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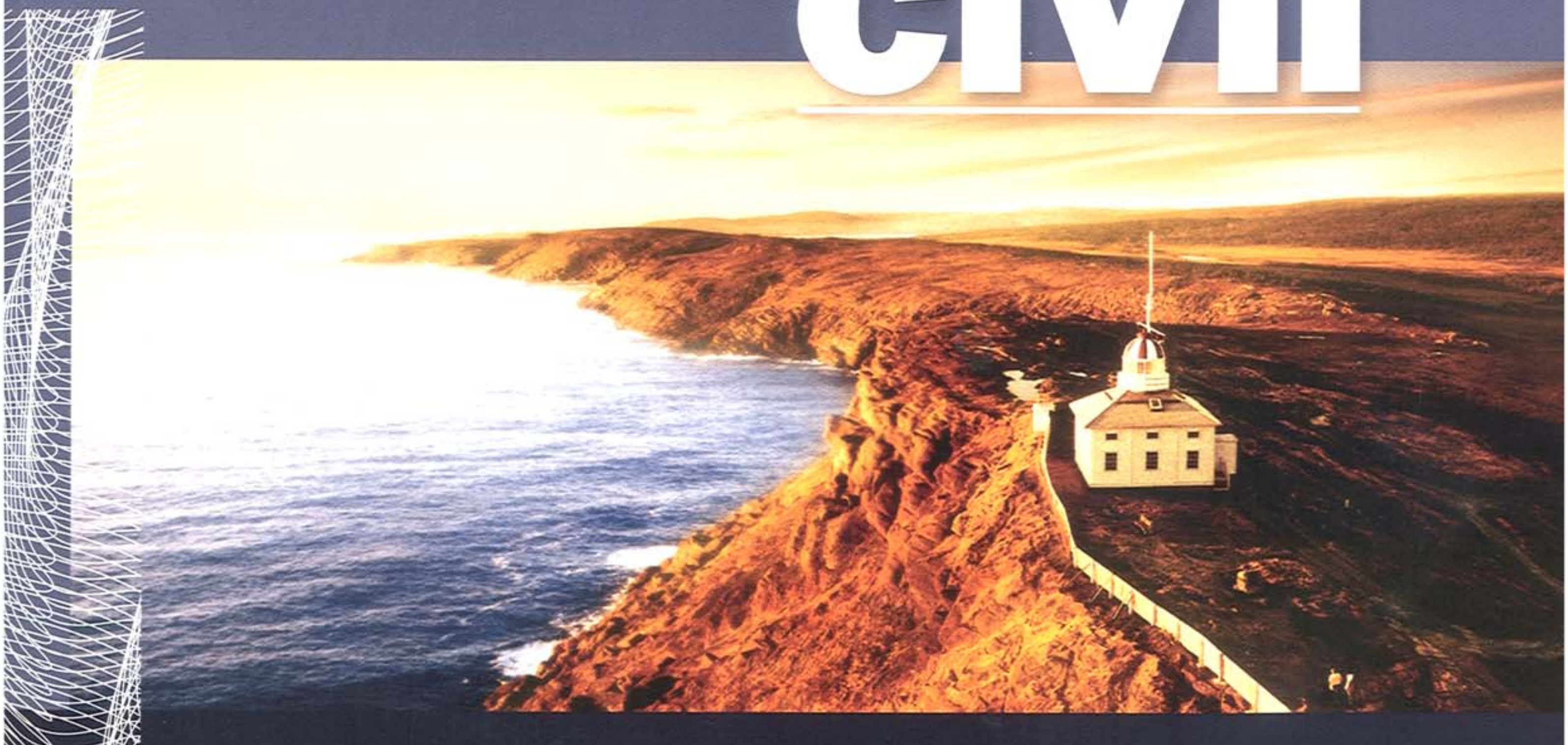

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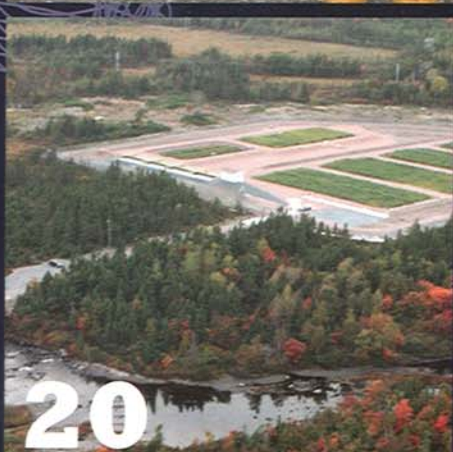

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Case Study of the Kickuth Engineered Wetland Servicing the Towns of Appleton and Glenwood in Newfoundland

INTRODUCTION

The towns of Appleton and Glenwood are located on opposite sides of the majestic Gander River, in the central region of the Island of Newfoundland. Both towns had older sewage treatment plants with outfalls into the Gander River. These systems were overloaded and were costly to maintain and operate.

