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Canadian Consulting Engineering Awards 2012

The Annacis Island Co-digestion Facility: Advancing Waste to Energy Technology in Canada

Metro Vancouver

OPUS DaytonKnight

OPUS

1.3 Project Highlights

Metro Vancouver has recently constructed a full-scale co-digestion pilot plant at the Annacis Island Wastewater Treatment Plant (WWTP). Opus DaytonKnight Consultants Ltd. carried out conceptual detailed design and provided commissioning services for the facility.

The Annacis Island WWTP is the largest secondary treatment plant in British Columbia and serves a population of more than 1 million residents. Process sludge from the treatment plant is digested in thermophilic anaerobic digesters to generate biogas and produce Class 'A' biosolids. Biogas from the digesters is used in the boilers and co-generation engines at the treatment plant. The plant is largely self-sufficient in thermal energy and is about 50% self-sufficient in electrical energy. Currently there is surplus capacity in the anaerobic digesters.

Co-digestion is an innovative "waste to energy" technology where digestible waste products – such as waste fats, oils and grease – are combined directly into anaerobic digesters with the normal process sludge. In the high temperature anaerobic environment, biodegradable constituents in the waste are rapidly assimilated into the digestion process releasing methane and carbon dioxide. Co-digestion offers the potential to significantly increase biogas production, generating renewable energy and greenhouse gas (GHG) credits from the beneficial use of the waste by-products from food processing, restaurants and grocery businesses. Co-digestion is a relatively new technology developed in Europe and has only recently been used in a few wastewater treatment plants in North America.

The waste products used for co-digestion are typically trucked liquid wastes. As currently practised, the most common method of disposing of these products – throughout most cities in Canada – is to discharge the waste material into the headworks of a treatment plant for processing with the liquid treatment process. Treatment of high strength waste products through the liquid treatment process is very energy intensive. The surplus digester capacity at the Annacis Island WWTP presents Metro Vancouver with an opportunity to process these high strength wastes in the digesters, while simultaneously reducing energy consumption for liquid treatment and increasing energy production from solids treatment.

There are physical and process challenges related to the implementation of co-digestion that required careful evaluation during the conceptual and detailed design for the facility. High strength waste streams – particularly those containing fats, oils and grease – are particularly desirable for co-digestion. However these waste streams are difficult to handle, and certain grease wastes can congeal even at temperatures of 25°C to 30°C. Hot flushing is necessary to eliminate the risk of some of these streams congealing in the process piping or equipment. Automatic flush systems, with redundancy, were designed to flush the co-digestion piping, pumps, screens and tanks using hot water, or hot digested sludge from the digesters.

Quality control of these waste products is usually not a priority for either the producers or the haulers. Screening options for the co-digestion facility were evaluated to address the broadest range of potential incoming waste streams, while providing protection for the existing sludge process operations and equipment. The facility can accept diverse waste materials such as fat, oil and grease, glycerol, off-spec milk, concentrated sludge from the wastewater treatment systems of food processors, and also thickened primary sludge from other Metro Vancouver wastewater treatment plants.

Process considerations apply to the implementation of co-digestion. A key consideration is at what rate to feed the high strength material to the digesters to maximize gas production without risk of digester upset or process interruption. Digester feeding was configured for maximum flexibility. Metro Vancouver has the ability to independently test one feedstock in a digester, while processing tested and approved feedstocks in the other digester(s). Material can be pumped to any of the four thermophilic digesters individually, or all digesters simultaneously.

Another key process consideration is maintaining the quality of the biosolids produced by the digesters: it is essential that these high strength waste materials, which are introduced directly to the digesters, do not negatively impact the quality or quantity of biosolids produced at the plant.

