Appendix C-2:
Key Treatment System Capabilities and Selection Rationale, and Training and Procedures

Oil-Water Separator – Rationale for Method Selection

Project Location: 750 Pleasant Street, Dartmouth, Nova Scotia

Operator: Envirosoil Limited

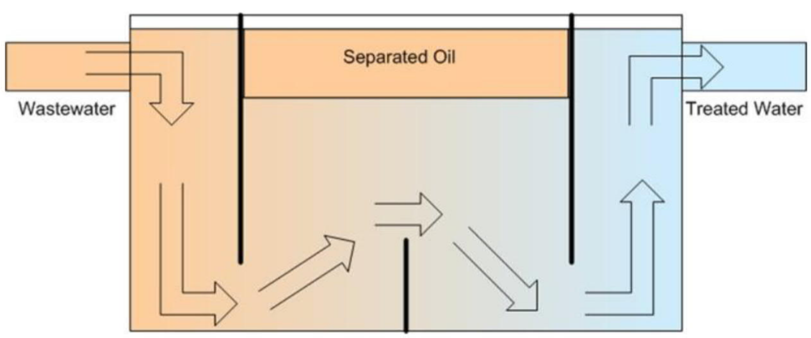
Oil-Water Separators (OWS) are multi-chambered devices used to remove oil from water. Oil-water separation applications include industrial processes, such as the petroleum industry, metal working industry, bilge water from ships, and the food industry which would include fats, oil, grease (FOG), and others. Oil-water separators may also be used as pretreatment prior to primary treatment at a water resource recovery facility, or as treatment for storm water runoff from areas where hydrocarbon products are handled, or spills are likely such as vehicle wash areas or fueling stations. In addition to collecting oil, oil-water separators collect sediment.

There are two primary types of oil-water separators: gravity and coalescing plate. Generally, oil-water separators consist of three chambers: a forebay, a separator section, and an afterbay. As the oil-water mixture progresses through the system, the oil naturally separates from the water and floats to the surface where it is removed.

Gravity OWS Units

Gravity OWS gravity separators, as illustrated in Figure 1, are liquid containment structures that provide sufficient hydraulic retention time to allow oil droplets to rise to the surface. The oil forms a separate layer that can then be removed by skimmers, pumps, or other methods. The wastewater outlet is located below the oil level so that water leaving the separator is free of the oil that accumulates at the top of the unit. The inlet is often fitted with diffusion baffles to reduce turbulent flow that might prevent effective separation of the oil and might re-suspend settled pollutants.

Figure 1: Gravity OWS Unit

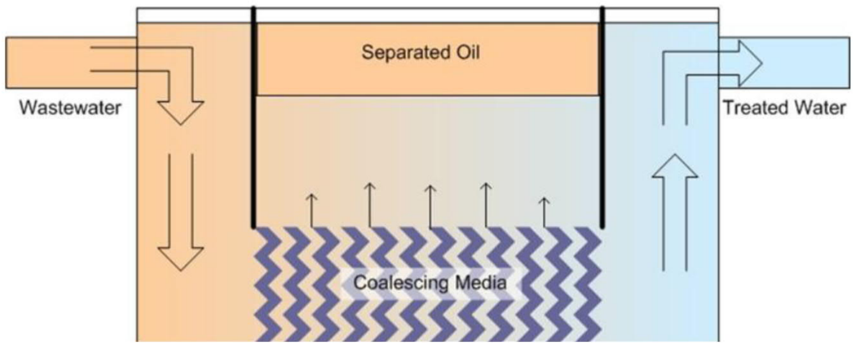


Gravity separators use a process that relies on the different densities of oil, water, and solids for successful operation. The wastewater is fed to a vessel sized to provide a quiescent zone of sufficient retention time to allow the oil to float to the top and the solids to settle to the bottom. An OWS of this type generally provides a discharge hydrocarbon concentration of 100 mg/L based on a 150 micron droplet size.

Coalescing OWS Units

Coalescing OWS separators allow the separation of smaller oil droplets within confined spaces. These separators use a variety of coalescing media and small diameter cartridges that enhance laminar flow and separation of smaller oil droplets that accumulate on the separator surface for removal. Figure 2 shows coalescing plates in the middle compartment (separator designs may vary).

Figure 2: Coalescing OWS Unit



In a coalescing type OWS the water passes through the inner section of the separator through an oleophilic media (polyethylene or polypropylene). The media facilitates the separation of the oil from the water by providing a surface area that attracts droplets of oil and holds them until they coalesce into larger droplets, which rise rapidly to the top of the separator. As oil collects in the top of the separator it displaces the water and forces the water level in the separator downward. An OWS of this type generally provides a discharge oil concentration of 15 mg/L or less with an oil droplet size of 20 - 30 microns.

Equipment Design and Selection

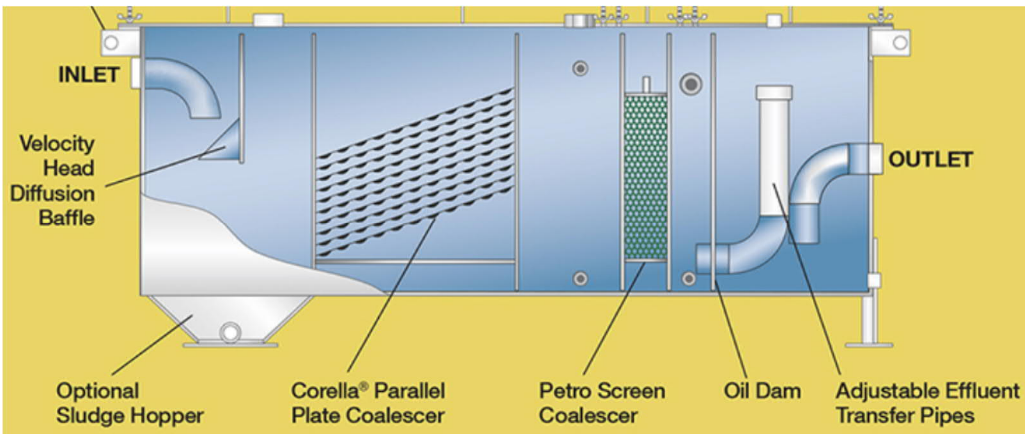
Besides the capital and operational costs, there are many factors that affect the selection of an OWS system. These factors include the following:

- Process specifications (metallurgy, temperature, pressure, etc.)
- Fluid viscosity, density, specific gravity, pH, etc.
- Temperature: 5 – 75 degrees C
- Oil Specific gravity: 0.7 – 0.94
- Average Inlet hydrocarbon concentration: 500,000 mg/L
- Removal efficiency: > 99% of free oil > 20 microns
- Maximum Horizontal flow < 1 m/min
- Maximum Reynolds number: 500
- Residence time at average flow: minimum 30 minutes
- Residence time at peak flow: minimum 15 minutes
- Coalescing plate incline: 40 – 60 degrees
- Coalescing plate area: 300 ft^2 minimum
- Instrumentation and safety
- Costs of hardware, filters, maintenance, disposal
- Calculate quantity of waste requiring offsite disposal

OWS Unit Selection

After consulting with industry experts and vendors and completing the required design calculations, Envirosoil Limited (Envirosoil) selected a dual stage coalescing OWS as the most appropriate equipment to suit the needs of the proposed facility. Figure 3 presents a generalized schematic of the proposed OWS unit.

Figure 3: Schematic of Proposed OWS Unit



The main advantages of the selected OWS are:

Diffusion Baffle: The velocity head diffusion baffle, located near the inlet of the separator, is designed to serve four basic functions:

- To dissipate the velocity head, thereby improving the overall hydraulic characteristics of the separator.
- To direct incoming flow downward and outward maximizing the use of the separator volume.
- To reduce flow turbulence and to distribute the flow evenly over the separator's cross-sectional area.
- To isolate inlet turbulence from the rest of the separator.

Primary Corella® Coalescer: The Corella® coalescer is a removable, inclined parallel, flat/corrugated plate coalescer that enhances separation of both oil and solids from all strata of the wastewater stream. It is individually engineered to specific application and job-site requirements to maximize utility. Corella® inclined parallel plate coalescers combine the features of flat and corrugated plate coalescers into a dual-function design that performs better than traditional plate coalescers.

Plate clogging is the primary reason for separator failure. Corella's® multi-purpose plates greatly reduce the accumulation of settleable solids in the plate pack and minimize separator shutdown and maintenance by simultaneously separating free oil droplets and settleable or suspended solids from water.

Corella® plates are assembled and arranged to allow settleable solids to accumulate on the flat top of the plates and slide downward, while the oil coalesces into sheets on the corrugated undersides and flows upward. Unlike other oil/water separators, both oil and solids are removed, minimizing shutdowns for periodic cleaning.

Secondary Coalescer: The Petro-Screen secondary coalescer is a polypropylene impingement coalescer comprised of an encased bundle of layered oil-attracting fibers used to intercept droplets of oil that are too minute to be removed by the Corella® Coalescer. The Petro-Screen effectively removes oil droplets down to 20 microns in diameter. The incorporation of the Petro-Screen secondary coalescer, and its enhanced oil removal capabilities, allows the design of the OWS to meet the UL-SU2215, 10 PPM effluent rating.

In addition, to its enhanced oil removal capabilities, the selected OWS incorporates the following:

- Adjustable oil collection skimmer
- Automatic oil removal from the main OWS
- Integrated, dedicated oil collection chamber
- Vapor tight design
- Automatic level sensors and alarms
- Capability to handle 50% greater than design oil content at reduced flow
- Capability to handle 100% oil plug flow for 30 minutes of full flow operation

OWS Operation

The operation of OWS units requires minimal manpower and attention. The system contains no moving parts and is almost 100% passive in its operations. The main process parameter requiring monitoring is the flow through the unit and accumulated oil volume.

The selected OWS design is engineered to handle a wide variety of inlet oil concentrations. The majority of oil in the wastewater is removed in the primary chamber (i.e. initial chamber plus the Corella unit). The higher the volume of oil in the wastewater the more oil the primary chamber will accumulate. In most situations the primary chamber will remove free oil to < 15 mg/L. For wastewater with very high concentrations of oil (i.e. >50% oil) the Corella unit in the primary chamber will pass more than 15 mg/L oil. This is generally not an issue as the secondary Petro-Screen coalescer will polish the water to remove any oil > 15 mg/L. In addition, for extremely high oil concentrations (i.e. >50%), any issues can be alleviated by reducing the flow rate through the OWS which allows for more time for efficient oil/water separation.

During operation, the wastewater flows into the OWS through the inlet pipe and is directed over the Velocity Head Diffusion Baffle which dissipates the velocity and turbulence of the incoming water.

In the sediment chamber, heavy solids settle out and are collected at the Sludge Baffle while concentrated oil slugs rise immediately to the surface.

The oily water then passes through the Corella® coalescer - an arrangement of parallel corrugated/flat plates. Oil rises and coalesces into sheets on the undersides of the plates. The oil migrates up the plate surface, breaking free at the top to form large globules of oil that rise quickly to the surface. At the same time, floating solids are stopped on the flat top surface of the angled plates and slide back off into the sludge collection area.

The water then passes through the Petro-Screen coalescer which intercepts oil droplets too minute to be removed by the Corella Coalescer. This bundle of oil-attracting polypropylene fibers traps oil particles down to 20 microns in size. These small particles coalesce into larger globules that eventually break free and rise to the surface.

The water then passes into the final clear well via a pipe located near the bottom of the final chamber. Water in the clear well is removed from the OWS and passed to downstream treatment components via a transfer pump.

During periods of operation oils continue to accumulate on the surface of the OWS while the clearer, heavier water migrates toward the bottom of the OWS. The accumulated oil is continuously skimmed from the surface via an integrated sawtooth type skimmer and transferred into an integrated oil collection chamber. Once sufficient oil has accumulated within the oil collection chamber it is transferred to the external bulk oil storage tank.

The OWS is equipped with a series of automatic sensor and level indicators. The OWS main chamber, clear well and recovered oil reservoir are all equipped with level indicators, high level alarms and high-high level alarms. All of these sensors provide continuous readout to the main PLC.

The level sensors will automatically activate transfer pumps at a preset level to remove oil from the collection reservoir and the clear well. The sensors will also, sound visual and audible alarms at the high-level set point and will automatically shut down the system at the high-high level setting.

Waste Generation

The waste generated by the operation of the OWS will primarily consist of solids that accumulate at the bottom of the primary settling chamber. Based on the anticipated volumes to be received and treated at the proposed Envirosoil facility, preliminary design calculations indicate that the removal of solids via the OWS will generate the annual equivalent of 6 – 10 m3 of oily solids.

