British Columbia Water and Waste Association
2019 Student Design Competition Problem Statement

Contents

Attachments – Provided Separately Upon Registration

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Questions

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Disclaimer

The project statement is intended only for use during the 2019 BCWWA Student Design Competition. Information provided in this document may not reflect actual conditions or requirements and is provided for the sole purpose of providing context for the design competition. Supporting information remains the property of the Vancouver International Airport.

1 PROBLEM STATEMENT

Students interested in entering the 2019 BC Water & Waste Association (BCWWA) Student Design Competition (SDC) are encouraged to form teams of maximum six (6) persons (refer to competition guidelines for further requirements) to:

Complete a comparative analysis and design of two (2) treatment, conveyance, and disposal solutions for aircraft de-icing fluid runoff and stormwater runoff at the Vancouver International Airport (YVR). The solutions must be capable of maximizing waste diversion, maximizing resource recovery where possible, protecting sensitive ecosystems and meeting all regulatory requirements. Additionally, solutions cannot disrupt airside operations in any way.

Students are to provide real-world solutions that are practical and creative while thinking critically about the constraints and design goals.

It is each team's responsibility to review the information and data provided. It is not mandatory to use all of the data provided in analysis. It is highly recommended that teams review all of the information provided in the attachments, as some key design data and information is provided only in the attachments. Refer to the competition guidelines for policies regarding questions on project scope, objectives, and information.

2 BACKGROUND

In its infancy, the Vancouver International Airport (YVR) started off as a single runway airport in 1931. Looking beyond its humble beginning and fast forwarding to present day, YVR has developed into the premier international gateway for Western Canada, playing a crucial role in promoting tourism, job creation, global connectivity, and driving local economic and sustainable development in the region. YVR is located on Sea Island, which sits adjacent to sensitive habitats such as the Fraser River Estuary, Sea Island Conservation Area, Surgeon Bank Wildlife Management Area, and the George C. Reifel Bird Sanctuary, where several million migratory birds pass through every year. Due to this proximity, YVR is determined to be a leader in environmental stewardship. As such, in 2014 YVR developed an Environmental Management Plan to lay the framework for future environmental stewardship initiatives.

2.1 OVERVIEW

During the freezing conditions in the winter months, snow, ice, or frost may precipitate on the surface of the aircraft. The removal of these formations (de-icing) is crucial, as their presence disrupts air flow over critical control surfaces, degrading the ability of the aircraft to generate lift, therefore posing a significant safety hazard during flight.

The current industry standard for the de-icing an aircraft prior to takeoff is spraying the aircraft with de-icing fluids such as ethylene or propylene glycol. One issue with the use of glycol based de-icing fluids is that it generates wastewater with high biochemical oxygen demand (BOD). This wastewater can be harmful if released untreated into the receiving environment. For this reason, YVR utilises a de-icing fluid containment system to prevent uncontrolled runoff during de-icing operations. However, this results in an accumulation of high strength de-icing runoff, which currently requires periodic offsite disposal. When de-icing operations are not conducted, stormwater runoff from the de-icing pad is collected and conveyed to the receiving environment via a ditch system adjacent to the de-icing pad.

2.2 CURRENT AIRCRAFT DE-ICING OPERATIONS

When YVR experiences frost conditions, aircrafts are routed to the designated communal de-icing pads (10 bays), prior to takeoff. De-icing consists of a de-icing truck spraying down critical control surfaces with diluted Ethylene Glycol- Based Type 1 de-icing fluid (Dow UCAR ADF Concentrate). Prior to usage, the de-icing fluid is diluted by a dilution factor of 3.33. It is estimated that an average 150 L of diluted de-icing fluid is utilized per aircraft.

Table 1 shows the number of aircrafts processed at the de-icing pad under average and peak conditions.