Metro Vancouver is at the leading-edge in the implementation of this “waste to energy” technology. Metro Vancouver is also a pioneer in the development of an operational protocol for co-digestion, laboratory analysis of co-digestion feedstocks and a screening tool for evaluating potential feedstocks from the food service industry. The co-digestion project allows the recovery of energy from the region's liquid waste streams and will contribute to the reduction of greenhouse gas emissions throughout the region. Other WWTP operators and consultants have expressed interest in learning and replicating this work. The decision to develop a co-digestion system that could be scaled up was a prudent decision made by Metro Vancouver because of the new cutting edge technology.

The project was completed on schedule and under budget, and entered trial service in May 2011.

The benefits of the co-digestion pilot project are many. Early results indicate that a 15 to 20 percent increase in gas production is achievable. Developing a steady source of high-quality feedstock, such as fats, oils and grease from the food service industry, will also produce regional benefits. Currently, more than $2 Million is spent annually in the region to clean sewer pipes of restaurant grease. Consultation with the food processing industry and food service sector is underway to develop policies that will ensure that organic waste is used beneficially in the co-digestion facility rather than disposed of in municipal sewers. Linking the implementation of the co-digestion project with the development of policy is an excellent example of the value and power of systems thinking in producing solutions that yield multiple benefits.

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SECTION 2.0 – PROJECT DESCRIPTION

2.1 Project Objectives, Solutions, and Achievements

BACKGROUND

Metro Vancouver has recently constructed a full-scale co-digestion pilot plant at the Annacis Island Wastewater Treatment Plant (WWTP). Co-digestion is a relatively new technology developed in Europe and has only recently been used in a few wastewater treatment plants in North America.

The Annacis Island WWTP is the largest secondary treatment plant in British Columbia and serves a population of more than 1 million people. Primary and secondary sludge generated at the plant is stabilized to Class A Biosolids in thermophilic anaerobic digesters. The biosolids are used in a variety of beneficial ways including mine reclamation, agriculture, landfill final cover, and as a soil amendment for landscaping. The digesters produce on average 40,000 m^3/day of biogas which is used by the boilers and co-generation engines at the plant. The plant is largely self-sufficient in Thermal Energy and is approximately 50% self-sufficient in the Electrical Energy required to operate the plant. The anaerobic digesters have surplus capacity, and based on current growth rates, will not need further expansion for 20 – 25 years.

Co-digestion is an innovative "waste to energy" technology where digestible waste products (such as waste fats, oil and grease) are combined directly into anaerobic digesters with the normal process sludge. The Co-digestion project takes advantage of the surplus digester capacity at the Annacis Island WWTP and allows Metro Vancouver to divert high strength organic wastes from other plants to relieve pressure on these plants.

The waste products used for co-digestion are typically trucked liquid wastes. As currently practised, the most common method of disposing of these products is to discharge the waste material into existing wastewater treatment plants for processing with the liquid treatment process. Treatment of high strength waste products through the liquid treatment process is very energy intensive, and can significantly increase the organic load on the plant. The surplus digester capacity at the Annacis Island WWTP presents Metro Vancouver with an opportunity to process these high strength wastes in the digesters, simultaneously reducing energy consumption and increasing energy production.

OBJECTIVES

The objectives of the project are as follows:

- Increase the production of biogas at the Annacis Island WWTP generating renewable energy from waste streams and greenhouse gas benefits for the plant.
- Provide an alternative means of disposing of difficult, high strength, liquid waste streams from food processing, restaurants and grocery businesses.
- Receive and test a variety of digestible organic materials, and measure the effects of these feedstocks on the performance of the digesters.
- Develop an operational protocol for co-digestion, supported by laboratory analysis, and a screening tool to evaluate potential feedstocks from the food process industry.
- Receive and screen thickened primary sludge from other wastewater treatment plants, providing relief to manage digester upsets, or for planned maintenance at these plants.

SOLUTIONS

Introducing waste products – particularly high strength wastes – directly into operating anaerobic digesters presents some key design challenges and risks. Conceptual and detailed design was a collaborative process between the project teams from Opus DaytonKnight and Metro Vancouver. Throughout the design, multiple discussions and meetings took place with the Engineering and Operations staff of Metro Vancouver to ensure their concerns were identified and addressed.