The solids contained within the OWS will be sent to an offsite facility that is approved by Nova Scotia Environment and Climate Change for the acceptance, treatment and/or disposal of the materials. Testing, packaging and transportation of the material to the facility will be performed in accordance with the facility requirements and applicable regulations.

Inspection and Maintenance Schedule

Because the OWS unit contains no moving parts and is passive in nature, maintenance requirements are minimal. All maintenance will be based on the manufacturer’s recommendations and schedule. All maintenance will be completed as soon as it is identified, and maintenance logs and records maintained.

At a minimum, the following items will be completed:

Daily:

- Visual inspection of OWS for leaks
- Visual inspection of all gaskets and seals
- Verification of sensor operations

Monthly:

- Visual inspection of OWS interior
- Visual inspection of all gaskets and seals
- Check on solids accumulation within OWS → remove if > 20% of OWS volume
- Visual check of Corella and Petro-screen → clean as required
- Verification of sensor operations

Annually:

The unit will be taken out of service and inspected for the following:

- Remove all accumulated solids
- Clean interior of OWS
- Replace all O-rings and gaskets
- Inspect interior for corrosion
- Remove and clean both the Corella and Petro-screen coalescers
- Inspect both the Corella and Petro-screen coalescers and replace if required
- Inspect all valves
- Calibrate all sensors and level controls

All wastewater generated during the maintenance operations will be returned to the dirty water storage tank to be treated via the system. Any solids will be removed and disposed of as per the waste disposal procedures.

Bag Filtration – Rationale for Method Selection

Project Location: 750 Pleasant Street, Dartmouth, Nova Scotia

Operator: Envirosoil Limited

A bag filter system is one of the most commonly used and universally accepted filtration methods for liquid process applications. It provides a versatile, cost effective and consistent filtration system suitable for a broad range of applications from small batch operations to bulk processing.

Bag filter housings are available in a wide range of materials and sizes, enabling operators to select a system to handle any fluid type and flow rate between 5 m^3/hr and 960 m^3/hr. Replacement filter bags are selected from the broadest possible range of media. The required filter media is determined by the size of the particles to be removed (0.2 - 1500 microns), the type of particles to be removed (deformable or non-deformable), the required retention efficiency (60% – 99.98%) and the chemical and temperature compatibility of the media.

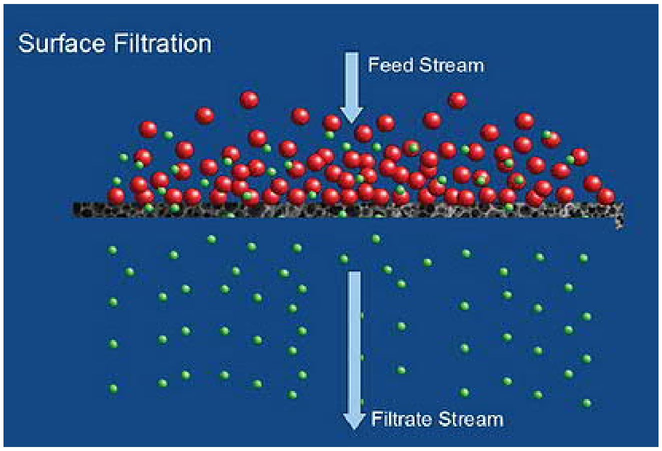
A filter bag unit is a pressurized filtration system. Liquid is delivered through a filter vessel inlet into the top of a filter bag supported by a retainer basket. Fluid travels through the supported filter media where the contaminant is entrapped. The cleaned filtrate exits through an outlet connection. Since the system is pressurized, the liquid is distributed over the entire surface of the filter, resulting in even flow and contaminate distribution. Contaminate particles are retained inside the filter bag for ease of change-out and disposal.

Bag filtration can be performed in one of two operational modes: surface filtration and depth filtration.

Surface Filtration

Surface media removes contaminate particles on their surface. They are generally two-dimensional woven structures and are only as deep as the diameter of the yarn from which they are woven.
They only trap particles that are larger than the window opening of their structure.

These provide surface filtration - a 'Sieving' mechanism, causing particles larger than the pore size of the media to be captured on the surface of the media. Micron ratings range from 1 – 1500 microns. They exhibit high mechanical strength, and are excellent for removing non deformable, solid particles or as an initial filtration of bulk wastewater to remove larger particle size solids. In this function, they traditionally serve as a type of "pre-filter" to remove bilk/larger particle sizes upstream of treatment components.



Depth Filtration

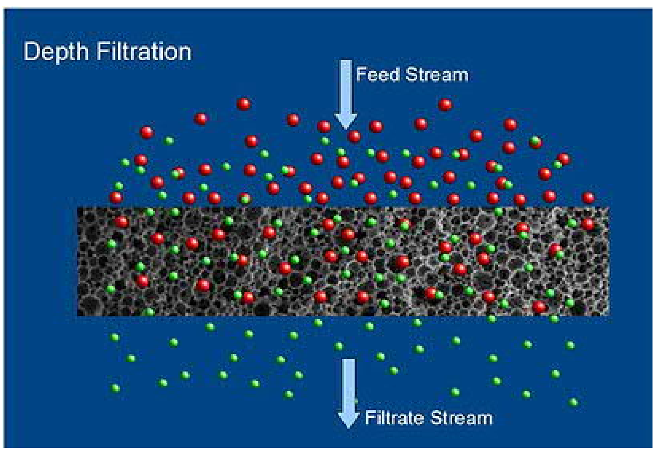
Depth media removes contaminant particles both on the surface and within the depth of the structure. They are, typically, of needled felt or melt blown, three-dimensional construction. This structure creates a tortuous path for particles to follow, often resulting in particulates of a size smaller than the actual pore openings being trapped.

They provide high efficiency depth filtration and are available in polypropylene and polyester, up to 99.98% absolute removal efficiency rated between 0.2 and 25 microns.

In this function, they traditionally serve as a type of “mid-process filter” and a “polishing filter” to remove smaller particles either prior to a treatment system component or as a final filtration step in the treatment process.

Advantages:

- High dirt holding capacity
- Higher void volume or pore volume
- Ability to remove both non-deformable and deformable gelatinous particles
- Ability to remove particles smaller than the mean pore size opening
- Long service life



Equipment Design and Selection

Besides the capital and operational costs, there are many factors that affect the selection of a bag filtration system. These factors include (a) design considerations and options, (b) process requirements, (c) maintenance requirements, (d) maintenance procedures, (e) mean-time-between changeout (MTBC), and (f) disposal costs.

The design of the bag filtration system is dependent on a variety of design factors such as

- Process specifications (metallurgy, temperature, pressure, etc.)
- Footprint, weight, clearance
- Filter flux rate
- Filter surface area, length, diameter, design type
- Filter type (bag, cartridge, other)
- Flowrate and pump requirements

- Solids concentration and solids characteristics
- Fluid viscosity, density, specific gravity, pH, etc.
- Changeout requirements, frequency
- Instrumentation and safety
- Costs of hardware, filters, maintenance, disposal

Important design steps include the following:

- Determine stream composition, flowrate and temperature
- Calculate total solids per day removal, know total suspended solids (TSS) and particle size distribution (PSD)
- Determine Flux rate (0.5 gal/ft2/min for pleated bags; 60–120 gal/min/bag for regular bags)
- Determine total surface area
- Determine bag or cartridge type
- Calculate best fit (number and size of filters required)
- Calculate number of vessels required
- Calculate total pressure drop (clean and fouled)
- Modify design to minimize changeout frequency
- Design vessel layout
- Calculate quantity of waste requiring offsite disposal

After consulting with industry experts and vendors and completing the required design calculations, Envirosoil Limited (Envirosoil) selected the most appropriate equipment to suit the needs of the proposed facility.

Bag Filter Selection

For the proposed facility, Envirosoil has selected both surface and depth bag filtration system based on the location of the filter within the treatment system and the anticipated properties of the solids loading at that point. The type of filters selected are:

1. Surface filtration was selected for the initial offloading of wastewaters and filtration prior to the oil/water separator. Surface filtration was selected for these locations due to the fact that the main goal was the removal of bulk solids >1000 microns. Removal of solids in this micron range will minimize filter changeout frequency as well as minimizing waste generation.
2. Depth filtration was selected for all filtration requirements downstream of the oil/water separator. Depth filtration was selected for these locations due to the fact that the solids loading leaving the oil/water separator would be greatly reduced and much finer particle removal efficiencies (0.5 - 25 microns, Beta 5000) are required as the water moves through the various treatment components. In addition, the ability of the depth filtration to remove deformable/gelatinous is important as the flocculated particles from both the electrocoagulation unit and the screw press unit have the potential to be deformable in nature.

In addition to the specific filtration mode, the actual bag filters to be used in the treatment system were selected based on the requirement to have >95% - 99.8% absolute filtration efficiency, extended life and possess high solids loading capacity. In order to achieve these criteria, extended life and high-capacity bag filters were selected as the main type of bag filter to be used in the treatment process.

Studies have shown that one high-capacity filtration unit can replace as many as 200 standard, 2.5-in. cartridges filters and that traditional single or multilayer bag filters cannot approach the dirt holding capacity of a high-capacity pleated bag filter. High efficiency bags are now being used in applications previously dominated by expensive cartridge filtration due to higher dirt holding capacities, longer service life and lower overall cost whilst maintaining or increasing the required filtration efficiency. The advantages of using extended life and high-capacity bags include:

- Prevention of premature blinding of the bags
- Up to 70% increase in available filtration surface area
- Reduced liquid retention by 25%
- High solids loading capacity
- Longer time between changeouts
- Lower waste disposal quantities

Filtration Housing Selection

The specific bag filter housing was selected to handle the selected filter bags and the following operational parameters:

1. Minimum pressure rating: 100 psi
2. Minimum flowrate: 100 gpm
3. Minimum surface area for surface filtration: 4.4 ft^2 per bag
4. Minimum surface area for depth filtration: 50 ft^2 per bag
5. Corrosion resistant
6. Minimum pressure drop rating: 35 psi
7. Maximum inlet velocity: 8 – 10 ft/s
8. Maximum temp: 75 C
9. Quick/snap ring closures
10. Ease of filter changeout

Based on the above parameters, both duplex and multi-round, stainless steel filter housings were selected.

A duplex vessel consists of two “separate” bag vessels that share the same inlet and outlet connections thus having the capacity to double the flow rate and filtration surface area by utilizing both vessels simultaneously. Alternatively, in applications where a continuous flow (without interruptions) is required, isolation valves are added to direct the flow through one vessel while a bag change-out is being performed on the other. This type of filter will be utilized in the offloading area of the facility to perform the removal of gross solids > 100 microns. Because of the anticipated high solids loading, this system was required to have the capability to change bags without being taken completely offline.

A multi-bag filter includes multiple bag filters integrated into a single filter housing. This allows for higher flow rates and the larger filter area extends the operating times between filter changeouts. The multi-unit filter selected by Envirosoil for use in its facility has the capability to accept up to 6 depth-type bag filters. Multi-bag type filtration units will be used at all locations within the treatment train except for the truck off-loading area.

Equipment Operation

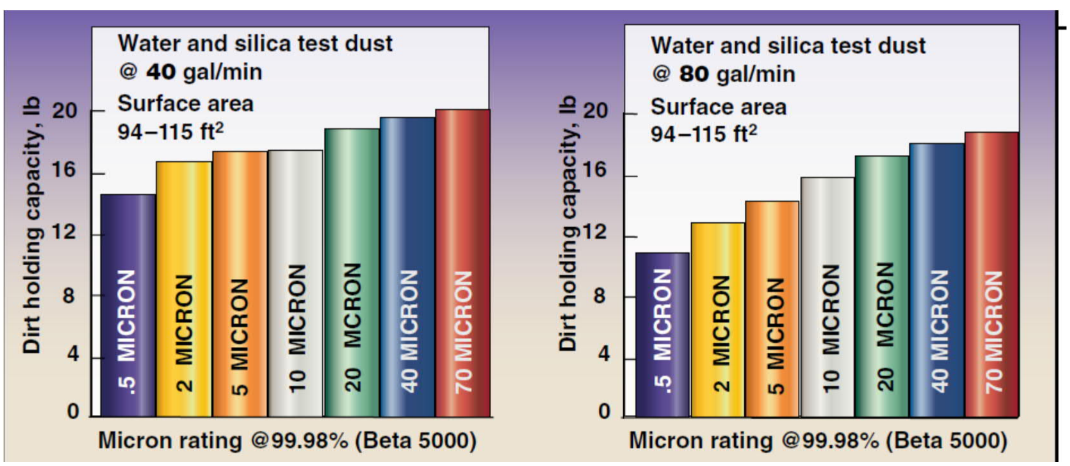
The operation of bag filtration units required minimal manpower and attention. The system contains no moving parts and is almost 100% passive in its operations. The main process parameter requiring monitoring is the differential pressure drop across the unit.

