of mechanical failure of the existing centrifuge. If that failure would occur during peak conditions, Post Point Plant may need to store thickened solids for a week or more and would likely see significant VFA formation and impacts to the liquids processes. Depending on thickening stress testing, the Post Point Plant may be able to delay thickening upgrades until mechanical reliability of the existing thickening system becomes impaired.

CDM also recommends that a preliminary design be completed for the new FBI, dewatered cake storage facility, and FOG receiving station. This preliminary design should be conducted to optimize FBI sizing and determine if power production is included with the design. The preliminary design should confirm plant space heat needs and select the appropriate heat recovery system.

Installation of the dewatered cake storage is not required from a capacity perspective until 2020. However, dewatered cake storage provides increased flexibility for Post Point to manage peak sludge production without storing peaks in the thickened sludge blend tank. Further, dewatered cake storage reduces the reliance on operation of both incinerators simultaneously and thus minimizes the risk associated with equipment failure.

A secondary benefit of dewatered cake storage would be to provide operational flexibility and permit 5 day incineration operation while operating centrifuges 7 days week. This would allow Post Point to control VFA production but avoid staffing and operating the centrifuges over the weekend. Thus, the Post Point Plant could delay staffing for 7 day a week incinerator operations until the new incinerator is brought on-line in 2020.

Appendix A:
Reference Drawings



FBI Siting Alternatives:

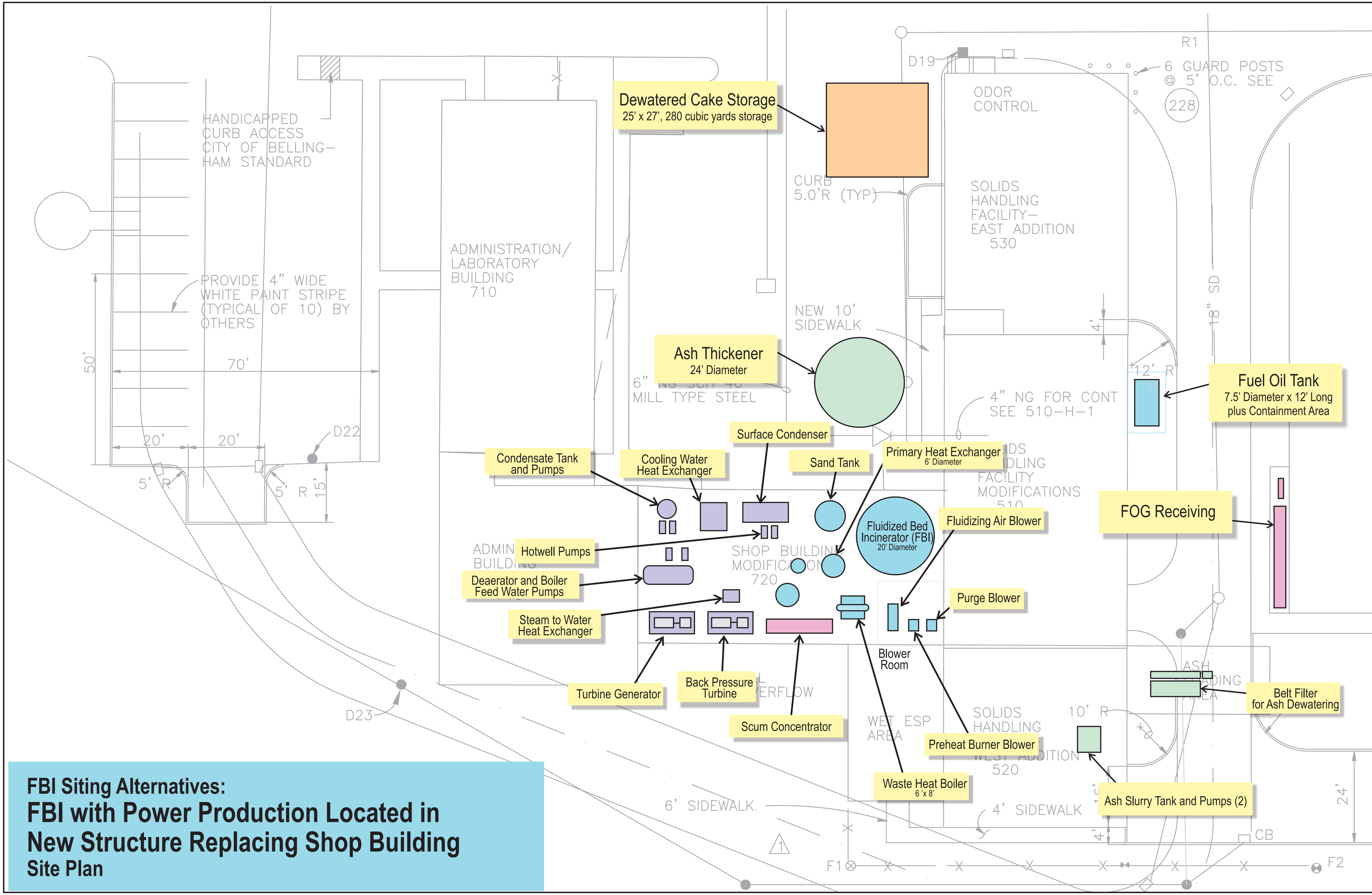
FBI Located in New Structure Replacing Shop Building

