Environmental and Geological Capstone Design Projects - 2015

Project Title:

Design of an Integrated Hybrid Renewable Energy Micro-grid System for a Water Distribution Network Pumping Station

Design Team Members:

Shadman Chowdhury, Frances Okoye, Thouheed A. Gaffoor, Khalil Martin

Technical Advisor:

Dr. Robert McKillop

Abstract:

The environmental benefits of utilizing renewable energy sources have been well documented. The purpose of the proposed work is to explore to what extent a pumping station in Ontario can feasibly operate independently of the electrical grid by using local, renewable energy. The project investigates the interface between two main subsystems – water and energy. The former involves developing a hydraulic model of a pilot-scale water distribution network, in Beamsville (Niagara Region, ON.). A Lagrangian approach is undertaken to optimise the dynamics of the system. This is done in order to determine the optimal pumping load profile and hence, pumping energy demand for the system. The latter involves the design of a suitable renewable energy system. A grid-connected wind-electrolyser-fuel-cell system was chosen for the availability of wind energy, desirability for storage to offset intermittency, and the absence of emissions and non-renewable inputs. This project simulates and analyses the flow of energy throughout the entire system to explore the economic and environmental benefits of using the renewable energy system to meet pumping load demand.

Project Title:

Fish Habitat Enhancements for Lower Spencer Creek

Design Team Members:

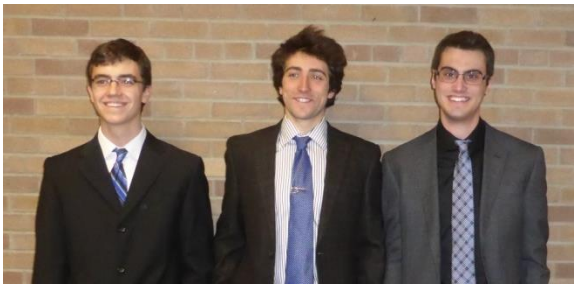
Robert Chlumsky, James Ehrman, Ryan Spencer

Technical Advisor:

Dr. William K. Annable

Abstract:

Lower Spencer Creek and its delta, Cootes Paradise, function as spawning habitat for many important migratory fish species, and the delta represents the most ecologically significant wetlands on Lake Ontario. Modern environmental stresses introduced through development have degraded the quality of fish spawning sites. The Hamilton Conservation Authority in partnership with JTB Environmental Systems had proposed a natural channel restoration which aims to promote floodplain connection and restore channel meanders. This Fourth Year Design Project undertaken by RJR Innovations proposes to introduce engineered fish habitat structures to 1.2 km of the Lower Spencer Creek. The goal of these structures will be to enhance spawning habitat through the introduction of bed and bank variability, while not interfering with required channel conveyance or introducing instability. The design will make use of 1D floodplain and 2D in channel modelling, basic sediment transport calculations, and a metric for comparing habitat improvements.



Project Title:

Tailings Pond Risk Management through River Engineering along the Fording River, British Columbia

Design Team Members:

Laura Bossers, Emma Buckrell, Luke McLeod, Frederick Cheng

Technical Advisor:

Dr. Bill Annable

Abstract:

The Fording River, located in south-eastern British Columbia, flows through properties owned by Teck Coal Ltd. where active open-pit mining operations are ongoing. Flooding occurred in 2013 which exceed the 100-year return period and notable lateral channel migration resulted which included sub-reaches adjacent to tailings ponds. The channel responses have raised concerns with respect to the long-term channel stability and potential for further migration towards the toe of the tailings ponds. HydroFELL has been engaged to explore quasi-stable river designs that minimize future risks of channel migration towards the tailings ponds while improving fish habitat and eliminating any migration barriers. This project will act as a pilot study to provide insight to channel design procedures that use natural processes to manage river courses in constrained river valley corridors.

Project Title:

Diversion of Commercial Food Waste using Anaerobic Digestion

Design Team Members:

Kylee McIntosh, Bhumi Mehta, Rebecca Staring, Rachel Trower

Technical Advisor:

Dr. Sheree Pagsuyoin

Abstract:

In the Region of Waterloo, grocery stores produce approximately 10,000 tonnes of food waste annually. Currently, grocery stores send the majority of food waste to the landfill. Food waste is comprised of starch and cellulose which, if extracted, can be useful resources. The goal of the project is to determine and design an alternative method to process the food waste from all grocery stores in the Region of Waterloo (approximately 200 stores) to generate a value added product. Four alternative disposal processes were analyzed: anaerobic digestion, composting, fermentation/distillation, and incineration. The alternatives were evaluated based on technical, economic, social, and environmental factors and anaerobic digestion was determined to be the preferred alternative. Multiple anaerobic digestion configurations were analyzed in terms of methane production and cost. The single continuous tank was chosen for detailed design. The current state the project is a high-level design, ready for implementation.