High strength waste streams containing fats, oils and grease are particularly desirable for co-digestion. However these waste streams are difficult to handle and certain grease wastes can congeal even at temperatures of 25 – 30^{o}C. Spill containment and hot water wash stations were designed at the unloading station. Automatic flush systems, with redundancy, were designed to flush the co-digestion piping, pumps, screens and tanks using hot water, or hot digested sludge. Hot flushing is necessary to eliminate the risk of these streams congealing in the process piping or equipment.

Hot sludge from the digesters is undergoing digestion and actively produces biogas. If used for flushing, and left unattended in the co-digestion system, this sludge could generate hazardous conditions at the co-digestion facility. Facility safety and venting systems are designed to counter this risk.

In order to maintain uninterrupted sludge processing operations at the plant, the piping connections from the co-digestion facility were hot-tapped into the digester recirculation and mixing piping systems.

Screening options for the co-digestion facility were evaluated to address the broadest range of potential incoming waste streams, while providing protection for the existing sludge process operations and equipment. The facility can accept diverse waste materials such as fat, oil and grease, glycerol, off-spec milk, concentrated sludge from the wastewater treatment process of food processors, and also thickened primary sludge from other Metro Vancouver wastewater treatment plants.

Waste receiving and facility operating protocols for the new co-digestion facility were developed to enable Metro Vancouver to maintain multiple levels of control through the Annacis Island WWTP Computer Data Acquisition and Control (CDAC) system, through which all plant operations are monitored and controlled from a central location.

ACHIEVEMENTS

The Annacis Island WWTP Co-digestion facility has achieved the following:

- Since entering operation, the full-scale pilot plant has been operating very successfully and has demonstrated that all design intents of the pilot facility have been met or exceeded. The positive outcomes have encouraged Metro Vancouver to proceed with a detailed market survey to explore the potential to expand the feedstock and upgrade / expand the co-digestion facility and program.
- Early results indicate that a 15 to 20 percent increase in gas production is achievable. In addition, the payback period on the initial investment is estimated to be 8 to 12 years based on reduced energy costs and revenues generated from the tipping fees charged to haulers of organic wastes.
- The anaerobic digestion process converts high strength organic wastes into usable energy and reduces greenhouse gas emissions, which is estimated to be worth 1,500 tonnes of CO_2e (carbon dioxide equivalent) annually for a system of this size.
- The project was the recipient of the Risk Taking - Implementation of Innovative Technologies Award offered by the Canadian Water and Wastewater Association in 2011.

2.2 Technical Excellence and Innovation

***Waste Receiving*:** The waste streams most desirable for co-digestion are the most difficult to handle and process. Handling of an accepted waste stream starts with the hauler submitting a manifest to the plant reception on arrival at the plant. As the hauler proceeds to the co-digestion facility, Metro Vancouver Operations staff review the manifest and determine the unloading procedure and appropriate destination for the waste product. The facility has been designed for easy access for the hauler, but, once the hauler has connected to the facility inlet, Metro Vancouver manage and control all aspects of the unloading process. Metro Vancouver samples each load, and performs a visual inspection to confirm that the load matches the manifest description.

Once the load is cleared, Metro Vancouver staff initiate the facility unloading operation, and from this point on, the operation is fully automated, and controlled by Metro Vancouver. Rotary lobe pumps were selected for the unloading pump station, the feed pump station and the digested sludge flushing pump station. An in-line rock trap is provided just upstream of the unloading pump station to protect the pumps. The CDAC Operator selects the screening based on the manifest details. Mixed waste material – the majority of the incoming material - is routed through a two-stage static screen into the storage tank. Temperature and pressures are monitored as the material is received. Thickened primary sludge from other wastewater treatment plants is routed through a pressurized in-line sludge screen, similar to that used elsewhere at the plant. Flushing is initiated automatically after the unloading operation is complete. For mixed waste loads, flushing of the inlet piping is carried out using hot water. Flushing using hot digested sludge can be initiated if warranted by facility conditions.