As the wastewater passes through the filter vessel and through the bag filter, solids are trapped/entrapped within and on the surface of the bags. As operations progress the quantity of the solids retained by the bags will increase and subsequently the pressure required to pass water through the bag will increase. Operations will continue until the pressure drop across the bag is 15 – 30 psi (depending on the type of bag). Once the appropriate pressure drop is reached the unit is taken offline and the bags changed. Depending on the configuration of the housing unit, the time required to complete a bag changeout is typically < 15 minutes.

The pressure drop across the bag filter unit is monitored by an electronic pressure differential sensor. The sensor will continuously monitor the pressure drop across the unit and provide real time data to the operator via the main PLC control unit. The PLC will alarm and alert the operator when the filter bags need to be changed. If the operator fails to change the bags and the pressure continues to rise, the PLC will automatically shut down the feed pump to the main treatment system.

Waste Generation

The waste generated by the operation of the bag filtration units will depend on the amount of wastewater treated, the concentration of solids within the wastewater and the "dirt holding capacity" (DHC) of the bag filter. The following figure presents a schematic of the DHC of various bag filters.



Based on the anticipated volumes to be received and treated at the facility, preliminary design calculations indicate that the removal of solids via bag filtration will generate the daily equivalent of 6 – 8 used bags containing a total of 15 – 20 kg of solids.

The solids contained within the bag filters and the used bags themselves will be sent to an offsite facility that is approved by Nova Scotia Environment and Climate Change for the acceptance, treatment and/or disposal of the materials. Testing, packaging and transportation of the material to the facility will be performed in accordance with the facility requirements and applicable regulations.

Annual Maintenance

Because bag filter units contain no moving parts and are passive in nature, maintenance requirements are minimal. All maintenance will be based on the manufacturer's recommendations and schedule. All maintenance will be completed as soon as it is identified, and maintenance logs and records maintained.

At a minimum, the following items will be completed:

Routine Filter Bag Change outs:

- Inspect all O-rings and gaskets
- Inspect internal support frames
- Inspect lid closing mechanisms
- Inspect seating of bags within the support frame
- Inspect housing interior for the presence of solids
- Inspect differential pressure transmitter

Annually:

The unit will be taken out of service and inspected for the following:

- Replace all O-rings and gaskets
- Inspect interior for corrosion
- Calibrate differential pressure transmitter

Electrocoagulation – Rationale for Method Selection

Project Location: 750 Pleasant Street, Dartmouth, Nova Scotia

Operator: Envirosoil Limited

There is an increasing demand for more eco-friendly approaches to wastewater treatment, especially in relation to sustainable advances towards energy utilization and the use of chemical coagulants. Electrocoagulation (EC) is one such approach that has been touted in recent years to be environmentally satisfactory.

Electrocoagulation (EC) is not a new process and was first proposed in the late 19th Century. The original patent was used to treat bilge water from ships. Over the past few decades, EC has emerged as a viable technology for the treatment of a wide range of industrial wastewaters generated by:

- Petroleum Refining
- Electrical Utilities
- Oil & Gas Exploration
- Metal Fabrication & Plating
- Mining and Ore Processing
- Bilge Waters
- Frac & Produced Waters
- Pulp & Paper
- Textile/Dyes manufacturing
- Landfill Leachate
- Cooling Tower Waters
- Cement Manufacturer
- Shipbuilding
- Food & Beverage Manufacturing

Most industrial waste waters are complex mixtures of various chemicals and compounds that require removal in order to meet discharge criteria. Because EC is a "non-selective" treatment process it will treat nearly all the contaminants contained within the wastewater. EC is therefore rapidly becoming the technology of choice for complicated wastewater treatment due to its ability to remove a wide range of contaminants. EC can effectively remove emulsified hydrocarbons, complex organics, BOD/COD, nitrogen, microbiological (i.e. bacteria, virus and cysts), PAHs, VOCs, phenols, pesticides, suspended/dissolved solids, and heavy metals in a single treatment unit. The typical removal efficiencies for most contaminants are > 95% with the vast majority being > 99.9%. Figure 1 presents a schematic of the range of target contaminants removed by EC versus other treatment technologies.

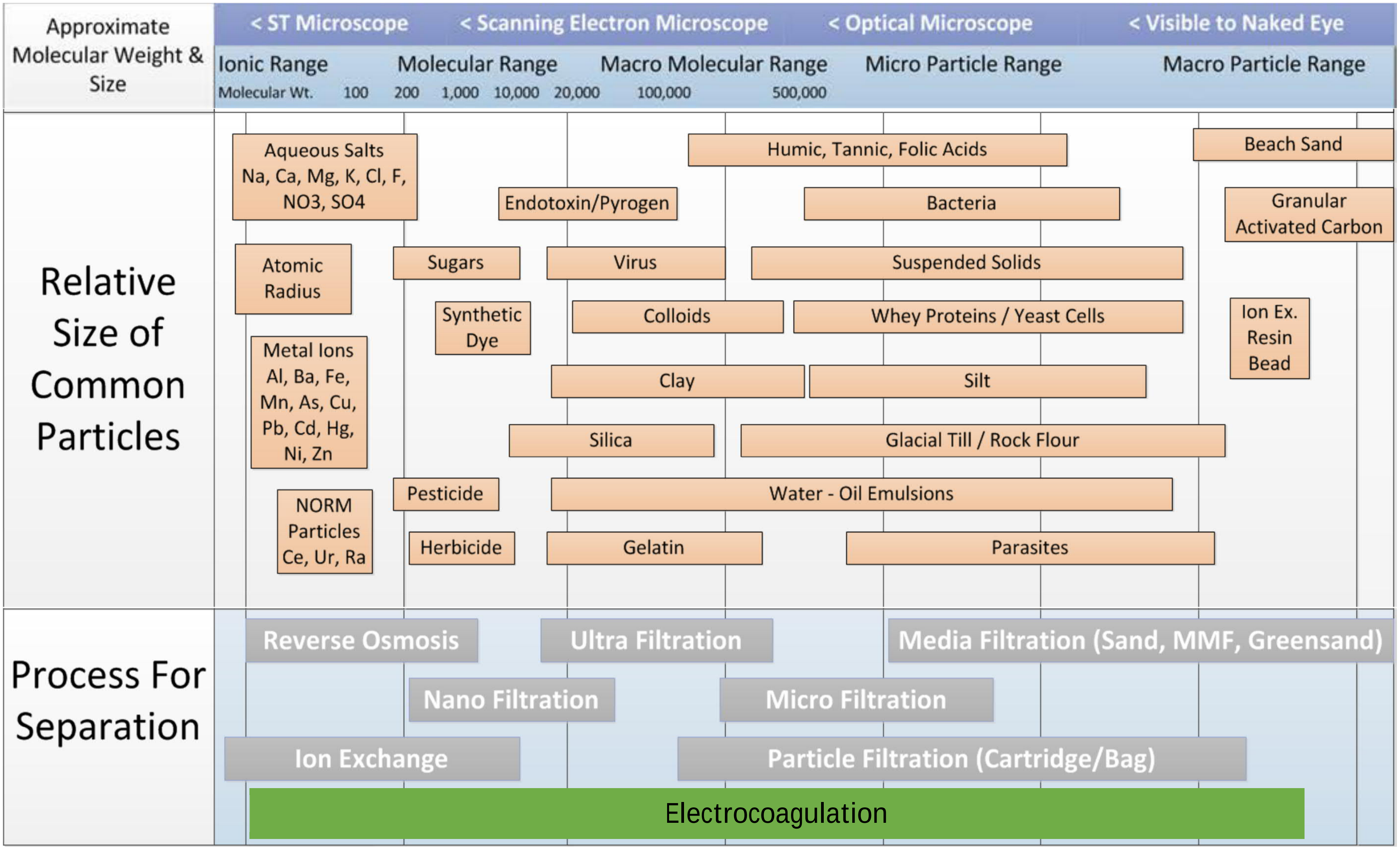
The key benefits of electrocoagulation technology are:

One-step treatment process capable of handling a wide range of pollutants

- Results superior to chemical treatment
- No chemicals used in the treatment
- Low power consumption
- Low residence/contact time required for efficient contaminant removal
- Environmental advantages ➔low sludge production, no chemicals
- EC is easily operated due to the simplicity of its equipment
- The EC process can be completely automated
- EC produces clear, colorless and odorless water
- Flocs formed by EC are much larger than chemical treatment processes and more stable, hence they are easily separated during filtration

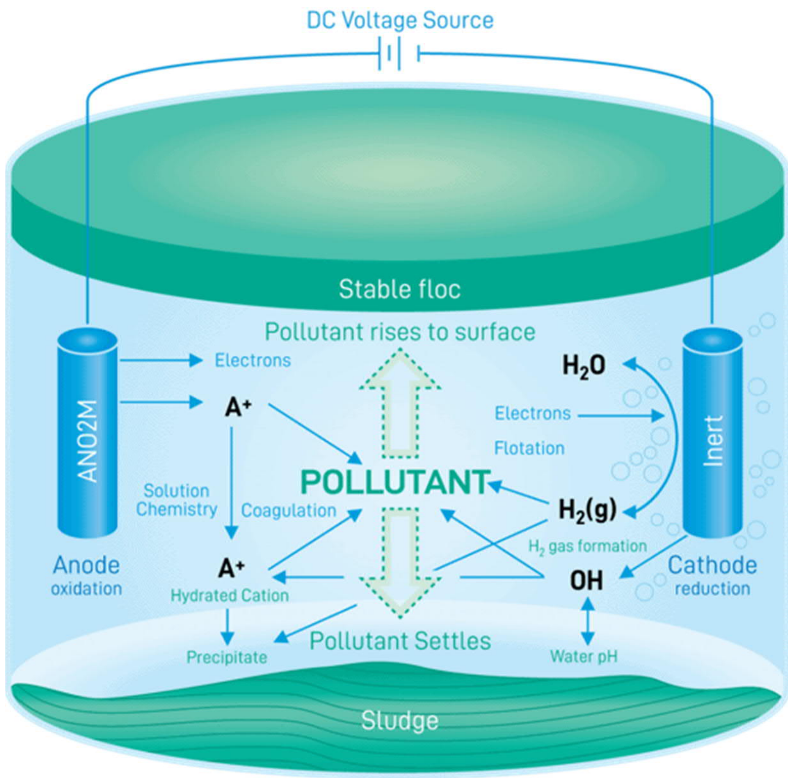
- EC produces much less sludge volume than chemical treatment processes
- Even the smallest colloidal particles are removed by EC Low maintenance and labor demand

Figure 1: EC Range of Target Contaminants Removed Versus Other Technologies



EC, which combines coagulation, flotation and electrochemistry is a process of destabilizing suspended, emulsified or dissolved contaminants in an aqueous medium by introducing an electric current into the medium. In its simplest form, an EC reactor is composed of an electrolytic cell with one anode and one cathode metal electrodes immersed in the solution to be treated and connected externally to a direct current power supply, as shown in Figure 1.

Figure 1: Typical EC Layout



An EC system essentially consists of pairs of conductive metal plates in parallel, which act as monopolar electrodes. During electrolysis, the positive side undergoes anodic reactions, while on the negative side, cathodic reactions are encountered. Consumable metal plates, such as iron or aluminum, are usually used as sacrificial electrodes to continuously produce ions in the water.

During EC there are several reactions that occur simultaneously that can enhance the treatment performance. These include, formation of metal hydroxide flocs that capture small solids by enmeshment, cathodic liberation of oxidants (hydroxyl radicals OH-) that react to reduce the COD, liberation of hydrogen bubbles that assist to “float” the flocs for enhanced removal and electrical disruption of bacterial cells to reduce viable microorganisms, such as E.coli. If the wastewater contains sufficient chloride ions the electrical current also produces hypochlorite that increases oxidation of organic material, ammonia and reduction of microorganisms. As a result, the reactive and excited state causes contaminants to be released from the water and destroyed or made less soluble.