Project Title:

Naturalization of Concrete Trapezoidal Section of Victoria Park Lake Tributaries in Kitchener, ON

Design Team Members:

Ronauq Sabharwal, Nicole Foris, Elizabeth Foran, Michael Nixon

Technical Advisor:

Dr. Bruce MacVicar

Abstract:

The Henry Sturm Greenway and Sandrock Greenway consist of concrete channels located in northeastern Kitchener, converge within Filsinger Park before flowing into Victoria Park Lake. These concrete channels were designed to prevent erosion and flooding. However, they facilitate sediment transport and they do not encourage groundwater interaction, support native ecology, or facilitate the improvement of water quality in the stream. The City of Kitchener has identified the need to restore the Henry Sturm Greenway and Sandrock Greenway to improve the conditions within the lake and the associated tributaries. Alternative designs were generated and evaluated in order to select an ideal design to address the City's concerns. The selected design of a fixed channel with riffle and pond features was then considered in detail to produce a plan for implementation within Filsinger Park.

Project Title:

The Design of a Groundwater Treatment System for the Removal of Sulphate

Design Team Members:

Dorothy Poon, Brandon O'Leary, Carl Tin, Kelly Ma

Technical Advisor:

Dr. Wayne J. Parker and Dr. Mark Pritzker

Abstract:

The groundwater at the Brackish Groundwater National Desalination and Research Facility has 1600-3000 mg/L of Sulfate (SO_4^{2-}), which is higher than the drinking water standard (250 mg/L of SO_4^{2-}) specified by World's Health Organization. Our project utilizes electrocoagulation for the removal of unwanted anionic contaminants and aims to improve the groundwater at the Facility to drinking water quality standard. The current prototype improves the water quality by utilizing aluminum plates as electrodes and passing current through the water sample. The full-design shows how the technology can be incorporated into groundwater treatment facility to serve areas with high sulphate concentration in their groundwater supply.

Project Title:

Removing Emulsified Oil from Brackish Water

Design Team Members:

Savannah Vetter, Andrew McMahon, Janice Cooper, and David Michael Stewart

Technical Advisors:

Dr. Wayne Parker & Shoeleh Shams

Abstract:

Oil-Water Separators Limited (OWS Ltd.) was tasked with designing a system to remove emulsified oil from a brackish industrial wastewater effluent. This is a common problem faced by a variety of industries, but most particularly by oil and gas companies operating in areas with brackish groundwater conditions. Specifications were provided by the client for the sizing and flow capacity required in the full-scale design, and a bench-scale model was requested to demonstrate the technology. After evaluating technologies based on separation efficiency, cost, feasibility, and health and environmental concerns, OWS Ltd. selected electrocoagulation as the preferred technology. This technology will be demonstrated with a functioning bench-scale model, and a complete full-scale design will be presented that meets industry needs. OWS believes that the use of electrocoagulation will provide a low consumption solution to the pressing need for processing this water stream to meet characteristics suitable for treatment and re-use.

Project Title:

Process Optimization via Ammonia Recovery at the Ashbridges Bay Wastewater Treatment Plant

Design Team Members:

Abdon Katter, Linda Li, Antonio Albornoz

Technical Advisor:

Dr. Wayne Parker

Abstract:

The Ashbridges Bay Treatment Plant is the largest wastewater treatment plant operated by the City of Toronto. Recent process changes in the plant have allowed for increased nitrification with a side-effect of higher ammonia concentrations in the centrate stream from biosolids dewatering. This has resulted in increased ammonia loading on the biological process which raised energy consumption in order to achieve acceptable effluent quality levels. The main design objective is to reduce the amount of Total Kjeldahl Nitrogen in the centrate stream to plant influent levels while incorporating a nutrient recovery approach. Technologies analyzed to achieve the project objective include ammonia recovery processes (ARP), struvite precipitation, algal biomass production, and electrodialysis. ARP was determined to be the most attractive alternative for its superior ability to recover nutrients and generate revenues. Process improvement options include water and carbon recovery, centrifuge upgrade, and other energy savings.

Project Title:

Design of an Enhanced Geothermal System (EGS) Pilot Injection Program in Kelowna, BC

Design Team Members:

Saif Y. Khan, Jai K. Duhan, Tirath T. Dave, Shengrui Yan

Technical Advisors:

Dr. Maurice Dusseault, Dr. Dipanjan Basu

Abstract:

Despite Canada's status as being among the largest exporters of fossil fuels in the world, vast amounts of the country's geothermal resources remain untapped. Our project is the design of an Enhanced Geothermal System (EGS) pilot injection program in the City of Kelowna, BC which makes use of the high geothermal gradient in the area. A major barrier to the widespread adoption and development of EGS technology, however, is the risk associated with induced microseismicity that may occur due to fluid injection as well as thermoelastic stress changes in the subsurface. Based on analytical solutions and conceptual models derived from available literature, the effects of various fluid injection parameters are analyzed in terms of their net thermal output and projected seismic moment magnitudes. These results are then used to design a pilot injection program that generates economically viable levels of thermal output while minimizing induced seismicity.