Table 1: Estimated Number of Aircraft Departure during Winter at YVR

Parameter	Winter Aircraft Departures (as of 2018)
Average Day (per day)	380
Peak Day (per day)	440
Peak Hour (per hour)	35

The number of flights expected to take-off from YVR is expected to increase each year. As such, the average and peak day flights are expected to increase at a rate of 4% over the previous winter period, and the peak hour to increase at a rate of 12% over the previous winter period.

2.3 CURRENT DE-ICING RUNOFF AND COLLECTION

During frost periods of the year, de-icing runoff is produced from de-icing operations and is collected via the existing collection system and pumped to the holding pond (West Lagoon) via the three existing pump stations (PS-1, PS-2, and PS-3). The West Lagoon has an approximate existing volume of 10,000 m^3 with dimensions of approximately 100 m x 30 m (L x W) and 3.5 m deep.

Outside of the frost periods of the year, when de-icing operations are not required, bypass valves are opened to direct stormwater runoff to the existing ditch drainage system. The stormwater runoff is expected to contain residual amounts of glycol. Glycol runoff in the ditch system must remain below 100 mg/L (as glycol) per the Canadian Glycol Guideline. Currently, exceedances above the limit occur between 0 to 4 times per year.

Only the runoff generated within the de-icing pad will be considered as contributory to the de-icing treatment system and stormwater management system. The area of the de-icing pad is approximately 90,000 m^2 and is comprised of hot mix asphaltic concrete (HMAC) and Portland cement concrete (PCC).

2.4 CURRENT DE-ICING RUNOFF DISPOSAL

To dispose of the collected de-icing runoff, vacuum trucks extract the collected contaminated runoff and dispose of it at the Annacis Island Wastewater Treatment Plant. Upon completion of the de-icing period, the entirety of the West Lagoon's contents will be disposed of at the disposal location.

The volume of each vacuum truck is approximately 10 m^3. The current disposal operation is estimated to cost approximately $1,000,000 a year in operational fees.

2.5 BACKGROUND RESOURCES

Below is a list of useful resources to start the design process. This list is not intended to be comprehensive; student teams are encouraged to complete their own literature review.

Pacific Climate Impact Consortium:
https://www.pacificclimate.org/

Online GIS database for BC
https://www2.gov.bc.ca/gov/content/data/geographic-data-services/web-based-mapping/imapbc

Applicable Regulations & Guidelines

BC Municipal Wastewater Regulation (MWR)
http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/87_2012

BC Reclaimed Water Guidelines
https://www2.gov.bc.ca/assets/gov/environment/waste-management/sewage/reclaimedwater.pdf

Wastewater Systems Effluent Regulation
http://laws-lois.justice.gc.ca/PDF/SOR-2012-139.pdf

Metro Vancouver Sewer Use Bylaw
http://www.metrovancouver.org/boards/Bylaws1/GVSDD_Bylaw_299-Unofficial_Consolidation.pdf

Canadian Water Quality Guidelines for the Protection of Aquatic Life
http://ceqg-rcqe.ccme.ca/download/en/181

Canadian Glycol Guidelines
https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/guidelines-objectives-codes-practice/order-council-glycol.html

3 OBJECTIVES

Student teams are required to complete and prepare two conceptual design options for the treatment, conveyance, and disposal of accumulated de-icing fluid runoff using the methods described below. The systems should be designed to meet capacity and treatment requirements for current conditions and future conditions until a design horizon of 2050. Students may consider innovative or alternative approaches to those outlined with prior approval of the SDC committee.

1. Option 1 – Biological Treatment
   a. Treatment system consisting of engineered wetland or attached growth bioreactor for treatment of de-icing fluid runoff
   b. Conveyance system of treated wastewater to selected disposal location
   c. Stormwater management system for general stormwater runoff outside of de-icing periods

2. Option 2 – Glycol Recovery System
   a. Treatment system consisting of a glycol recovery system for treatment and recovery of de-icing fluid from de-icing fluid runoff
   b. Glycol storage for reuse
   c. Conveyance system to selected disposal location for residual waste
   d. Stormwater management system for general stormwater runoff outside of de-icing periods

Consider and evaluate the options using quantitative and qualitative criteria, sensitivity analyses, and a triple bottom line analysis, and present the recommended approach and design with justification. The deliverables will be judged considering: depth and robustness of analysis, selection of integrated and creative designs, practicality of implementation, and operation and maintenance requirements.