***Waste Storage, Handling and Flushing*:** A fibreglass-reinforced plastic (FRP) tank with heat traced panels and insulation is provided for storage of the incoming mixed waste. Certain waste streams (for instance glycerol from biodiesel production or fat, oil, grease –FOG– from a local rendering plant) will solidify at 25˚C and must be maintained at or above this temperature. The heating panels can, if necessary, provide sufficient heat to increase the temperature of the liquid inside the tank. Storage tank mixing is provided by an external loop and chopper pump which also adds heat to the tanks contents and maintains fluid consistency for the digester feed. In addition, Metro Vancouver can add heat to the storage tank utilizing the hot digester flush system if necessary. Odour control is provided by a passive activated carbon package system, and the vent piping is protected from hazardous off-gasses by a flame arrestor and gas monitor.

2.3 Environmental, Economic and Social Sustainability and Aesthetic Aspects

Environmental Sustainability – Long term environmental sustainability was a paramount consideration for the project. The following specific features of the project enhance environmental sustainability and protection:

- high-strength by-products from industry that might otherwise be disposed as waste, or might be treated with the liquid treatment process, are used as a resource to boost the production of biogas in the anaerobic digesters, while at the same time reducing the energy demands of operating the liquid waste stream;
- the increased biogas production enhances recovery of heat and electrical power, making the plant more self-sustaining in terms of energy consumption; biogas could also be scrubbed and sold to the grid as a renewable energy resource to heat homes or power vehicles;
- enhanced production of biogas, which is a source of renewable energy, results in increased greenhouse gas credits and smaller carbon footprint for the treatment plant;

Beyond the environment, the overall improvement to the anaerobic digestion and biogas production process has far reaching impacts both economically and socially.

Economic Sustainability – As with all engineering works, costs play a key role often dictating the project's overall viability. Financial benefits resulting from this project include a reduction in purchased electrical power and fossil fuels at the treatment plant, as well as reduced costs to local industry for trucking and disposal of high-strength wastes. Addition of the high-strength wastes significantly boosts biogas production without significantly increasing the production of residual solids (biosolids), so that the costs of solids handling and beneficial use of biosolids are not increased. Co-digestion ultimately reduces the amount of problematic wastes discharged to sewer, with a consequent reduction in sewer maintenance costs. These benefits contribute to a reduction in the life-cycle cost of infrastructure for local taxpayers.

Social Sustainability – The primary goal of the project was to make the Annacis Island WWTP more self-sufficient in terms of energy use, and to reduce its carbon footprint. Industry benefits from the utilization of waste by-products in an effective manner which provides a long term, sustainable option for beneficial use instead of disposal for waste products from food processing or food service industries. Metro Vancouver is proceeding with a market survey to assess the possibility of expanding the range of feedstocks and extending the co-digestion program.

Aesthetic Aspects – Although function takes precedence over aesthetics in engineering, it is often the physical appearance of a project which garners the most attention. The co-digestion occupies a small footprint in the Annacis Island WWTP and is located close to the digesters. There are no negative impacts on the visual aspects of the plant. There are positive aesthetic benefits, in particular reduced odours, from the diversion of waste products from landfill, from septage receiving facilities and from waste treatment processes.