Within the electrocoagulation reactor, several distinct electrochemical reactions are produced independently. These are:

- Seeding, resulting from the anode reduction of metal ions that become new centers for larger, stable, insoluble complexes that precipitate as complex metal ions.
- Emulsion Breaking: oxygen and hydrogen ions that bond into the water receptor sites of emulsified oil molecules creating a water-insoluble complex that separates water from hydrocarbons, dyes, inks, fatty acids, etc.
- Halogen Complexing: metal ions bind themselves to chlorines in a chlorinated molecule resulting in a large insoluble complex molecules that separate water from PAHs, phenols, TCE, etc.
- Bleaching: oxygen ions produced in the reaction chamber oxidizes dyes, cyanides, bacteria, viruses, etc. In addition, the current generated between the electrodes creates an osmotic pressure that typically ruptures bacteria, cysts, and viruses.
- Oxidation and Reduction: Redox reactions chemically convert contaminants to less toxic compounds that are less mobile, lower solubility and/or inert.
- pH Swing: The EC process "pushes" the pH of the water toward neutral.

All of the above reactions help to make the EC process non-selective in contaminant treatment and significantly efficient in the treatment of mixed industrial wastewaters.

Equipment Design and Selection

Besides the capital and operational costs, there are many factors that affect the selection of an EC system. These include design factors as well as supplier factors.

Design factors include the following (Figure 2 depicts a general schematic of the various design parameters):

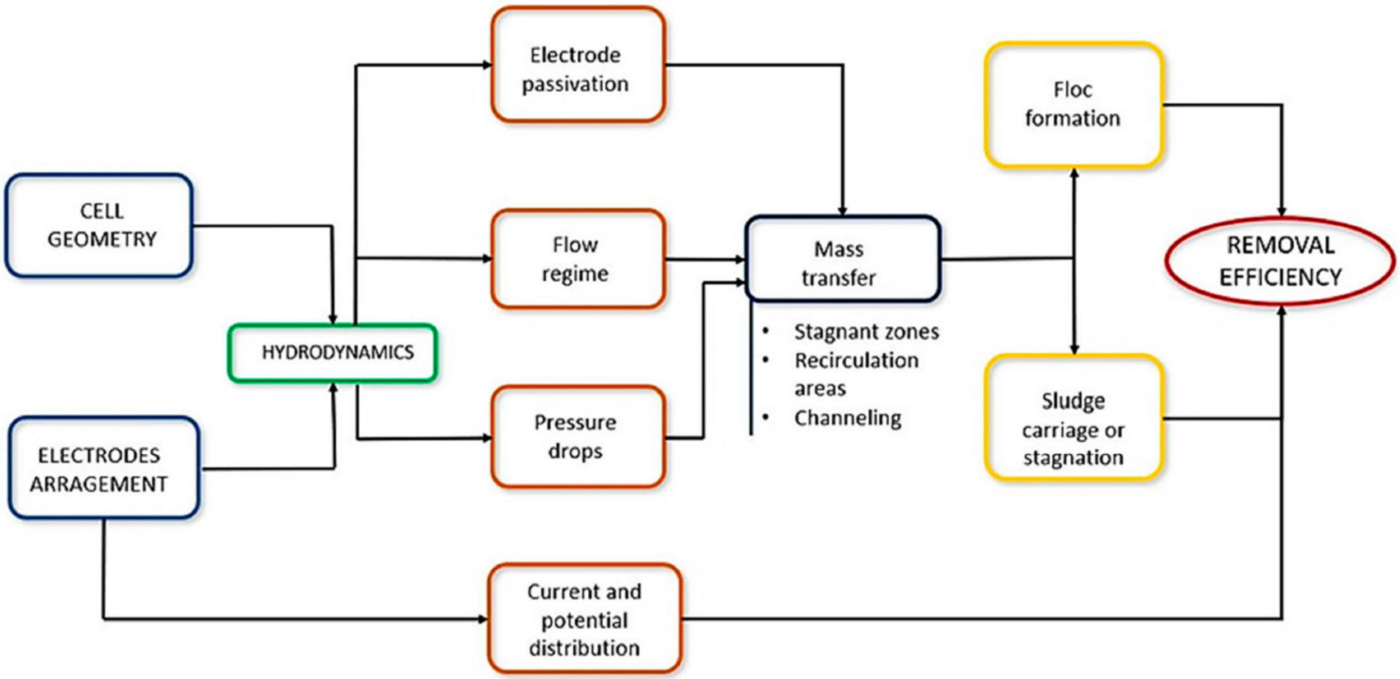
- Retention Time
- Electrode Gap
- Mixing Regime
- Electro/Type Material
- Flowrates
- pH
- Power Supply
- Current Density
- Conductivity
- Electrode Arrangement
- Anticipated Inlet & Effluent Contaminants
- Automation Capability

Most of the specific design parameters are specifically related to the inhouse design of the equipment manufacture and are therefore proprietary in nature. Specific design parameters for a unit are not generally published.

Supplier factors include:

- Supplier experience
- Number of installations
- Inhouse R&D and Laboratory Facilities
- Manufacturing Capabilities
- Installation Support
- Training Support
- Remote Troubleshooting Capabilities
- Pilot Testing Capabilites

Figure 1: Typical EC Design Parameters



EC Unit Selection

After consulting with industry experts and vendors and completing the required design calculations, Envirosoil Limited selected a manufacturer that has extensive experience in the design, manufacturer and operation of EC units.

Some of the expertise/experience of the company include:

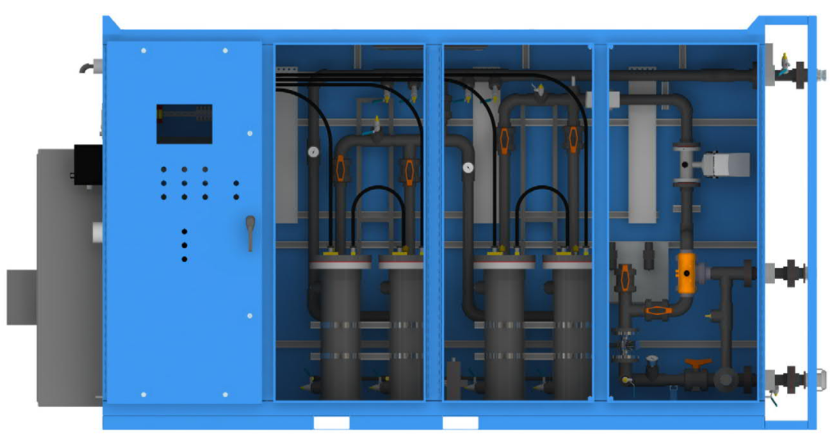
- Completed over 1200 projects worldwide
- Operates in 15 countries (including 3 Canada provinces) and 27 USA states
- Has over 195 Permanent installations
- Operates over 50 rental EC units
- Treats over 500 million gallons of water annually
- Owns a 38,000 square foot facility complete with a full laboratory for water solution development, research, testing, product/process evaluations, wet chemistry experimentation, as well as water quality testing.
- Equipment delivery is accompanied by comprehensive operation & maintenance manuals, classroom and field equipment training, and operator instructional videos
- A dedicated online remote, monitoring and troubling shooting program that is manned by live technicians
- Remote system notification of alarms, events and status for past 24 hours to email
- Immediate online alert notification of critical alarms

Technical aspects of the selected EC unit were based on the fact that the potential wastewater streams anticipated at the facility can fluctuate in contaminant type and concentration. As a result, the system was overdesigned to include a large factor of safety in order to ensure compliance with discharge criteria. Some of the technical aspect of the selected EC unit include:

- Scalable electrochemical dosing
- Single pass flow dosing levels of 2 times recommended standard dosing for similar plants (i.e. factor of safety of 2)
- Industry leading loop-flow mode cell design that involves an internal recirculation loop that results in a dosing level of 4 times standard dosing (i.e. factor of safety of 4).
- Automated voltage/current monitoring and adjustment
- EC works best when the electrical conductivity is > 3000 microS. At levels below this additional chemicals or power is required to treat the wastewater. In keeping with the goal of minimal chemical usage, the unit is designed with a second power system to handle low electrical conductivity wastewaters.
- Capability to increase residence times from 2 to 4 times that of similar systems
- Upflow configuration to automatically clean the anode and cathode and to prevent the accumulation of solids in the bottom of the vessel which greatly reduced cleanout requirements
- Instantaneous and variably-timed polarity reversal system that automatic reverses electrical polarity to eliminate passivity within the EC cells. This options greatly improves the efficiency of the unit, extends the EC cell lifetime, greatly reduces maintenance
- Low electrical power consumption of 30 Amps under nominal load and 60 Amps under full load.
- Full PLC and HDMI operational controls to monitor all process parameters to improve efficiency
- Real-time water quality monitoring and reporting systems
- In addition to the above, the EC unit is supplied with a laboratory pilot unit for conducting treatability testing of wastewaters. The laboratory unit can perform treatability testing at a rate of 2 gpm and the results are directly scalable to the full-sized EC unit.

All of the incorporated design features will ensure that the EC unit can accommodate a very wide array of contaminant types and concentrations. Figure 3 presents a picture of a typical EC unit.

Figure 3: Typical EC unit



EC Operation

The operation of EC unit required minimal manpower and attention. The system contains no moving parts and is almost 100% passive in its operations. The main process parameter requiring monitoring is the flow and pressure through the unit, electrochemical dosing and voltage/current adjustment. All of these parameters are fully programmable and automatic alerts and alarms are sent to the main PLC to notify the operator of any upset conditions.

During operations, the operator will establish and set the appropriate process parameters based on the analysis of the water to be treated and the specific contaminants to be removed. Alternatively, the process parameters can be set to a more generalized set of requirements that allows for more robust treatment (i.e. longer residence times, higher dosing, etc.) regardless of the types and concentrations of contaminants in the wastewater.

As the wastewater is passed though the EC unit the electrochemical process will effectively remove the various contaminants in the form of flocs. The wastewater containing the flocs exit the EC unit and passed through downstream components for the removal of the flocculated material.

The EC unit is equipped with a series of automatic sensor and indicators for all process parameters. All of these sensors provide continuous readout to the main PLC. The level sensors will automatically activate at a preset level to alert the operator of any issues or upset conditions. If the sensors/alarms are not acknowledged the PLC will automatically shut down the system.

Waste Generation

The EC unit itself does not generate any waste requiring disposal.

Annual Maintenance

Because the EC unit contain no moving parts and is passive in nature, maintenance requirements are minimal. All maintenance will be based on the manufacturer's recommendations and schedule. All maintenance will be completed as soon as it is identified, and maintenance logs and records maintained.

The primary maintenance items associated with the EC unit is the replacement of the anodes. During operations the anodes will undergo loss and be "consumed" by the treatment process. The loss of metal from the anode means that the anode system must be replaced on a regular basis when the plate cross sectional area reaches a minimum operating condition. The plate life is determined by the rate of metal loss and the mass of the plate. It is anticipated that a single cell will require replacement after 3,000 – 10,000 m^3 of wastewater. The HMI is equipped with a "low Dose" alarm that indicated that the anode requires replacement.

To expedite the replacement operation the electrode assembly is generally constructed in a modular configuration whereby the complete assembly is replaced. The changeout of a single EE cell can be completed in 10 minutes. The spent EC cells are then sent back to the manufacture for refurbishment.

At a minimum the following items will be completed:

Daily:

- Visual inspection of the EC for leaks
- Visual inspection of all gaskets and seals
- Verification of sensor operations

Monthly:

- Visual inspection of EC interior for solids accumulation ➔ Clean as necessary
- Visual inspection of all gaskets and seals
- Verification of sensor operations

Annually:

The unit will be taken out of service and inspected for the following:

- Remove any accumulated solids
- Clean anodes as required
- Replace all O-rings and gaskets
- Inspect all valves
- Calibrate all sensors and level controls

All wastewater generated during the maintenance operations will be returned to an untreated water storage tank to be treated via the system.

Multi-Disk Screw Press

Project Location: 750 Pleasant Street, Dartmouth, Nova Scotia

Operator: Envirosoil Limited

The treated water from the electrocoagulation (EC) process will contain flocculated particles that will need to be removed from the water in order to ensure that the contaminants are efficiently captured. Dewatering the sludge with a dewatering device also significantly reduces its weight and volume requiring disposal. This process is normally achieved by using a sludge dewatering machine such as a screw press, filter press or centrifuge.

Traditionally centrifuges and belt/filter presses were used as common methods to dewater EC sludge. However, they require continuous watching, high energy consumption and maintenance. Over the past several decades multi-disk screw presses (MD press) have begun to replace centrifuges and filter presses as the main technology to dewater process sludge such as those generated by an EC unit. Table 1 presents a summary of the characteristics of the various dewatering technologies.