The Gander River is an important salmon river, and the mayors and the Gander River Management Association have lobbied for years to have the sewage problems corrected. The towns hired in late 2002 a local consulting firm, CECON Ltd., to investigate the possible options and costs associated with a modern, more efficient treatment system. The benefits to the two towns in maintenance and operations made a combined system the preferred choice. The two selected options were the Kickuth Engineered Wetland and an Aerated Lagoon system, and the consultant prepared cost estimates for both, as follows.

	Capital Costs	Operating Costs
Kickuth Engineered Wetland system	$4,319,854	$35,500
Aerated dual Lagoon system	$3,780,690	$45,484

30 year life cycle costs	
Engineered Wetland	$1,094,520
Aerated Lagoon system	$1,367,037

Although the capital costs were higher, the engineered wetland was chosen for lower life cycle costs, and the benefits of a green natural system with greater environmental benefits. Abydoz, as licensee for the Kickuth system, was then commissioned to provide the engineering design and drawings for tender.

DESIGN LOADING CONDITIONS

The loadings for the design of the treatment system were calculated theoretically based on the combined population and the provincial guidelines. The system for Appleton/Glenwood services both communities with an approximate population of 1470 and a population equivalent of 1800.

Actual flow information showed there was significant infiltration into the sewage collection system, so that the system would have to deal with flows above the provincial guidelines. The selected design flows were an average daily design flow of 3037 m^3, with a peak capacity of 1.5 times average flow of 4555 m^3/day or 1,203,500 US gallons/day. Separate treatment was required for large flows during storms, to avoid direct bypass of effluent into the Gander River.

The organic loading used an average loading rate of 60g/PE/day with an additional 50% loading during times of additional storm water infiltration. With the design population this resulted in a loading of approximately 150 kg/day BOD. The allowable limits for discharge were set by the regulations for discharge into a water body as specified by the Newfoundland Environmental Water Control Act.

This system would be the first full scale Kickuth Engineered Wetland Treatment system in Newfoundland and Labrador, and also the first Engineered Wetland system of this type providing full secondary treatment in Canada.

DESIGN ENGINEERED WETLAND SIZING

The design of early wetland systems was based on empirical data and used rule-of-thumb loading methods to size the systems. Later, other approximate methods were implemented. The design for the Kickuth engineered wetland comes from specific calculations of the movement of the effluent through a soil or matrix.

FIGURE 1. View of grinder building foundation with pit for grinder and spiral lift; the settling chambers are directly behind.

The basis for the design is the "Root Zone" method pioneered by Dr. Reinhold Kickuth in the 1960s in Germany. He adapted it to become the Kickuth Engineered Wetland design, a patented system with over 600 systems operating world wide. The size is calculated based on the reduction required in BOD and TSS, and the requirement for an overall secondary treatment level of effluent. The method uses a first order equation with Root Zone constants based on extensive degradation curves established from analysis of different matrix designs. It takes into account daily fluctuations.

The calculations led to an overall wetland sizing for the main treatment beds of 8,860 m^2. After consideration of other parameters, such as nitrogen and phosphorus reduction, and the available local materials, the Appleton/Glenwood main treatment zone was increased to 12,400 m^2.

After the size was determined the shape and configuration were designed. The variables include the average daily flow, the hydraulic conductivity of the root zone matrix, the cross-sectional area of the system and the hydraulic pressure gradient.