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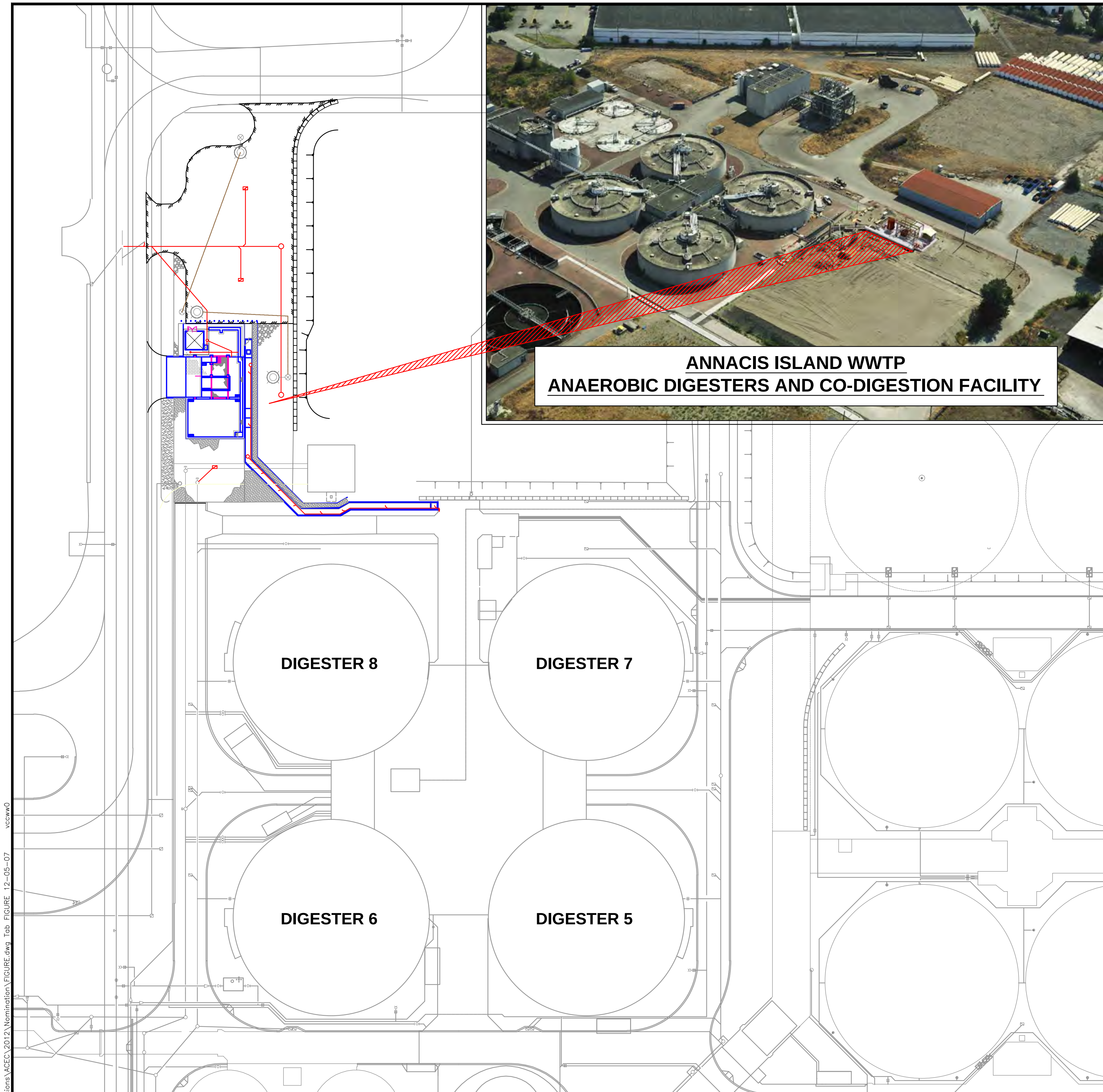