Project Title:

Design of Technology to Remove Arsenic from Drinking Water in Mandari, Lakshmipur, Bangladesh

Design Team Members:

Adriana MacDonald, Saloni Singh, Thadsha Chandrakumaran, Sabrina Li

Technical Advisor:

Prof. Peter Huck

Abstract:

A large percentage of the Bangladeshi population relies on arsenic-contaminated groundwater for drinking water. Our team aims to design a point-of-use technology to remove arsenic from drinking water at a low cost. Two options are being explored: 1) coagulation/co-precipitation and filtration (CCF); and 2) solar oxidation and removal of arsenic (SORAS). Coagulation and co-precipitation involve transferring dissolved arsenic into larger solids so that they can be easily removed through filtration. SORAS utilizes low-cost materials such as PET bottles, lemon juice (a citrate source), and sunlight to remove arsenic using oxidation, irradiation, and adsorption. In addition to arsenic removal, this project addresses the management of any arsenic-contaminated wastes produced from treatment.

Project Title:

Development of a Sediment Cap Design for Contaminated Sediment Control in Randle Reef, Hamilton Harbour

Design Team Members:

Siang Li, David Yu, Kevin Pesengco, Gary Tran

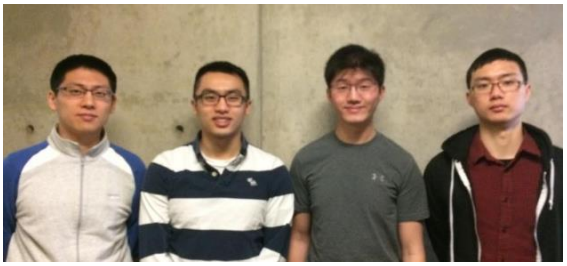
Technical Advisors:

Tom Krug and Matt Vanderkooy, Geosyntec Consultants

Dr. Leo Rothenburg

Abstract:

Environment Canada has been evaluating methods to remediate the contaminated sediments in Randle Reef at Hamilton Harbour; however, the proposed designs exceed the allocated budget. The sediments consist of highly concentrated polycyclic aromatic hydrocarbons (PAHs), with total concentrations above 73,000 mg/kg. An alternative solution is an in-situ sediment cap system that physically isolates the contaminated sediments from the overlying water. The objective of the design is to reduce the concentrations released to the water to below toxicity endpoints reported by Environment Canada. A numerical model is utilized to evaluate the transport mechanisms of the PAHs through the sediment cap. The geotechnical assessments of the design include the slope stability, bearing capacity, consolidation, and erosion protection.



Project Title:

Undersea Mining of Volcanogenic Massive Sulphides at the Axial Seamount

Design Team Members:

Ksenia Merkoukhina, Michael Jefkins, Cameron Drever, Dylan Klazinga, Johnson Trinh

Technical Advisor:

Dr. Maurice Dusseault

Abstract:

The role of this project is to outline the procedure for undertaking mining operations at the Axial Seamount site. The Axial Seamount is an active submarine volcano situated on the seafloor of the Pacific Ocean at the coordinates 45.95° N and 130.00° W. The vent sites, which provide sulphide mineral enriched zones, are typically situated 1.6 kilometers below the mean sea level. Based upon current understanding of the geology at the site, as well as similar land based analogs, the expected minerals of interest are: sphalerite (zinc), galena (lead), pyrite (iron), chalcopyrite (copper) and small concentrations of silver, gold and rare earth elements. The project will provide an examination of the site geometry, site geology, mineral processing and extraction methods, a baseline environmental and economic assessment, an initial design of the mine plan, a geotechnical assessment for tunneling as well as a detailed safety and monitoring plan.

