Environmental Design of Soft Drink Bottling Plant

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ABSTRACT

This project is directed at properly and creatively applying civil engineering knowledge to generate a safe and practical environmental design for the construction of a new soft drink bottling plant in Youngstown, Ohio. Aspects of such a design include pollution prevention plans, environmental analysis reports, and the design of all pumps, pipes, and appurtenances to deliver water to the site as well as direct effluent back to the main sewer line. In addition, the goal of reusing all bottling wastewater will be achieved via sufficient water treatment processes to be performed on-site. This environmental design was completed in conjunction with other individuals' designs for the remaining civil scopes of work: geotechnical, structural, transportation, and water resources.

SITE DESCRIPTION

The parcel of land available for construction is approximately 30 acres, located at the intersection of Salt Springs Road and North Meridian Road in Youngstown, Ohio. The main structure is a 75,000 square-foot, pre-engineered building with a length of 500 feet and a width of 150 feet. There is also a 40-foot tall overhead crane located behind the building and above the loading dock. The design of foundations, the overhead crane, access roads, parking lots, and storm water infrastructure is required and are the responsibilities of other group members. The environmental design, illustrated in Figure 1 and Figure 2, includes various environmental permits, providing water to the site, and treating and disposing of all wastewaters.

ENVIRONMENTAL ASSESSMENT

The environmental assessment (EA) for the site is a technical analysis of potential environmental dangers that may be a product of construction. When applicable, mitigation measures are proposed to counteract the environmental impacts. Environmental impacts include but are not limited to hazardous air emissions, increased noise, soil disruption, surface water and ground water infiltration, and destruction of animal and biological habitats. A few mitigation examples are shown below:

Air emissions are an inevitable result of heavy equipment use necessary for construction. Emissions will be controlled by proper and efficient use of machinery.

Increased noise will occur during working hours. To mitigate, noise-causing activities will be halted before 8 am and after 5 pm on weekdays, and weekend work will be avoided whenever possible.

STORM WATER POLLUTION PREVENTION PLAN

The storm water pollution prevention plan (SWP3) is required for all construction disruptions of areas greater than one acre. The purpose is to outline all initiatives taken to prevent disruptions of nearby storm water infrastructures and water quality. Measures to be taken for this site include the use of silt fence around the perimeter of the construction area and temporary seeding and mulching of land that will go undisturbed for long periods of time during the construction process.

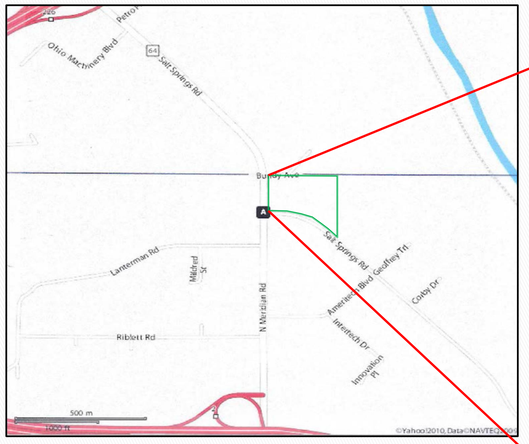


Figure 1. Site Map

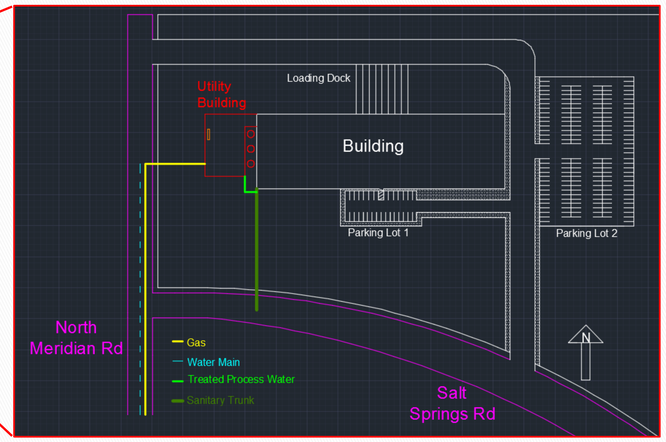


Figure 2. Site Design

- Tank that collects wastewater at varying flows and discharges wastewater at a constant flow
- Necessary for efficiency of subsequent processes
- 2 – 20,000 gallon tanks required
- Aeration required to prevent settling of solids