TREATMENT SYSTEM COMPONENTS

The final design of the Engineered Wetland had 5 main Engineered Subsurface Wetland Beds, consisting of one main Vertical bed and 4 Horizontal beds. It included two main trains, or passageways for the towns' effluent, the main flow and the storm-water flow. The sewer flow from both communities is pumped to the treatment facility by a combination of lift stations. On entering the treatment facility the effluent passes through a grinder and a spiral lift screen to remove any non-organic materials, such as plastics. The flow then enters a series of settling chambers where the majority of solids and suspended solid are removed by gravity and settle to the bottom of the chambers. The settling chambers provide a minimum of 4 hr retention time. The flow is then split at the end of the last settlement chamber by a weir arrangement that allows the main flow to move onto the engineered wetland treatment beds. The weir directs storm-water flows into a storm-water treatment bed.

The storm water flow is separated in the settling chamber and goes to a 1,216 m^2 stormwater bed with a much deeper basin. It holds the effluent and slowly releases it after treatment.

The two flows are then again combined and flow out into the Gander River through a diffuser outfall. Other than the screen and grinder there are no mechanical or electrical components in the Engineered Wetland System. No electricity or chemicals are required.

The overall layout of the system can be seen from the aerial photo in Figure 3, with the horizontal beds in the foreground,

FIGURE 2. View of Horizontal Beds — August 2007.

FIGURE 3. Aerial View of Appleton/Glenwood System — Spring 2007.

and the vertical bed and storm-water bed behind. The concrete settling chambers are to the far left, with the location of the outfall to the far right perpendicular to the system.

Solids can also be treated in a sludge cell system pioneered by the Kickuth Organization, which may be implemented after the main Engineered Wetland system is established. This will eliminate the transportation of sludge to an acceptable disposal site, the largest maintenance cost of the project. These sludge cells will also constitute the last component of a full system, providing treatment of both the solid and liquid portion of the municipal wastewater.

HOW THE ENGINEERED WETLANDS PROVIDE SECONDARY TREATMENT

Secondary treatment removes organic matter (Biochemical Oxygen Demand or BOD) and suspended solids (SS) from wastewater. Tertiary treatment removes nutrients, such as nitrogen and phosphorus, in addition to the removal of BOD and SS. The engineered wetland was designed for secondary treatment but also provides some tertiary treatment.

The wetlands remove and/or transform contaminants in wastewater through a variety of biological, physical and chemical mechanisms. The wetland beds are filled with a very specific matrix material that can have a variety of natural elements to provide for chemical interaction as required. The matrix also acts as a filter, trapping and binding contaminates, but the majority of treatment occurs by means of biological degradation by micro organisms.

The wetland beds are planted with a mono-culture of nursery produced and adapted common reed plants (phragmites australis) which transfer oxygen to their root system and into thousands of zones within the matrix with varying levels of oxygen. These zones and the boundary between these zones create a perfect habitat for the growth and reproduction of species of beneficial micro organisms. The micro organisms in their life processes consume most of the organic matter, and convert and breakdown nitrogen and other pollutants as food for energy to grow and reproduce, thereby purifying the wastewater.

OPERATION AND TREATMENT RESULTS

The system was designed in 2005 and construction was started in June 2006, and completed within 6 months, by November 2006. Effluent started flowing through the system in December 2006. The system has run continually since that time, including commissioning activities in the first year.

The operational requirements for the system have been as expected. The grinder and screen are checked regularly and the debris from the screen is removed weekly or bi-weekly. The beds are checked weekly, with a more thorough review monthly. In the first years of a system weeding and plant propagation are required, but are not a long term maintenance activity. The highest maintenance activity is removing the settled sludge from the settling tanks, in this case every 3 months. This will be reduced next year to pumping the sludge to sludge cells, scheduled to be constructed during 2009.

The overall labour requirement is approximately 600 hr/year. Other costs to the system are electricity for the grinder and the spiral screen, approximately $3,000 per year. The sludge removal and transportation costs of approximately $18,000 will be eliminated with the installation of the sludge cells. Thus the overall operational costs will be approximately $20,000 to $25,000 per year depending on the labour rate, once the sludge cells are in operation, and approximately $40,000 if sludge continues to be pumped and transported from site.

The system has performed above expectations in the first year. The treatment objectives have been exceeded from day one, even though the test data have indicated that the level of contamination entering the system is higher than expected. The average value of BOD over the first year was 106 mg/l entering the system, resulting in a 40% increase in the loading from expectations.