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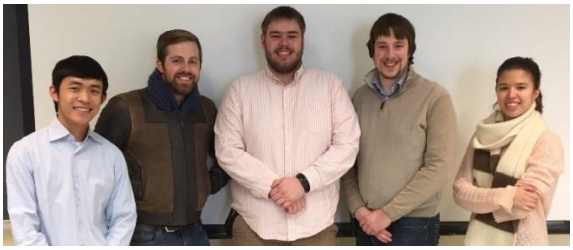

Project Title:

Multi-Residential Greywater Recovery System

Design Team Members:

Joel Upsdell, Connor Werstuck, Paul Schiller, Kathy Hui

Technical Advisor:

Dr. Sheree Pagsuyoin

Abstract:

Nearly 70% of wastewater produced is considered greywater which has a significantly lower contaminant loading than what it is being treated for. This presents an opportunity to reduce water demand and create value by treating and reusing greywater on site.This project involves designing a greywater recovery system for multi-residential application in the State of California. The system collects greywater using a dedicated pipe network and sends it through a treatment train which includes a preliminary filter, a rooftop integrated biolfilter, and final UV deactivation. The integrated biofilter system has been designed with horizontal layers of porous media and native wetland plants for both contaminant removal and residence time. The symbiotic relationship between greywater treatment and irrigation is unique to this system. The detailed design was confirmed using material testing, a contaminant model and a hydraulic piping network model. This project has potential for application in large scale water resource conservation.

Project Title:

Town of Lakeshore Sanitary Sewer Collection System Upgrade

Design Team Members:

Max Taylor, Thomas Demers, Felix Weinhardt, Justin Seminario

Technical Advisor:

Mike Kocher, P.Eng. (CH2M Hill, Kitchener)

Abstract:

During periods of heavy rainfall, the town of Lakeshore, Ontario currently experiences high levels of flow in the sanitary sewer lines. This is causing adverse impacts to residents and to the environment. A hydrological model was created using PC-SWMM to simulate the parameters and characteristics of the sanitary sewer during a 5-year design storm. By using the model to generate performance data, the effectiveness of three potential solutions has been assessed with regards to technical, economic, environmental, and social impact criteria. The selected alternative then undertook a detailed design stage, where further details of the solution were considered, and presented as recommendations to the town of Lakeshore.

Project Title:

Hydraulic Fracture Simulation in an Unconsolidated Media

Design Team Members:

Ben Pratt, Stuart McColl, Michael McIsaac, Jesse Hayes

Technical Advisor:

Dr. Maurice Dusseault

Abstract:

The WatFrac Undergraduate Research Group has designed an apparatus with the ability to create hydraulic fractures and physically model the fracture propagation. With the ability to change the stress orientations, it is possible to understand how the stresses affect fracture growth, both in magnitude and direction. Tests have been completed under varying stress regimes to simulate the real-world geological conditions found in the petroleum industry. The declining oil price has placed an emphasis on process optimization to economically recover the resource. Understanding the mechanics of hydraulic fracturing can lead to increased production at minimal costs. The engineering design of this apparatus required technical theory of fluid mechanics, porous media flow, rock mechanics and petroleum geomechanics.

Project Title:

Ashbridges Bay Wastewater Treatment Plant Anammox and Struvite Composite Centrate Stream Treatment and Recovery Process

Design Team Members:

Renee Hum-Hsiao, Dao Zhong Yu, Eugenia Acosta

Technical Advisor:

Dr. Elsayed Elelbeshbishy

Abstract:

Neue Solutions is an up and coming Environmental Consulting company that focus on innovative designs to refurbish existing municipal wastewater treatment plants. The latest project taken on by Neue Solutions was the Ashbridges Bay Wastewater Treatment Plant as a two phase endeavour. The Ashbridges bay requires a side stream treatment system of their centrate stream to treat high nitrogen concentrations and recover nutrients before re-entry into the main process train. Through research on several biological treatment methods, it was determined that the CANON Anammox process coupled with struvite precipitation would be best suited for the harmonized removal and recovery system. A detailed analysis on the mechanical implementation ofthe chosen technologies, their operating parameters, and maintenance requirements was also conducted. These tasks were completed with the aid ofBioWin, a wastewater process simulating software.

Project Title:

Ashcroft Landslide Mitigation Project

Design Team Members:

Taidhg Mulroy, Jenna Cegnar, Christy Rouault, Kristen Sperduti, Dustin Martin

Technical Advisor:

Dr. Stephen Evans

Abstract:

In the Thompson River Valley near Ashcroft, BC, the CN and CP rail lines have been affected by landslides along a 10-km stretch since their construction over 100 years ago. The operation of these tracks is vital to the Canadian economy. The South Landslide is of particular concern and requires a mitigation design to arrest all slope movement. A multidisciplinary site assessment was conducted at this site to consider hydrological, hydrogeological, and slope stability. The mitigation design involves the combination of toe reinforcement, using piles and a toe stabilizing load, to arrest slope movement and erosion protection to prevent undercutting of the toe. This design was chosen by optimizing environmental impact, cost, performance, and construction feasibility with respect to mitigation alternatives. In addition, the cost of mitigation is justified by a completed risk analysis which identifies human lives at risk.

SPERDUTI AND ASSOCIATES