3.1 SCOPE OF WORK

- Climate Change Analysis
    - Establish current and future climactic conditions for design including, but not limited to, number of frost days and rainfall
- Flows and Loads Analysis
    - Conduct analysis to determine the current and future flow and BOD_5 loading and taking into account the anticipated increase in flight frequency and climate change effects.
    - Design the hydraulics capacity of each de-icing runoff treatment option to accommodate the 2050 peak hour flow that corresponds peak de-icing operations and a storm event that corresponds to a 60 minute, 1 in 200-year return period with climate change.
- Treatment Process Design
    - Identify suitable disposal location and identify treated effluent requirements
    - Provide conceptual design of two options, as outlined in Section 3, for the treatment, conveyance, and disposal of treated de-icing runoff for current and future conditions
    - Provide a hydraulic profile of each treatment option from intake to discharge
    - Provide P&IDs of each treatment option
    - Provide a site layout for each option
    - Identify and provide opportunities for resource recovery
    - Estimation of GHG (as CO_2e) reduction or increase from current operations
- Stormwater Management System
    - Reuse existing ditch system to manage stormwater runoff outside of frost season.
    - Provide modifications to existing ditch system to minimize glycol exceedances as required by the Canadian Glycol Guideline.
    - Stormwater management approach can be same across both evaluated treatment options.
- Class D Cost Estimate
    - Class D Capital NPV estimate
    - Class D Life Cycle cost estimate including revenue generated or costs offset by recoverable resources

3.2 DESIGN CONSIDERATIONS AND CONSTRAINTS

- **Climate Change:** Consider future climate effects of an RCP8.5 scenario
- **Site Constraints:**
    - Design treatment, conveyance, disposal systems, and stormwater management system within the site constraints presented in the supplementary attachments.
    - Solutions must not interfere with airside operations.
    - Consideration should be given to maximizing usage of existing assets where possible.
    - The designs shall not have the potential to attract wildlife (e.g. birds) that may impede airport operations.
- **Project Constraints:**
    - Project must be confined to within the airside fence line
- **Regulatory Requirements:** Meet all applicable municipal, provincial, and federal regulatory requirements.
- **Project Lifespan:** Design horizon is approximately 30 years (2020 to 2050). Assume a discount rate of 5%.

3.3 DELIVERABLES

1. Progress Report
2. Design Notebook formatted to Competition Guidelines and containing the following:
    a. Climate change analysis
        i. Summary of current climactic conditions based off historical climate normals
        ii. Projection of future climactic conditions incorporating climate change (RCP8.5)
    b. Flows and Loads analysis
        i. Estimation of current and future flows and loads
    c. Conceptual design of two treatment options
        i. Design description
        ii. Preliminary sizing of process components
        iii. Hydraulic profile for treatment options
        iv. Plans, figures or drawings illustrating design concepts (i.e. P&IDs, Site layouts)
    d. Conceptual design of stormwater management solution
        i. Design description
        ii. Preliminary sizing of stormwater management system components
        iii. Plans, figures or drawings illustrating design concepts (i.e. Cross sections, Site layouts)
    e. Recommendation of preferred solutions
        i. Evaluation of resource recovery opportunities
        ii. Evaluation of waste diversion and GHG reduction or increase from current operations
        iii. Class D Cost Estimates for two options and comparison to current operations where relevant
            1. Life cycle cost estimate
            2. Capital NPV estimate
        iv. Triple Bottom Line (TBL) assessment to and recommendation of preferred solution
3. Oral Presentation