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BOD from the Engineered Wetland was reduced by over 90%, and 96% when measured down river. For TSS the reduction is above 96% from the Engineered Wetland and 99% down river. Nitrogen, Phosphorus, Total and Fecal Coliform were tested to determine the level of additional tertiary treatment that was being performed. The overall treatment reduction of these items is also very good, and the down river results are all below the required levels. The levels achieved by the treatment in the Engineered Wetland prior to entry to the Gander River exceed the provincial requirements for secondary treatment, with values actually below tertiary treatment levels.

In summary, the effluent is clear, colourless and very low in organic matter, suspended solids, phosphorus, ammonia, nitrogen and pathogenic micro organisms. The effluent meets all of the effluent standards set by the Newfoundland and Labrador government for discharge into a sensitive fresh body of water.

CONCLUSION

The installation of the Appleton/Glenwood Engineered Wetland has shown that this technology can be used for full scale applications to provide the treatment requirements for municipal sewage, under Canadian climatic conditions and under Canadian loadings. The testing results provide evidence that engineered wetlands using this technology can provide treatment levels that not only meet secondary treatment levels, but can reduce contaminants to tertiary limits. This technology can now be considered as a proven method for providing low maintenance, environmentally responsible sewage treatment to Canadian Municipalities.

ACKNOWLEDGEMENTS

Flynn, D., Mayor of Appleton, Newfoundland; Kickuth, R., Kickuth A., Kickuth Organization, Germany; Thomson, B., P. Eng, Central Engineering Consultants of Newfoundland Ltd. ■

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Wallace, D.S., Knight, L.R., 2006. *Small-Scale Constructed Wetland treatment Systems Feasibility, Design Criteria, and O&M Requirements*, IWA,WERF (Water Environment Research Foundation), London, United Kingdom.

COMING EVENTS / CALENDRIER DES ACTIVITÉS

Domestic Venues

International Conference on Nutrient Recovery from Wastewater Streams
Vancouver, BC
May 10–13, 2009
Conference Chair: Dr. Don Mavinic, FCSCE
E-mail: dsm@civil.ubc.ca
Conference Secretariat: mmori@venuewest.com

2nd Climate Change Technology Conference/ 2e Conférence sur les technologies du changement climatique
Hamilton, ON
May 12–15, 2009
Web site: http://www.cctc2009.ca/

CSCE 2009 Annual Conference
St. John's, NL
May 27–30, 2009
Web site: http://www.csce.ca/2009/annual

ASCE-CSCE-ICE Triennial Conference
St. John's, NL
June 1–2, 2009
Web site: http://www.csce.ca/2009/triennial

19th Canadian Hydrotechnical Conference and 33rd IAHR Congress — Water Engineering for a Sustainable Environment
Vancouver, BC
August 10–14, 2009
Web site: http://content.asce.org/conferences/iahr09/index.html

8TH International Conference on Medium and Short Span Bridges (SMSB-8)
Niagara Falls, ON
August 3–6, 2010
Web site: http://www.csce.ca/2010/smsb/

International Venues

ICCEM — ICCPM 2009
Jeju, Korea
May 27–30, 2009
Web site: http://www.iccem-iccpm.org

2nd International Workshop on Performance, Protection & Strengthening of Structures under Extreme Loading (PROTECT2009)
Hayama, Japan
August 18–21, 2009
Web site: www.nda.ac.jp/cc/users/fujikake/protect2009

Coasts, Marine Structures and Breakwaters 2009
Edinburgh, Scotland
September 16–18, 2009
Web site: http://www.ice-breakwaters.com/

5TH International Structural Engineering and Construction Conference — ISEC-5
Las Vegas, Nevada, USA
September 21–27, 2009
E-mail: www.ISEC-5@unlv.edu
Web site: http://www.isec.uni-mb.si

2nd International Conference on Technology of Architecture and Structure — ICTAS2009
Shanghai, China
October 15–17, 2009
Contact: Professor Zhang Qilin or Professor Li Yuanqi
E-mail: liyq@mail.tongji.edu.cn

APFIS 2009
Seoul, Korea
December 9–11, 2009
Web site: http://www.apfis2009.hanyang.ac.kr/

6th International Conference on Concrete under Severe Conditions — CONSEC'10
June 7–10, 2010
Web site: http://www.consec10.com/

2nd International Conference on Sustainable Construction Materials and Technology SCMT 2010
Ancona, Italy
June 28–30, 2010
Web site: http://www.cbu.uwm.edu