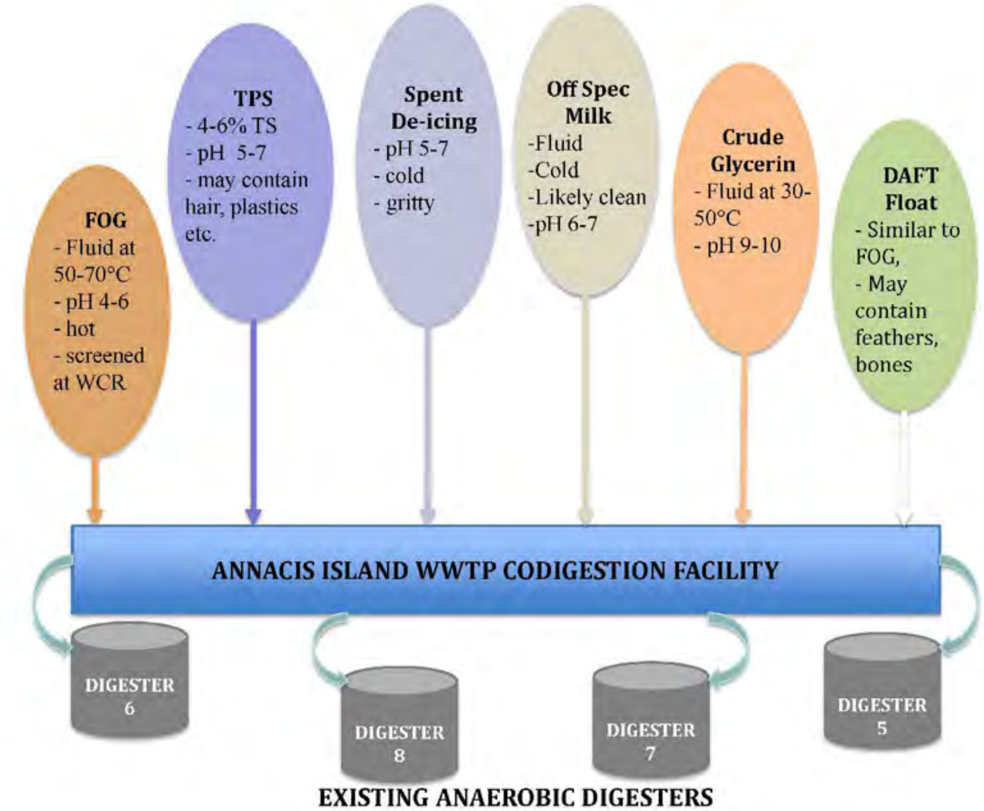
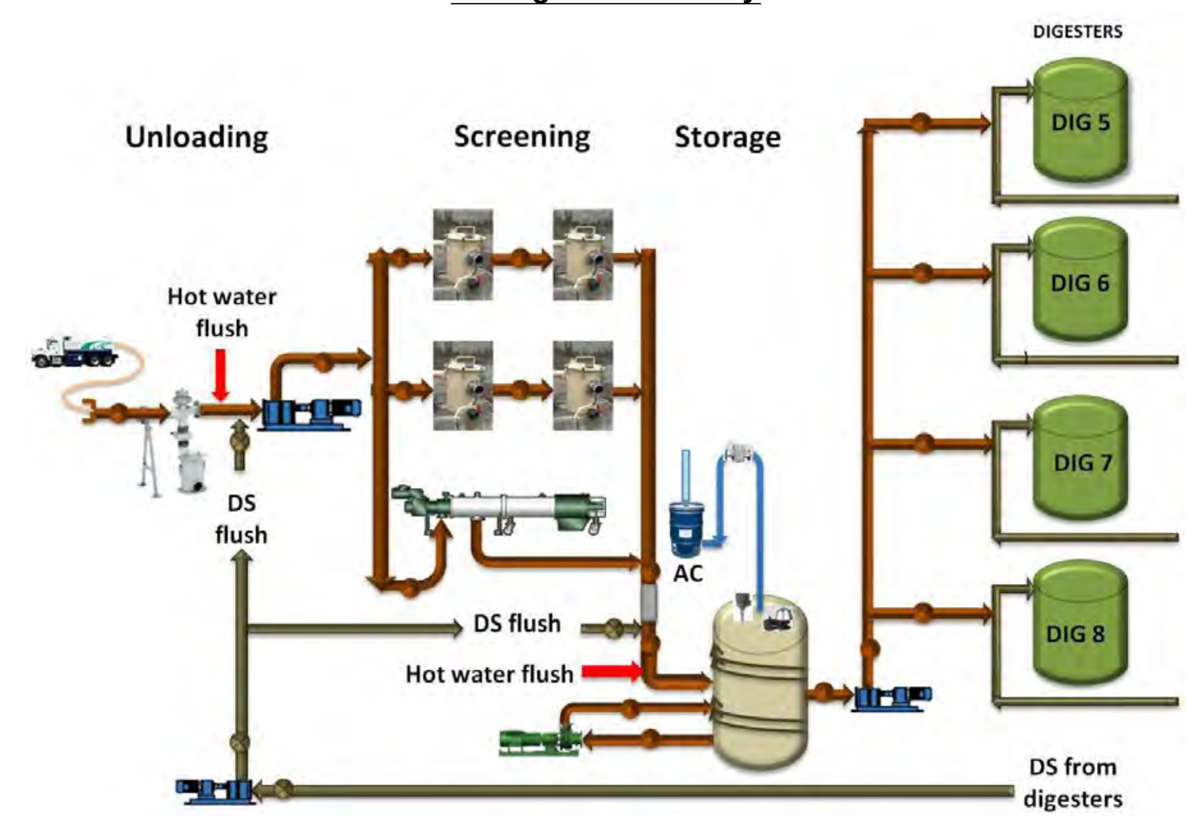
SECTION 3.0 – PROJECT PHOTOS AND SKETCHES