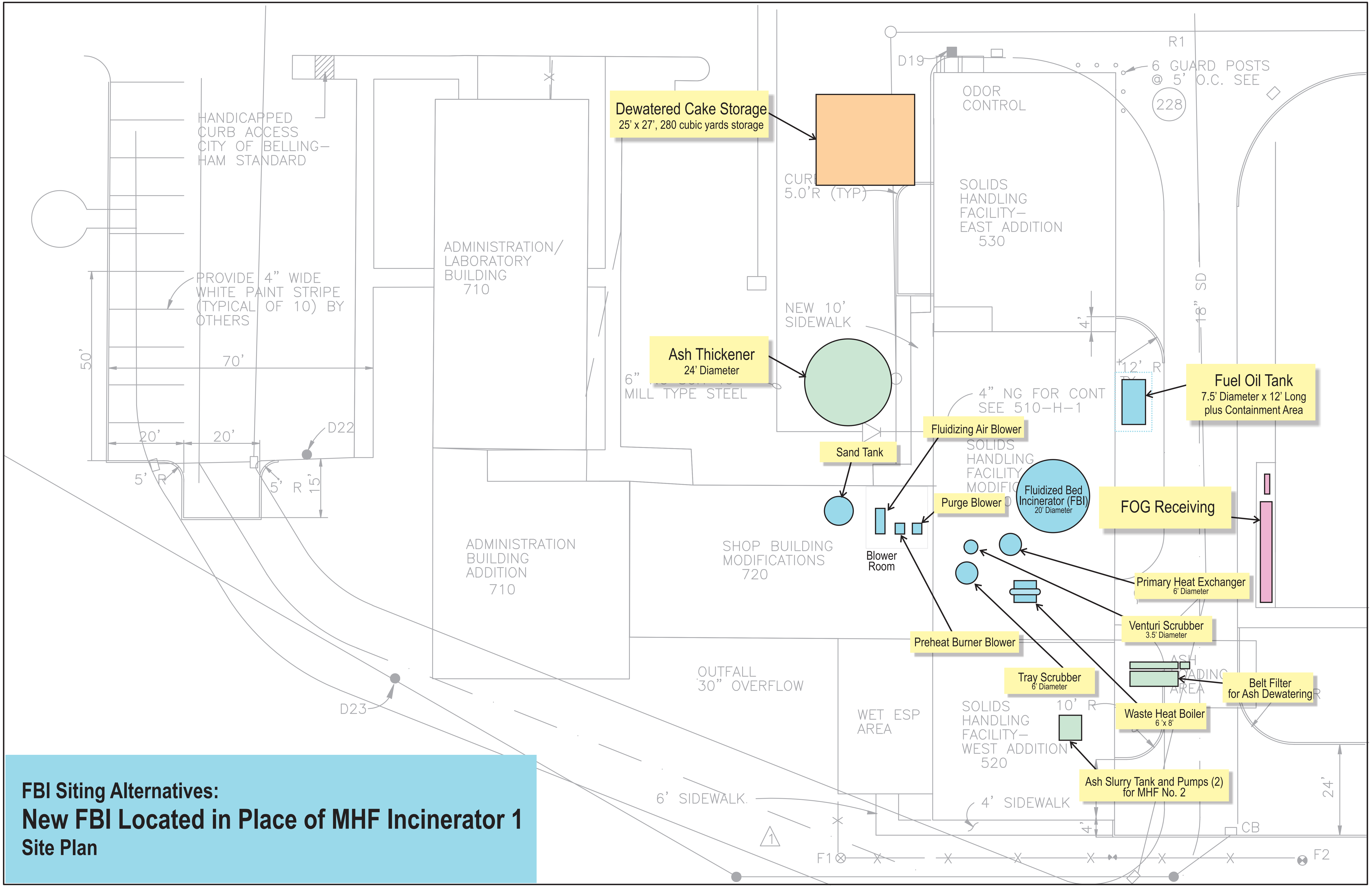
Site Plan

FBI Siting Alternatives:

FBI with Power Production Located in New Structure Replacing Shop Building

Site Plan

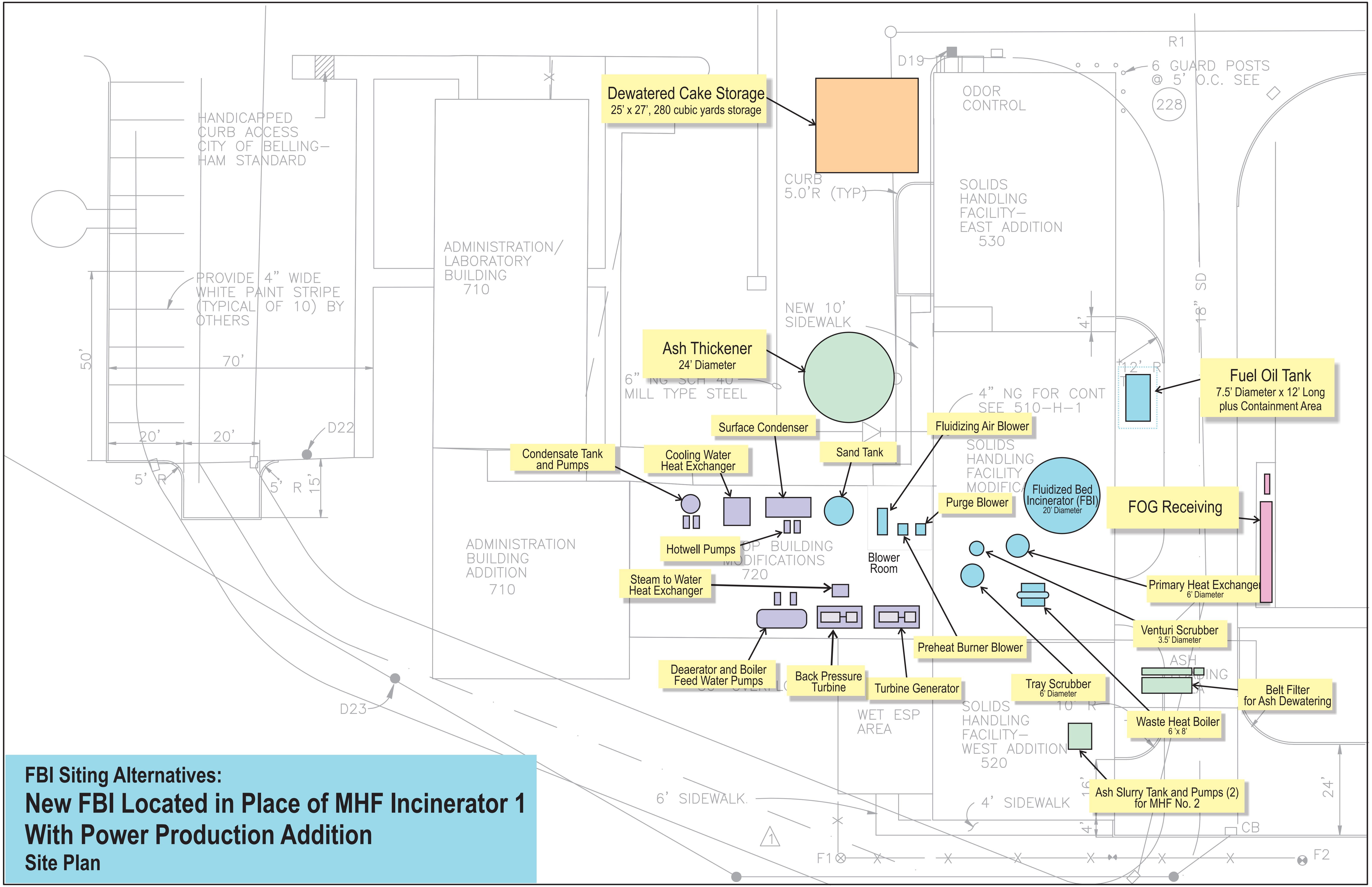




FBI Siting Alternatives:

New FBI Located in Place of MHF Incinerator 1

Site Plan



FBI Siting Alternatives:

New FBI Located in Place of MHF Incinerator 1 With Power Production Addition

Site Plan

City of Bellingham

CDM