Table 1: Comparison of Sludge Dewatering Technologies

Item/Parameter	MD Screw Press	Belt/Filter Press	Centrifuge
Energy Consumption	Low	Moderate	High
Labour Requirements	Low	High	Low
Footprint	Low	High	Low
Automation Degree	High	Low	High
Maintenance Requirements	Low	High	High
Sludge Moisture Content	Moderate	Low	Moderate
Chemical Requirements	Low	High	Moderate
Capacity	Moderate	High	High
Separate Pre-thicking Requirement	Low	High	High
Capability to Handle Very Dilute Feed Sludge	High	Low	Low
Capability to Handle Variable Flow Characteristics	High	Low	Moderate
Capability to Handle Oily Sludge/Flocs	High	Low	High

An MD screw press is a dewatering device that separates liquids from solids. An MD screw press can be used in place of a belt press, centrifuge, or filter press. It is a simple, slow-moving device that accomplishes dewatering by continuously increasing pressure and gravitational drainage. Multi-disk screw presses are often used for materials that are difficult to press, for example those that tend to pack together. The MD screw press squeezes the material against a screen or filter and the liquid is collected through the screen for collection and use.

Over the past few decades, MD screw presses have been used to effectively treat sludges generated by the treatment of a wide range of industrial wastewaters generated by:

- Petroleum Refining
- Electrical Utilities
- Pulp & Paper
- Textile/Dyes manufacturing

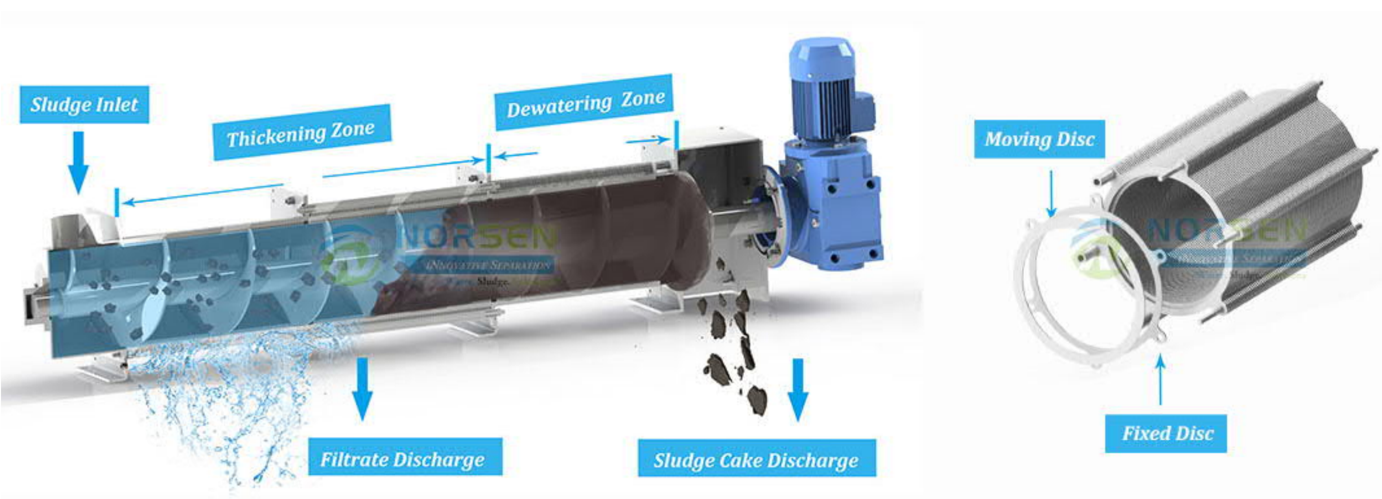
- Oil & Gas Exploration
- Metal Fabrication & Plating
- Mining and Ore Processing
- Bilge Waters
- Frac & Produced Waters
- Landfill Leachate
- Cooling Tower Waters
- Cement Manufacturer
- Shipbuilding
- Food & Beverage Manufacturing
-

An MD screw press is an enclosed high performance sludge dewatering system. It utilizes a central screw auger and a slowly oscillating multi-disc filter to gradually increase pressure on flocculated sludge to produce an exceptionally dry sludge cake.

The sludge is thickened and dewatered progressively along the length of the vessel, which comprises a series of fixed and rotating rings, via the inner screw conveyor. The screw pitch becomes smaller as the material moves towards the end plate, resulting in increased pressure to dewater the sludge. The strong squeezing force generated by the change of screw diameter and screw pitch, and the tiny gap between the floating ring and the fixed ring, ensures sufficient pressure to efficiently dewater the material.

As the material moves along the screw, the filtrate is drained from the gaps between the rings, creating a thickening and a dewatering zone in different regions of the vessel. The gap between the rings is large enough to allow for the passage of water but not the solids. The sludge cake is discharged at the end plate, achieving a minimum solid content of 20%. Water from the process is pumped downstream for further treatment/polishing. Figure 1 presents a general schematic of how a multi-disk screw press works.

Figure 1: Multi-Disk Screw Press – General Schematic



Equipment Design and Selection

Besides the capital and operational costs, there are many factors that affect the selection of an MD screw press. These include design factors as well as supplier factors.

Design factors include the following:

- Capability to handle variable flow rate
- Capability to handle inlet sludge concentrations from 0.2% - 5%
- Energy efficiency
- Dewatered sludge solids content: Minimum 20% - 40%
- Low utility water requirements
- Full automation
- Low/no chemical requirements
- Corrosion resistant
- Capability to handle oily sludge and inorganic materials

Supplier factors include:

- Supplier experience
- Number of installations
- In-house R&D and Laboratory Facilities
- Manufacturing Capabilities
- Installation Support
- Training Support
- Remote Troubleshooting Capabilities
- Pilot Testing Capabilities

Multi-Disk Screw Press Selection

After consulting with industry experts and vendors and completing the required design calculations, Envirosoil Limited selected a manufacturer that has extensive experience in the design, manufacturing and operation of multi-disk screw presses.

Some of the expertise/experience of the company include:

- Numerous systems installed throughout Canada (currently in at least five Canadian provinces), USA, Mexico, Asia, Europe and Australia.
- Installed systems have treated and recovered over 41 billion gallons of wastewater
- Provided one of the largest standalone dewatering systems in the USA with a capacity to handle 1 million gallons/day of wastewater.
- Received several awards from the US EPA and USDA for the efficiency of their system in recovering water for reuse.
- Past recipient of the Canadian Business Excellence Award for Private Businesses given annually to only 25 private businesses in Canada. The award was for their innovative process to recover valuable water from wastewater streams.
- Owns a large manufacturing and testing facility in Canada and the USA, complete with a full laboratory for water solution development, research, testing, product/process evaluations, as well as water quality testing.

- Equipment delivery is accompanied by comprehensive operation & maintenance manuals, classroom and field equipment training, and operator instructional videos.

Technical aspects of the selected MD screw press were based on the fact that the potential wastewater streams anticipated at the facility can fluctuate in contaminant type and concentration. This may result in varying concentration of floc particles within the wastewater. As a result, the system was overdesigned to include a factor of safety in order to ensure compliance with discharge criteria. Some of the technical aspects of the selected MD screw press unit include:

- The MD screw press has two (2) dewatering screws that can be operated independently with each screw designed to handle anticipated flow at peak conditions. The additional screw can be brought online as required. The additional screw offers a factor of safety of 2 to account for any unanticipated process flow conditions (i.e. higher flow, higher inlet solids loading, etc.).
- The dual screw configuration allows for a 2-fold increase in residence time if required.
- Capability to handle inlet sludge concentrations from 0.05% - 10%.
- The advanced design of the unit makes it a self-cleaning unit due to the friction free movement between the rings.
- The special tungsten carbide coating of the inner screw and its slow rotation reduces friction and assures a long-life span of the system components.
- Low energy requirements ➔ less than 10% of an equivalent centrifuge.
- Low utility water requirement ➔ less than 1% of an equivalent belt filter press.
- Integrated, multiple clean in place nozzles for superior cleaning and rinsing.
- Can handle oily, fibrous and inorganic sludges.
- Fully integrated polymer injection system (if required).
- Full PLC and HDMI operational controls to monitor all process parameters to improve efficiency.
- Real-time water quality monitoring and reporting systems.

All of the incorporated design features will ensure that the MD screw press can accommodate a very wide array of contaminant types and concentrations. Figure 3 presents a picture of a typical MD screw press.

Figure 3: Typical MD Screw Presst

MD Screw Press Operation

The operation of MD press requires minimal manpower or attention and is fully automated. The main process parameter requiring monitoring is the flow and pressure through the unit, screw speed and gap at the end plate. All of these parameters are fully programmable and automatic alerts and alarms are sent to the main PLC to notify the operator of any upset conditions.

Since the equipment is constructed in order to avoid clogging, continuous washing of the plates and auger is not needed in maintain filtration performance. However, a small amount of cleansing water is used on to ensure that all rings and auger parts are kept clean. The frequency of the cleansing spray is programmable and is normally set at one 10 second spray per 10 minutes (1 min/hr). The water utilized for the cleaning process will be obtained from the clean water storage tank. It is not anticipated that City/Municipal water will be required.

The main principle of the MD screw press is to use the adjustable gap between the fixed ring and the moving ring to intercept the solid phase material. When the sludge enters the thickening zone the relative movement of the fixed ring and the floating ring is used to make the filtrate quickly discharged through the gap while the sludge moves on to the dewatering zone. The gap between the rings is narrow enough to allow for the passage of water but not the solids.

When the sludge enters the dewatering zone the screw pitch is constantly shrinking. As the sludge moves along the screw the internal pressure to increase, and coupled with the back pressure of the back pressure plate, the sludge is squeezed to remove water. The dewatered material is continuously discharged out of the machine into a collection bin.

By adjusting the speed of the screw shaft and the gap of the pressure of the back pressure plate, the sludge treatment capacity and the sludge moisture content can be effectively adjusted to achieve maximum solids capture.

The MD screw press is one of the most efficient dewatering units on the market. Due the lack of shear forces on the flocs, high separation efficiencies are achieved. Solid separation in excess of 90% is normally achieved and efficiency of over 99% can be achieved on some applications. The system will normally achieve over 98% efficiency on flocs generated by EC treatment of industrial wastewaters.

In the rare event that a chemical flocculent is required to facilitate floc growth, an automatic flocculant dosing system will automatically add the desired quantity of flocculant. Flocculation is the process which uses gentle stirring to bring suspended particles together so they will form larger aggregate particles, called flocs. Organic polymers are often utilized at this stage to provide bridging of floc particles, which tends to form even larger floc agglomerates. Preliminary design of the MD screw press indicates that a flocculant will not be required. If required, a standard organic flocculant that is traditionally used in drinking water systems will be used to promote floc growth.

The MD screw press is equipped with a series of automatic sensor and indicators for all process parameters. All of these sensors provide continuous readout to the main PLC. The level sensors will automatically activate at a preset level to alert the operator of any issues or upset conditions. If the sensors/alarms are not acknowledged, the PLC will automatically shut down the system.

Waste Generation

The MD screw press unit itself does not generate any waste requiring disposal. The waste from the MD screw press will be generated by removing and dewatering the flocs that were generated by the electrocoagulation treatment process. The quantity of dewatered sludge generated per day is highly dependent on the type and concentration of the contaminants in the wastewaters. The higher the contaminant loading, the higher the quantity of dewatered sludge generated.

Based on preliminary engineering design, it is anticipated that the MD press will generate 200 – 600 kg of dewatered sludge per 10-hour operational shift. Once the facility is operational at full capacity (i.e. 24/7) this translates into an annual sludge generation of approximately 150 – 350 tonnes per year.

As the sludge is generated, it will be stored within a covered, watertight roll-off bin. Once the bin is full the sludge will be sent to Envirosoil's facility in Bedford, NS for treatment. Prior to shipment to Envirosoil, the sludge will be sampled and analyzed for all appropriate parameters related to Envirosoil's acceptance criteria. Typically, the sludge generated from electrocoagulation treatment of industrial wastewater is non-leachable and is not classified as a Waste Dangerous Good. In the unlikely event that Envirosoil cannot accept the material, it will be sent to an out of province facility for disposal.

Maintenance

All maintenance will be based on the manufacturer's recommendations and schedule. All maintenance will be completed as soon as required, and maintenance logs and records will be maintained.

The primary maintenance item associated with the EC unit is the replacement of the moveable rings on the high-pressure section of the screw. Other parts such as pumps and control devices are replaced as required when they fail through fair wear and tear. The life expectancy of a high-pressure moving ring section is about 30,000 hours while the screw auger has a life expectancy of 10,000 hours. The time required to provide maintenance/replacement of either component is < 0.5 days.