SITE PLAN



Examples of Organic Wastes (Feedstocks) that can be Used for the Co-digestion Facility



FLOW DIAGRAM

OPUS DAYTONKNIGHT
DRAWN BY: CWW
210 - 889 Harbourside Drive
North Vancouver, BC
V7P 3S1, CANADA
North Vancouver Office
604-990-4800

FIGURE 1

Photo 1: AIWWTP Co-digestion Facility – Unloading at the completed facility.
The Sludge Digesters are to the right of the photo.
(photo courtesy of Metro Vancouver)

Photo 2: AIWWTP Co-digestion Facility – Another view of the completed facility.
(photo courtesy of Metro Vancouver)

Photo 3: Heat Traced and Insulated Feedstock Storage Tank; the digester gas flare is in the background.

Photo 4: Co-digestion Operations Building / Utility Shed; the Parkson Sludge Strainer for thickened primary sludge and screenings bin are illustrated also.

Photo 5: Utility Chase to Convey Piping and Cables to/from Digesters

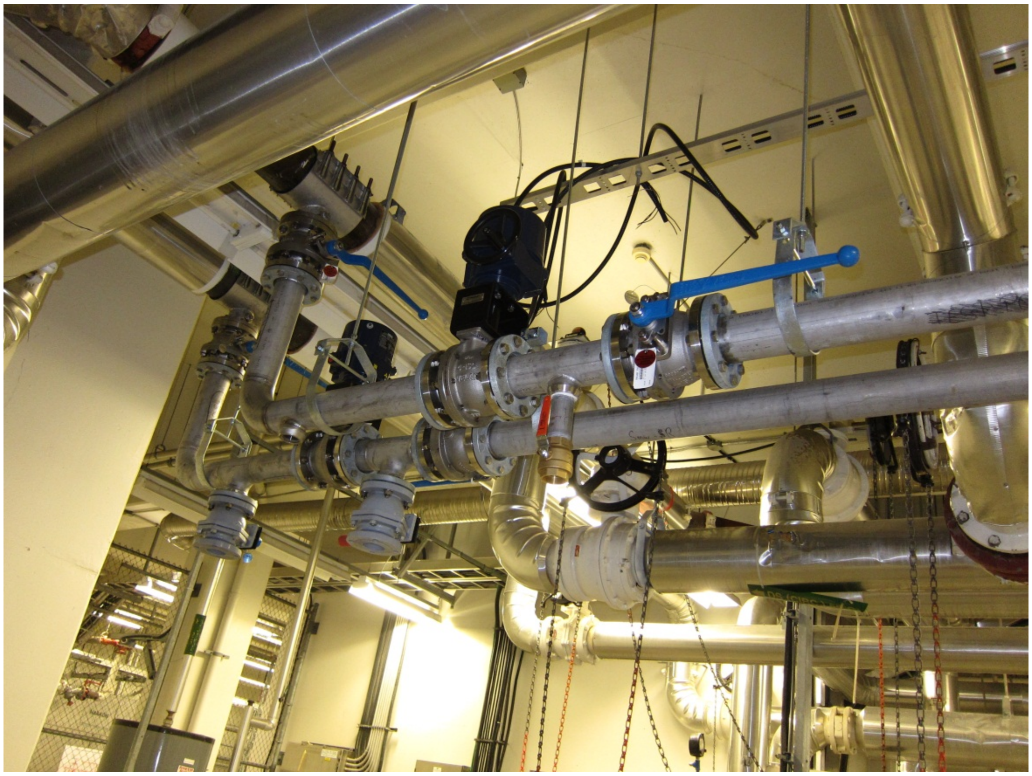


Photo 6: Digester Feed and Digested Sludge Suction Lines in the Pipe Gallery; both connections were 'hot-tapped' to the existing sludge pipes to maintain digester operations

Photo 7: Feedstock Unloading Pump and Piping Undergoing Testing

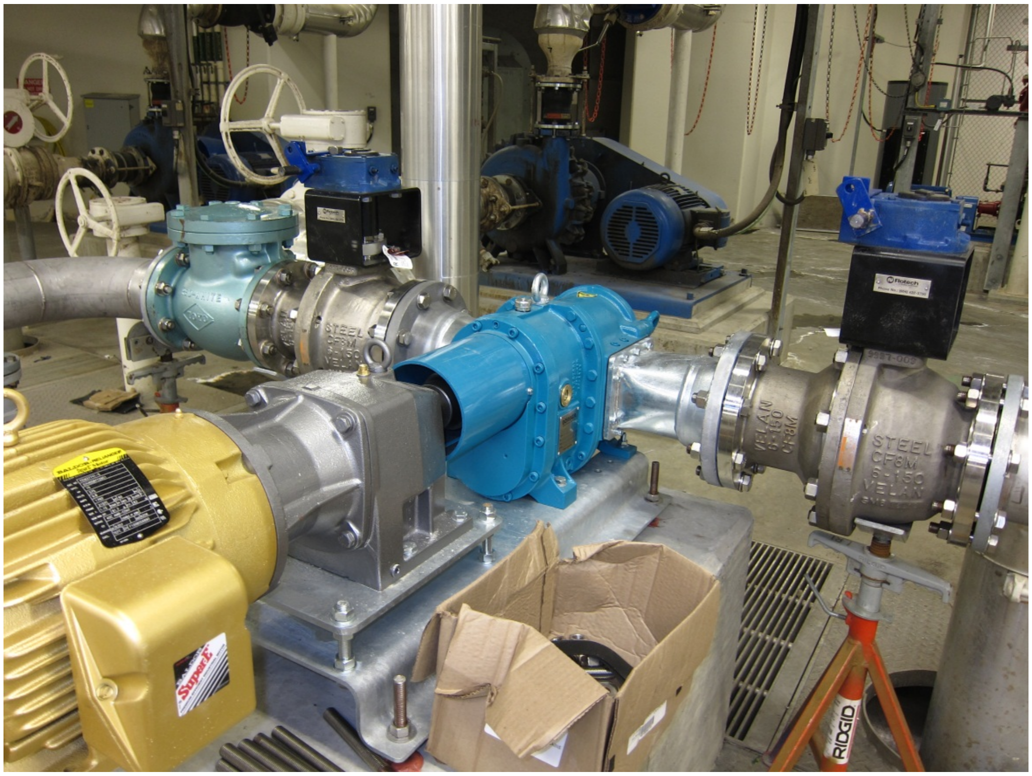


Photo 8: Hot Digested Sludge Flushing Pump