- pH can be adjusted via chemical addition
- Common chemicals:
  - Carbonic acid
  - Hydrochloric acid
  - Sulfuric acid
- "Black box" process

Process Wastewater → Equalization → Sequencing Batch Reactor → pH Adjustment → Disinfection

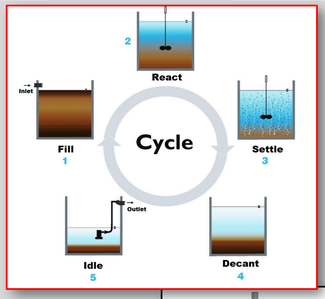
- Primary treatment process to remove BOD and TSS
- Designed via Monod biologic growth kinetics equations

$$\mu = \frac{\mu_m S}{K_s + S} - k_d$$

$$\theta_c = \frac{1}{\mu}$$

$$X = \frac{\theta_c Y (S_o - S)}{\theta (1 + k_d \theta_c)}$$

- 3 – 14' diameter by 20' tall tanks required



- 1 mg/L chlorine residual is required for reuse
- Because the majority of process wastewater is from washing bottles, pathogen levels are assumed to be negligible
- 2 baffled basins will be required due to redundancy standards
- Dechlorination is required prior to sending water to sewer

- Sulfur dioxide will be used to form sulfurous acid, which then reacts with chlorine to produce chloride and sulfate ions

TREATMENT & SEWER PIPES

Pipe will be required to connect wastewater treatment processes and to dispose of process and sanitary wastewater to the city sewer. All pipes will conform to the 10 States Standards. Sewer lines will be composed of ductile iron pipe. A typical cross section for the sewer pipe is provided in Figure 3. All pipe appurtenances, such as joints and fittings, are included in the report. All bedding and backfill will be 57 Limestone.

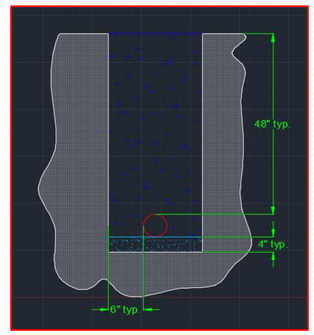


Figure 3. Typical Sewer Line Cross Section

WATER TREATMENT

The bulk of the environmental design is focused on designing treatment for the process wastewater. The process wastewater has traits that make it too potent to dispose directly to the sewer, as shown in Table 1. The treatment processes designed to reduce these characteristics are illustrated to the right. The average flow of process wastewater for this site is 60,000 gallons per day.

Table 1. Process Wastewater Characteristics

Characteristic	Unit	Process Wastewater	Typical Sanitary Wastewater*
BOD	mg/L	430	200
TSS	mg/L	220	210
Alkalinity	mg/L	290	100
pH		10.8	7.0-7.5

*From Metcalf and Eddy, 2003

WATER REUSE

To create a more innovative environmental design, all process water will be reused on-site prior to discharging to the city sewer. After comparing costs and feasibility of several reuse applications, it was determined that the treated water should be used to feed a steam boiler for power generation and building heat. The boiler, shown in Figure 4, was sized based on square footage to provide 4,000,000 BTU/hr of heat, and also requires natural gas. The natural gas line is illustrated in Figure 2.

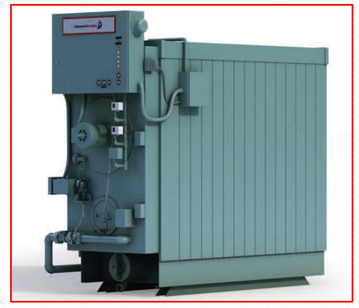


Figure 4. Cleaver-Brooks Model 5 – 5000 Steam Boiler

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