At a minimum, the following items will be completed:

Daily:

- Visual inspection of the unit for leaks
- Visual inspection of all gaskets and seals
- Visual quality of the dewatered cake
- Verification of sensor operations

Monthly:

- Visual inspection of MD screw press interior for solids accumulation ➔ Clean as necessary
- Visual inspection of auger and rings for wear
- Visual inspection of all gaskets and seals
- Verification of sensor operations

Annually:

The unit will be taken out of service and inspected for the following:

- Remove any accumulated solids
- Clean entire system as required
- Replace all O-rings and gaskets
- Visual inspection of auger and rings for wear
- Inspect all valves, pumps, motors, etc.
- Calibrate all sensors and level controls

All wastewater generated during the maintenance operations will be returned to the untreated water storage tank to be treated via the system.

Adsorption Treatment Train

Project Location: 750 Pleasant Street, Dartmouth, Nova Scotia

Operator: Envirosoil Limited

Although the main treatment components (i.e. oil/water separator, electrocoagulation and multi-disk screw press dewatering) of the facility are more than capable of effectively removing the anticipated contaminants from the wastewaters, the system is enhanced by the addition of an adsorption treatment section.

In many industrial wastewater treatment facilities, the entire treatment system is comprised mainly of an oil/water separator and an adsorption train. The integration of an adsorption system into the main component of Envirosoil's treatment process will provide the following benefits:

- Greatly enhance the capabilities and efficiency of the overall treatment system
- Provide "redundant/backup" components capable of handling all anticipated waste streams
- Add a significant factor of safety for any upset conditions or unanticipated contaminant concentrations
- Provide a continuous "polishing" system for all treated water to ensure that discharge criteria are achieved

The adsorption treatment section consists of the following components:

- Organoclay for the removal of dissolved hydrocarbons
- Granular activated carbon for the removal of a wide range of organic contaminants
- Zeolite media for the removal of heavy metals, ammonia, etc.

Although each of the components listed above can provide excellent, stand alone, water treatment capabilities, when combined into a single adsorption train their individual capabilities work together to greatly enhance overall efficiency, improve contaminant reduction and reduce waste.

The following sections will discuss each individual component of the adsorption train.

Organoclay Adsorption

Since the mid-1970s, the use of organoclay (OC) in wastewater treatment has become commonplace in industrial wastewater treatment operations. OC exhibits an excellent synergistic effect with the most commonly utilized water treatment unit type - granular-activated carbon (GAC) adsorption.

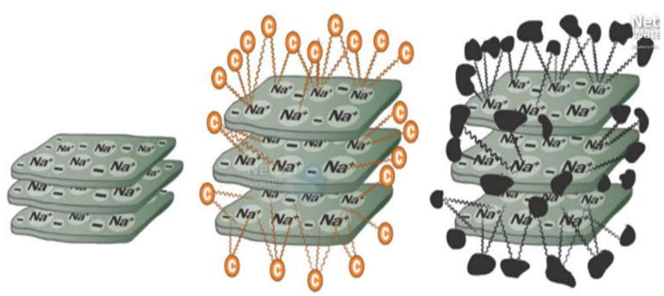
Organoclays have found increased acceptance as pre-treatment for GAC systems in the treatment of many types of industrial wastewaters. Although GAC has a high capacity to adsorb large molecular compounds, they tend to become blinded at higher inlet concentrations (i.e. > 500 mg/L). It is also well established that activated carbon is more efficient at low concentrations of organic contaminants (i.e. < 500 mg/L) than at higher ones. With OC material it is exactly the opposite; they do not get blinded by large organic molecules and they are better at removing organics at higher concentrations. It is therefore more efficient to "pretreat" wastewater using OC before treatment via GAC.

When used as a pre-treatment for GAC, organoclay will effectively remove the majority of hydrocarbons, allowing the GAC to remove other soluble organic compounds more efficiently. The use of OC before GAC treatment can increase the life of the GAC media by a factor of 7 to 9 times. In addition, organoclays, which are natural ion exchange resins, will remove ammonia, nitrates, phosphates and small amounts of heavy metals from industrial wastewaters.

Organoclays consist of bentonite that is modified with quaternary amines. Bentonite is a volcanic rock whose main constituent is the clay mineral montmorillonite. This gives the bentonite an ion exchange capacity of 70-90 meq/gram. By exchanging the nitrogen end of a quaternary amine onto the surface of the clay platelets, the bentonite becomes organically modified and thus organophilic (i.e. attractive to hydrocarbons and organics).

The clay is arranged in a layered structure, platelets stacked on top of each other. When these platelets are placed into water, the amine chains are activated and stand up like dry hair causing pillaring of the platelets, and allowing the end of the amine chains to stand or dangle into the water, reacting with organics that pass by. The chains will then dissolve or partition into large organic compounds, such as hydrocarbons and chlorinated organics. This makes OC media extremely efficient and in granular form it can remove 60% to 70% of its dry weight in hydrocarbons and other large, soluble, chlorinated hydrocarbons with a removal efficiency approaching 99%. Figure 1 depicts the removal of organics by OC.

Figure 1: Organoclay Removal Mechanism



Regular Bentonite | Modified Bentonite (i.e. Organoclay) | Organoclay Saturated with Organics

Similar to GAC, OC treatment systems have been used to effectively treat wastewaters generated by a wide range of industrial wastewaters generated by:

- Petroleum Refining
- Electrical Utilities
- Oil & Gas Exploration
- Metal Fabrication & Plating
- Mining and Ore Processing
- Bilge Waters
- Frac & Produced Waters
- Pulp & Paper
- Textile/Dyes manufacturing
- Landfill Leachate
- Cooling Tower Waters
- Cement Manufacturer
- Shipbuilding
- Food & Beverage Manufacturing

The adsorption mechanisms of OC are very similar to those of GAC which are presented in detail in the specific GAC document in Appendix C-2. These factors are summarized below:

1. MTZ: As a contaminated water stream passes through a bed of OC, a mass transfer zone (MTZ) is established. As the MTZ moves through the OC, contamination concentrations above the desired treatment criteria begins to show in the effluent. This condition is classified as "breakthrough" and the amount of contaminant adsorbed is considered the breakthrough capacity. If the bed continues to be exposed to the water stream, the MTZ will pass completely through the bed and the effluent contaminant level will equal the influent. At that point, saturation capacity is reached.

2. Isotherms: Liquid phase adsorption isotherms are used to predict OC adsorption capacity and to estimate the mass of contaminant (i.e. mg contaminant removed/kg of OC) that the OC can remove. This isotherm data is then used to calculate the quantity of OC required for a particular treatment system and to estimate the time until the OC is exhausted or consumed and needs to be replaced. However, the availability of isotherms for OC is not as extensive as for GAC and often the capacity is estimated on the demonstrated capability of OC to adsorb 60% - 70% or more of its dry weight of hydrocarbons and other large, soluble, chlorinated hydrocarbons with a removal efficiency approaching 99%.

3. Half Lengths: The "Half Lengths" concept tells us that if it takes x number of minutes to reduce a particular contaminant concentration by 50%, it will take x number of minutes to reduce the residual level of contaminant by an addition 50%. So, if one half-length removes 50%, two half lengths will remove 75% and three will remove 87.5%. About seven half lengths are required to remove 99% and ten to reach >99.9%. Because of the high adsorption properties of OC, the required contact time (EBCT) is less than that of a GAC system. OC has been demonstrated to achieve very low discharge criteria concentrations (i.e. >99% removal) with EBCTs of 10 - 20 minutes.

Because OC is used as a pre-treatment step for GAC, along with its high adsorption capacity, it is routine to have only 1 vessel of OC media in the treatment train (except in very large systems/facilities). Any breakthrough of organic contaminants from the OC unit will be captured by the downstream GAC unit. This allows the MTZ to pass completely through the OC prior to its removal from service and replacement of the spent OC media. Effluent quality is maintained by the downstream beds of GAC.

Equipment Design and Selection

Similar to GAC, the selection and design of an efficient OC adsorption system relies on many factors and calculations. These factors and associated calculations are well established and utilized by virtually all OC system suppliers. Many manufacturers and suppliers of GAC also supply OC media.

Similar to GAC, the main design factors include the following:

- Influent contaminant type and concentration
- Removal efficiency required to achieve discharge criteria
- EBCT
- OC usage rate
- Bed Depth
- Surface loading rate

- Pressure drop
- Temperature of water
- Full automation
- Corrosion and abrasion resistance

OC Unit Selection

After consulting with industry experts and vendors, and completing the required design calculations, Envirosoil Limited selected a manufacturer that has extensive experience in the design, manufacturing and operation of OC units. It should be noted that there are numerous qualified vendors of OC units in Canada and the USA. All vendor designs are based on clearly established guidelines, calculations and adsorbent properties. The main variations between vendors are the actual configuration and layout of the adsorption vessels themselves.

Technical aspects of the selected OC unit were based on the fact that the potential wastewater streams anticipated at the Envirosoil facility can fluctuate in contaminant type and concentration. This may result in varying concentrations of contaminants within the wastewater. As a result, the system was overdesigned to include a factor of safety in order to ensure compliance with discharge criteria. Some of the technical aspects of the selected OC unit include:

- A single vessel configuration operating upstream of a GAC unit
- The OC unit has a capacity for 6,000 lbs (approx. 2700 kg) of OC material
- The OC unit has an EBCT of approximately 60 minutes at nominal flow rate. This represents a 3 x factor of safety over the recommended EBCT of 20 minutes.
- The OC unit has an EBCT of approximately 30 minutes at peak flow rate. This represents a 1.5 x factor of safety over the recommended EBCT of 20 minutes.
- Interior liner to resist corrosion and abrasion
- Pressure differential switches across each vessel

OC Operation

The OC unit has no moving parts and requires minimal manpower or operator attention. The main process parameter requiring monitoring is the flow and pressure through the unit. Both of these parameters are fully programmable and automatic alerts and alarms are sent to the main PLC to notify the operator of any upset conditions.

During operations, the wastewater will enter the OC adsorber from the top and flows down through the media. The treated water is collected in the underdrain system and discharged through the effluent piping to the downstream GAC treatment component.

Water samples are collected at the discharge of the OC vessel on a weekly basis to monitor OC usage and breakthrough of contaminants. As the OC media becomes exhausted/spent the concentration of contaminants leaving the unit will begin to increase. Once full breakthrough of the contaminant is reached the OC unit is taken offline and the media changed out.

Waste Generation

The operation of the OC unit will generate waste in the form of spent OC material. Once the OC media is deemed to be exhausted it is taken out of service, drained and the spent OC removed using a vacuum truck. The water removed from the OC is returned to the dirty water storage tank for retreatment.

The quantity of OC waste generated is highly dependent on the type and concentrations of the various contaminants in the wastewaters. The higher the contaminant loading, the higher the quantity of OC waste generated. Based on preliminary engineering design, it is anticipated that the OC operations will consume approximately 4,000 lbs (i.e. 1,800 kg) of OC media per year. Based on this data, the OC media would require changeout and replacement every 1 – 1.5 years.

Similar to the GAC media, the "spent" OC media will still retain significant adsorbent capacity for contaminates in other applications requiring less stringent criteria. As such, the spent OC would typically contain sufficient adsorbent capacity to be used in Envirosoil's cement-based soil stabilization/solidification (S/S) process at its facility in Bedford. This reuse of the spent OC in the S/S operations offers the most environmentally friendly manner for recycling/disposal of the material.
Prior to shipment to Envirosoil's facility in Bedford, the OC will be sampled and analyzed for all appropriate parameters related to Envirosoil's acceptance criteria. Typically, the OC treatment of industrial wastewater is non-leachable and is not classified as a Waste Dangerous Good. In the unlikely event that Envirosoil cannot accept the material, it will be sent to an out of province facility for disposal.

Maintenance

Since the OC units have no moving parts, maintenance requirements are minimal. All maintenance will be based on the manufacturer's recommendations and schedule. All maintenance will be completed as soon as it is identified, and maintenance logs and records maintained.
At a minimum the following items will be completed:
Daily:

- Visual inspection of the unit for leaks
- Visual inspection of all gaskets, seals and valves
- Pressure drop across vessels
- Verification of pressure differential sensor operations

Weekly:

- Collection of water samples after the OC unit for laboratory analysis

During OC Changeout:
The unit will be taken out of service, emptied and inspected for the following:

- Clean entire system as required
- Replace all O-rings and gaskets
- Inspect interior for corrosion
- Check vessel lining
- Check underdrain screens
- Calibrate all sensors and level controls

All wastewater generated during the maintenance operations will be returned to the dirty water storage tank to be treated via the system.

Granular Activated Carbon

The use of granular activated carbon (GAC) for water purification became common around the start of the 20th century (1906) when the "activation" process was applied to charcoal (which had been used for centuries). Thermal activation of charcoal greatly improves its pore volume, surface area and structure making it a modern day standard for numerous types of water treatment.

For the thousands of chemicals that can pollute water, the best technology available for removing them is activated carbon. For the vast majority of the water contaminants listed by the United States Environmental Protection Agency (USEPA), activated carbon is the preferred treatment.

The largest single section of the "EPA Regulated Water Contaminants" is the section on Organics. In this category the USEPA lists numerous toxic contaminants such as BTEX, dichlorethylene, carbon tetrachloride, dioxin, PCBs, PCP, PAHs, phenols, styrene, toluene, chloroform, vinyl chloride, aldicarb, chlordane, heptachlor, lindane, etc. For the Organics category, the primary treatment in all cases, and in most cases the only recommended treatment, is activated carbon.

GAC is a particularly good adsorbent medium due to its high surface area to volume ratio. One gram of a typical commercial activated carbon will have a surface area equivalent to 1,000 square meters. This high surface area permits the accumulation of a large number of contaminant molecules. The specific capacity of GAC to adsorb organic compounds is related to:

a) molecular surface attraction
b) contaminant solubility
c) the total surface area available per unit weight of carbon
d) the concentration of contaminants in the wastewater stream.

One of the major attributes of activated carbon treatment is its ability to remove a wide variety of toxic organic compounds to non-detectable levels (99.99% removal efficiency). In general, organic contaminants with a higher molecular weight are adsorbed more effectively by GAC. Also, organic contaminants with low water solubility are adsorbed more effectively. Many of the toxic contaminants typically encountered in industrial wastewaters have either a high molecular weight or a low water solubility – and a significant number have both.

Over the past 100 years, activated carbon systems have been used to effectively treat wastewaters generated by a wide range of industrial wastewaters generated by:

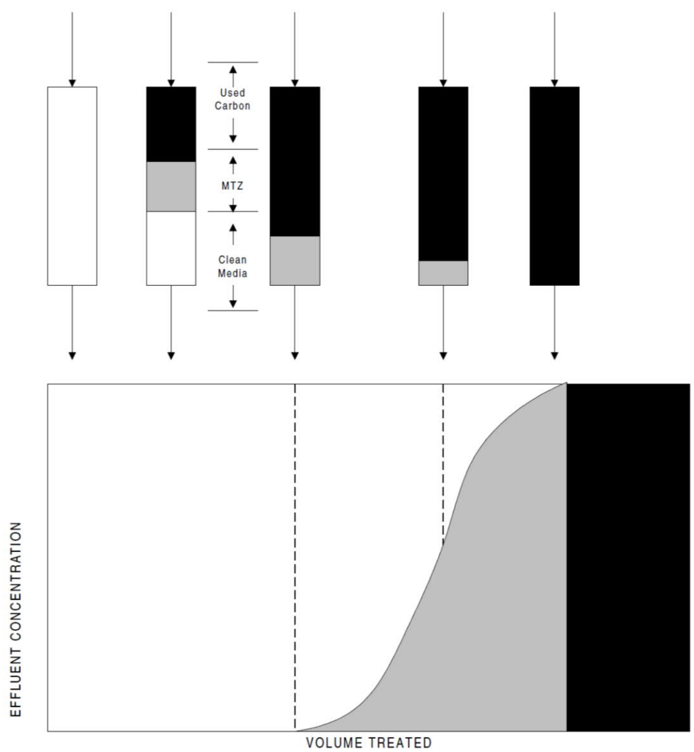
- Petroleum Refining
- Electrical Utilities
- Oil & Gas Exploration
- Metal Fabrication & Plating
- Mining and Ore Processing
- Bilge Waters
- Frac & Produced Waters
- Pulp & Paper
- Textile/Dyes manufacturing
- Landfill Leachate
- Cooling Tower Waters
- Cement Manufacturer
- Shipbuilding
- Food & Beverage Manufacturing

As a contaminated water stream passes through a bed of GAC, a dynamic condition develops which establishes a mass transfer zone (MTZ). This "mass transfer zone" is defined as the carbon bed depth required, at a given flow rate, to reduce the contaminant from its initial concentration to the desired treatment criteria concentration.

As the MTZ moves through the GAC, contamination concentrations above the desired treatment criteria begins to show in the effluent. This condition is classified as “breakthrough” and the amount of contaminant adsorbed is considered the breakthrough capacity. If the bed continues to be exposed to the water stream, the MTZ will pass completely through the bed and the effluent contaminant level will equal the influent. At that point, saturation capacity is reached. Figure 1 presents a schematic of the movement of the MTZ through a GAC bed.

To take full advantage of the adsorption capacity difference between breakthrough and saturation, several GAC beds are operated in series. This allows the MTZ to pass completely through the first bed prior to its removal from service and replacement of the spent GAC. Effluent quality is maintained by the subsequent beds in the series. Operations in series allows for 100% usage of the GAC and therefore results in less waste generation.

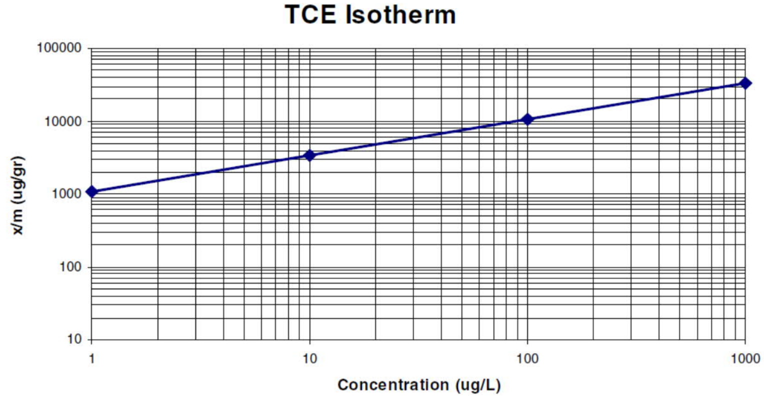
Figure 1: Typical GAC Mass Transfer Zone (MTZ) Movement



In order to estimate the quantity of GAC required for treatment, calculations are performed based on the mass of contaminant that can be removed per mass of GAC in a system. These calculations are based on published adsorption isotherms.

Liquid phase adsorption isotherms have been developed for most commercial GAC products for a wide variety of compounds. A typical adsorption isotherm used to predict GAC adsorption capacity and to estimate the mass of contaminant (i.e. mg contaminant removed/kg of GAC) that the GAC can remove. This isotherm data is then used to calculate the quantity of GAC required for a particular treatment system and to estimate the time until the GAC is exhausted or consumed and needs to be replaced. A typical isotherm is shown in Figure 2.

Figure 2: Typical GAC Isotherm



Equipment Design and Selection:

Selection and design of an efficient GAC adsorption system relies on many factors and calculations. These factors and associated calculations are well established and utilized by virtually all GAC system suppliers. One of the main factors when sizing a GAC is to calculate the appropriate contact time for the wastewater and the carbon. The term used to describe this parameter is the empty bed contact time (EBCT). EBCT is simply defined as the total volume of GAC divided by the liquid flow rate and is usually expressed in minutes.

The appropriate EBCT for a particular application is related to the rate of adsorption for the organic compound to be removed. While this rate will vary for individual applications, industry experience has shown that for most low concentration dissolved organics (i.e. < 500 mg/L) an EBCT contact time of 10-15 minutes is typically adequate to achieve > 95% contaminant reduction.

Another important concept in establishing a final contact is that of "Half Lengths". This tells us that if it takes x number of minutes to reduce a particular contaminant concentration by 50%, it will take x number of minutes to reduce the residual level of contaminant by an additional 50%. Therefore, if one half-length removes 50%, two half lengths will remove 75% and three will remove 87.5%. About seven half lengths are required to remove 99% and ten to reach >99.9%. This is why many GAC systems used for achieving very low discharge criteria concentrations (i.e. parts per billion) will have EBCTs of 25 - 30 minutes.

Design factors include the following:

- Influent contaminant type and concentration
- Removal efficiency required to achieve discharge criteria

- EBCT
- GAC usage rate
- Bed Depth
- Surface loading rate
- Pressure drop
- Temperature of water
- Full automation
- Corrosion and abrasion resistance

GAC Unit Selection

After consulting with industry experts and vendors and completing the required design calculations, Envirosoil Limited selected a manufacturer that has extensive experience in the design, manufacturing and operation of GAC units. It should be noted that there are numerous qualified vendors of GAC units in Canada and the USA. All vendor designs are based on clearly established guidelines, calculations and adsorbent properties. The main variations between vendors are the actual configuration and layout of the adsorption vessels themselves.

Technical aspects of the selected GAC unit were based on the fact that the potential wastewater streams anticipated at the Envirosoil facility can fluctuate in contaminant type and concentration. This may result is varying concentration of contaminants within the wastewater. As a result, the system was overdesigned to include a factor of safety in order to ensure compliance with discharge criteria. Some of the technical aspects of the selected GAC unit include:

- A dual vessel configuration operating in a series lead-lag mode was selected. This allows each vessel to be operated as the primary (lead) or secondary (lag) GAC adsorber unit.
- Each GAC unit has a capacity for 5,000 lbs (approx. 2300 kg) of GAC material.
- Each GAC unit has an EBCT of approximately 60 minutes at nominal flow rate. For the dual system operating in series the total EBCT contact time is 120 minutes at nominal flow rates. This represents a 4 x factor of safety over the recommended EBCT of 30 minutes.
- Each GAC unit has an EBCT of approximately 30 minutes at peak flow rate. For the dual system operating in series the total EBCT contact time is 60 minutes at peak flow rates. This represents a 2 x factor of safety over the recommended EBCT of 30 minutes.
- Interior liner to resist corrosion and abrasion.
- Pressure differential switches across each vessel.

All of the incorporated design features will ensure that the GAC unit can accommodate a very wide array of contaminant types and concentrations. Figure 3 presents a picture of a typical GAC setup operating in a series, lead-lag mode.

Figure 3: Typical GAC Setup

GAC Operation

The GAC unit has no moving parts and requires minimal manpower or operator attention. The main process parameter requiring monitoring is the flow and pressure through the GAC unit. Both of these parameters are fully programmable and automatic alerts and alarms are sent to the main PLC to notify the operator of any upset conditions.

During operations, the wastewater will enter the GAC adsorber from the top and flows down through the two carbon bed. Since the GAC vessels are piped in series all of the water must pass through both GAC units. The first GAC unit in series is called the primary/lead unit while the downstream GAC unit is called the secondary/lag unit. The treated water is collected in the underdrain system and discharged through the effluent piping to the next downstream treatment component.

Water samples are collected at the discharge of each GAC vessel on a weekly basis to monitor GAC usage and breakthrough of contaminants. As the lead GAC unit becomes exhausted/spent the concentration of contaminants leaving the unit will begin to increase. Once this occurs the valving between the two vessels is adjusted so that the lead absorber (the unit nearing exhaustion) becomes the lagging adsorber while the lagging absorber (still fresh) becomes the lead adsorber. This mode of operation ensures maximum efficiency of the system while minimizing waste generation.

Waste Generation

The operation of the GAC units will generate waste in the form of spent GAC material. Once a GAC unit is deemed to be exhausted it is taken out of service until the GAC is drained and the spent GAC removed using a vacuum truck. The water removed from the GAC is returned to the dirty water storage tank for retreatment.

The quantity of GAC waste generated is highly dependent on the type and concentrations of the various contaminants in the wastewaters. The higher the contaminant loading, the higher the quantity of GAC waste generated. Based on general design guidelines for treating wastewaters with mixed contaminants, the general GAC usage for various types of water treatment operations are:

1. Pretreatment operations: 60 – 200 grams of GAC/m3 of water treated
2. Tertiary operations: 25 – 50 grams of GAC/m3 of water treated
3. Polishing operations: 5 – 25 grams of GAC/m3 of water treated

Although in Envirosoil's treatment the primary usage of the GAC unit is for polishing operations, the GAC average usage rate for tertiary operations was used to estimate GAC consumption and waste generation. Based on preliminary engineering design, it is anticipated that the GAC operations will consume approximately 1,400 lbs (i.e. of GAC 630 kg) per year. Based on this data, each GAC vessel would be capable of operating 3.5 years before the GAC would become completely exhausted and require changeout.

Although the GAC is deemed to be spent based on its capability to meet the discharge criteria, the GAC will still retain significant adsorbent capacity for contaminates in other applications requiring less stringent criteria. As such, the spent GAC would typically contain sufficient adsorbent capacity to be used in Envirosoil's cement-based soil stabilization/solidification (S/S) process at its facility in Bedford. The facility routinely purchases amendment for use in its treatment operations and GAC is an excellent amendment for S/S operations. This reuse of the spent GAC in the S/S operations offers the most environmentally friendly manner for recycling/disposal of the material.

Prior to shipment to Envirosoil (Bedford), the GAC will be sampled and analyzed for all appropriate parameters related to Envirosoil's acceptance criteria. Typically, the GAC treatment of industrial wastewater is non-leachable and is not classified as a Waste Dangerous Good. In the unlikely event that Envirosoil cannot accept the material, it will be sent to an out of province facility for disposal.

Maintenance

Since the GAC units have no moving parts, maintenance requirements are minimal. All maintenance will be based on the manufacturer's recommendations and schedule. All maintenance will be completed as soon as it is identified, and maintenance logs and records maintained.

At a minimum the following items will be completed:

Daily:

- Visual inspection of the unit for leaks
- Visual inspection of all gaskets, seals and valves
- Pressure drop across vessels
- Verification of pressure differential sensor operations

Weekly:

- Collection of water samples after each GAC unit for laboratory analysis

During GAC Changeout:

The unit will be taken out of service, emptied and inspected for the following:

- Clean entire system as required
- Replace all O-rings and gaskets
- Inspect interior for corrosion
- Check vessel lining
- Check underdrain screens
- Calibrate all sensors and level controls

All wastewater generated during the maintenance operations will be returned to the dirty water storage tank to be treated via the system.

Zeolite Adsorption

The first known uses of zeolite can be traced back to B.C.E when the Roman's employed the mineral in their aqueducts. In the 1970's it began to be used in the treatment of wastewaters containing heavy metals, ammonia and radioactive materials. As the mineral's excellent absorption capabilities became more known, its use in general wastewater treatment became more widespread. Since the 1980's zeolite usage has been widely growing in the treatment of industrial wastewaters.

Zeolites are hydrated aluminosilicate materials having cage-like structures with internal and external surface areas of > 200 m^2/gram and cation exchange capacities (CEC) of up to several meq/kg. At least 41 types of natural zeolites are known to exist, and many others have been manufactured. Both natural and synthetic zeolites are widely used in industry as adsorbents, soil modifiers, ion exchangers, and molecular sieves.

Modification of natural zeolites can be performed by several methods, such as acid treatment, ion exchange, and surfactant functionalization. These modifications can greatly improve zeolite properties and increase its efficiency in water treatment.

Similar to organoclay (OC) and granulated activated carbon (GAC) treatment systems, zeolites have been used to effectively treat wastewaters generated by a wide range of industrial wastewaters generated by:

- Petroleum Refining
- Electrical Utilities
- Oil & Gas Exploration
- Metal Fabrication & Plating
- Mining and Ore Processing
- Bilge Waters
- Frac & Produced Waters
- Pulp & Paper
- Textile/Dyes manufacturing
- Landfill Leachate
- Cooling Tower Waters
- Cement Manufacturer
- Shipbuilding
- Food & Beverage Manufacturing

In industrial wastewater treatment applications, zeolites are primarily used for the removal of heavy metals, ammonia and ammonium.

The high adsorption capability and ion exchange capabilities of zeolites allows them to achieve the removal of numerous heavy metals at efficiencies > 95% and often approaching > 99%. Table 1 below presents some of the more common metals that can be removed by zeolite treatment.

Table 1: Zeolite Typical Target Metals

• Aluminum	• Chromium	• Magnesium	• Silver
• Antimony	• Cobalt	• Manganese	• Tin
• Arsenic	• Copper	• Mercury	• Uranium
• Barium	• Iron	• Nickel	• Zinc
• Cadmium	• Lead	• Selenium	•

The other primary application of zeolites in industrial wastewater treatment is for the removal of ammonia and ammonium compounds. Natural and modified zeolites are widely used for their removal and have demonstrated up to 97% removal of ammonia and ammonium from industrial wastewaters.

The adsorption mechanisms of zeolite media are very similar to those of OC and GAC which are presented in other treatment system component specific documents presented in Appendix C-2. These mechanisms are summarized below:

4. MTZ: As a contaminated water stream passes through a bed of zeolite, a mass transfer zone (MTZ) is established. As the MTZ moves through the zeolite, contamination concentrations above the desired treatment criteria begins to show in the effluent. This condition is classified as "breakthrough" and the amount of contaminant adsorbed is considered the breakthrough capacity. If the bed continues to be exposed to the water stream, the MTZ will pass completely through the bed and the effluent contaminant level will equal the influent. At that point, saturation capacity is reached.

5. Isotherms: The equilibrium distribution of metal, ammonia and ammonium compounds between the zeolites and the wastewater is an important factor in determining the maximum sorption capacity. Several well established isotherm models are available to describe the equilibrium sorption distribution. Liquid phase adsorption isotherms are used to predict zeolite adsorption capacity and to estimate the mass of contaminant that the media can remove (i.e. mg contaminant removed/kg of zeolite). However, the availability of isotherms for zeolites is not as extensive as for GAC and often the zeolite capacity is estimated by using readily available ion exchange data. In ion exchange operations, the cation exchange capacity (or CEC) is used to determine the amount of a cation that can be removed by a specific zeolite media. Since

zeolites have varying capacities for different ion and compounds, the overall adsorption capacity will vary depending on the contaminant to be removed. Table 2 presents some examples of zeolite adsorption capacities for various contaminants.

Table 2: Examples of Zeolite Capacity for Various Contaminants

Contaminant	Typical Capacity
Lead	500 mg/g
Mercury	21 mg/g
Arsenic	45 mg/g
Cadmium	80 mg/g
Copper	68 mg/g
Ammonium	19 mg/g
Ammonia	15 mg/g

6. Half Lengths: The "Half Lengths" concept tells us that if it takes x number of minutes to reduce a particular contaminant concentration by 50%, it will take x number of minutes to reduce the residual level of contaminant by an additional 50%. Therefore, if one half-length removes 50%, two half lengths will remove 75% and three will remove 87.5%. About seven half lengths are required to remove 99% and ten to reach >99.9%. Because of the high adsorption properties of zeolite media and the fast reaction times associated with the ion exchange process, zeolite media require much lower contact times (EBCT) when compared to OC and GAC media. Depending on the contaminant to be removed, the EBCT for zeolite can be as low as 90 seconds and still achieve removal efficiencies >95%. In general, for systems treating wastewaters with varying types and concentrations of contaminants, the recommended EBCT is 20 minutes for removal efficiencies approaching 99%.

Because the zeolite unit is located at the end of the treatment system, the majority of contaminants will be removed by upstream treatment components. In this system layout the zeolite unit is functioning as a "polishing" unit to remove residual dissolved contaminants. In these types of treatment trains, it is typical to have only 1 vessel of zeolite media in the treatment train (except in very large systems/facilities). Any breakthrough of organic contaminants from the zeolite unit will be very gradual. Breakthrough of contaminants can easily be caught by routine sampling of the water leaving the zeolite unit before the media reaches saturation and the required treatment criteria is exceeded.

When used as part of a treatment train that includes OC and GAC adsorption, zeolites will provide the required capabilities to remove residual and trace metals and ammonia (contaminants not typically removed by OC or GAC). A full treatment train of OC, GAC and zeolites can provide extremely effective treatment and removal of an extremely wide array of contaminants.

Equipment Design and Selection

Similar to OC and GAC, the selection and design of an efficient zeolite adsorption system relies on many factors and calculations. These factors and associated calculations are well established and utilized by virtually all zeolite system suppliers. Many manufacturers and suppliers of OC and GAC also supply zeolite media.

Similar to OC and GAC, the main design factors include the following:

- Influent contaminant concentration
- Contaminant form ➔ cation or anion
- Type of zeolite
- Removal efficiency required to achieve discharge criteria
- EBCT
- Zeolite usage rate
- Bed depth
- Surface loading rate
- Pressure drop
- Temperature of water
- Full automation
- Corrosion and abrasion resistance

Zeolite Unit Selection

After consulting with industry experts and vendors and completing the required design calculations, Envirosoil Limited selected a manufacturer that has extensive experience in the design, manufacturer and operation of zeolite media. It should be noted that there are numerous qualified vendors of zeolite media in Canada and the USA. All vendor designs are based on clearly established guidelines, calculations and adsorbent properties.

Technical aspects of the selected zeolite unit were based on the fact that the potential wastewater streams anticipated at the facility can fluctuate in contaminant type and concentration. This may result is varying concentration of contaminants within the wastewater. As a result, the system was overdesigned to include a factor of safety in order to ensure compliance with discharge criteria. Some of the technical aspects of the selected zeolite unit include:

- A single vessel configuration
- The zeolite unit has a capacity for 6,500 lbs (approx. 3,000 kg) of zeolite media
- The zeolite unit has an EBCT of approximately 60 minutes at nominal flow rate. This represents a 3 x factor of safety over the maximum recommended EBCT of 20 minutes.
- The zeolite unit has an EBCT of approximately 30 minutes at peak flow rate. This represents a 1.5 x factor of safety over the maximum recommended EBCT of 20 minutes.
- Interior liner to resist corrosion and abrasion
- Pressure differential switches across each vessel

The selected zeolite media is a product specifically formulated for wastewaters having varying contaminant types and concentrations. It contains zeolite media that is designed to remove both soluble and insoluble metals, chelated metals, ammonia and ammonium. Its broad-spectrum activity makes it ideal for polishing wastewater after conventional or advanced treatment systems.

Zeolite Operation

Similar to the OC and GAC adsorption units, the zeolite unit has no moving parts and requires minimal manpower or operator attention. The main process parameter requiring monitoring is the flow and pressure through the unit. Both of these parameters are fully programmable and automatic alerts and alarms are sent to the main PLC to notify the operator of any upset conditions.

During operations the wastewater will enter the zeolite adsorber from the top and flows down through the media. The treated water is collected in the underdrain system and discharged through the effluent piping to the downstream treatment component.

Water samples are collected at the discharge of the zeolite vessel on a weekly basis to monitor zeolite media usage and breakthrough of contaminants. As the zeolite media becomes exhausted/spent the concentration of contaminants leaving the unit will begin to increase. Once full breakthrough of the contaminant is reached the zeolite unit is taken offline and the media changed out.

Waste Generation

The operation of the zeolite unit will generate waste in the form of spent zeolite media. Once the zeolite media is deemed to be exhausted it is taken out of service, drained and the spent zeolite media removed using a vacuum truck. The water removed from the zeolite vessel will be returned to the dirty water storage tank for retreatment.

The quantity of zeolite waste generated is highly dependent on the type and concentrations of the various contaminants in the wastewaters. The higher the contaminant loading, the higher the quantity of zeolite waste generated. Based on preliminary engineering design, it is anticipated that the zeolite operations will consume approximately 2,000 lbs. (i.e. 900 kg) of zeolite media per year. Based on this data, the zeolite media would require changeout and replacement every 3 – 3.5 years.

Similar to the OC and GAC media, the "spent" zeolite media will still retain significant adsorbent capacity for contaminates in other applications requiring less stringent criteria. As such, the spent zeolite media would typically contain sufficient adsorbent capacity to be used in Envirosoil's cement-based soil stabilization/solidification (S/S) process at its facility in Bedford. This reuse of the spent zeolite in the S/S operations offers the most environmentally friendly manner for recycling/disposal of the material.

Prior to shipment to Envirosoil, the zeolite media will be sampled and analyzed for all appropriate parameters related to Envirosoil's acceptance criteria. Typically, the zeolite treatment of industrial wastewater is non-leachable and is not classified as a Waste Dangerous Good. In the unlikely event that Envirosoil cannot accept the material, it will be sent to an out of province facility for disposal.

Maintenance

Since the zeolite units have no moving parts, maintenance requirements are minimal. All maintenance will be based on the manufacturer's recommendations and schedule. All maintenance will be completed as soon as it is identified, and maintenance logs and records maintained.

At a minimum the following items will be completed:

Daily:

- Visual inspection of the unit for leaks
- Visual inspection of all gaskets, seals and valves
- Pressure drop across vessels
- Verification of pressure differential sensor operations

Weekly:

- Collection of water samples after the zeolite unit for laboratory analysis

During Zeolite Changeout:

The unit will be taken out of service, emptied and inspected for the following:

- Clean entire system as required
- Replace all O-rings and gaskets

- Inspect interior for corrosion
- Check vessel lining
- Check underdrain screens
- Calibrate all sensors and level controls

All wastewater generated during the maintenance operations will be returned to the dirty water storage tank to be treated via the system.