Bioretention Application for Stormwater Management in Cold Climate

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Background

- Urbanization has altered the natural hydrologic cycle by turning the absorbent green lands into hard surfaces and resulted in increased storm water runoff and deteriorated water quality.
- As a remedy, Low Impact Development (LID) concept has been introduced to storm water management.
- LID is an ecosystem-based approach to manage storm water by replicating natural hydrology and processes to manage storm water close to its source and to restore the biodegradation processes in soils and vegetation.

Background

- Bioretention, as one form of LID, is becoming best management practices for managing urban storm water quantity and quality.
- Bioretention systems are shown effective in reducing storm water volume and peak flow as well as improving storm water quality in warm and temperate climate.
- The applicability of bioretention systems in cold and semi-arid climate, such as Alberta and Canadian Prairies, needs to be studied and demonstrated.

Goal

Examine the effectiveness of bioretention system for stormwater quantity and quality management in cold climate with emphasis on sustainability of the system

Objectives (NSERC-CRD w/ City of Edmonton)

1. To investigate local soil amendment options and determine amended media characteristics and composition to be used in bioretention systems
2. To evaluate and improve stormwater volume and peak flow reduction and stormwater quality improvements by bioretention system in terms of suspended solids, organics, nutrients and heavy metals

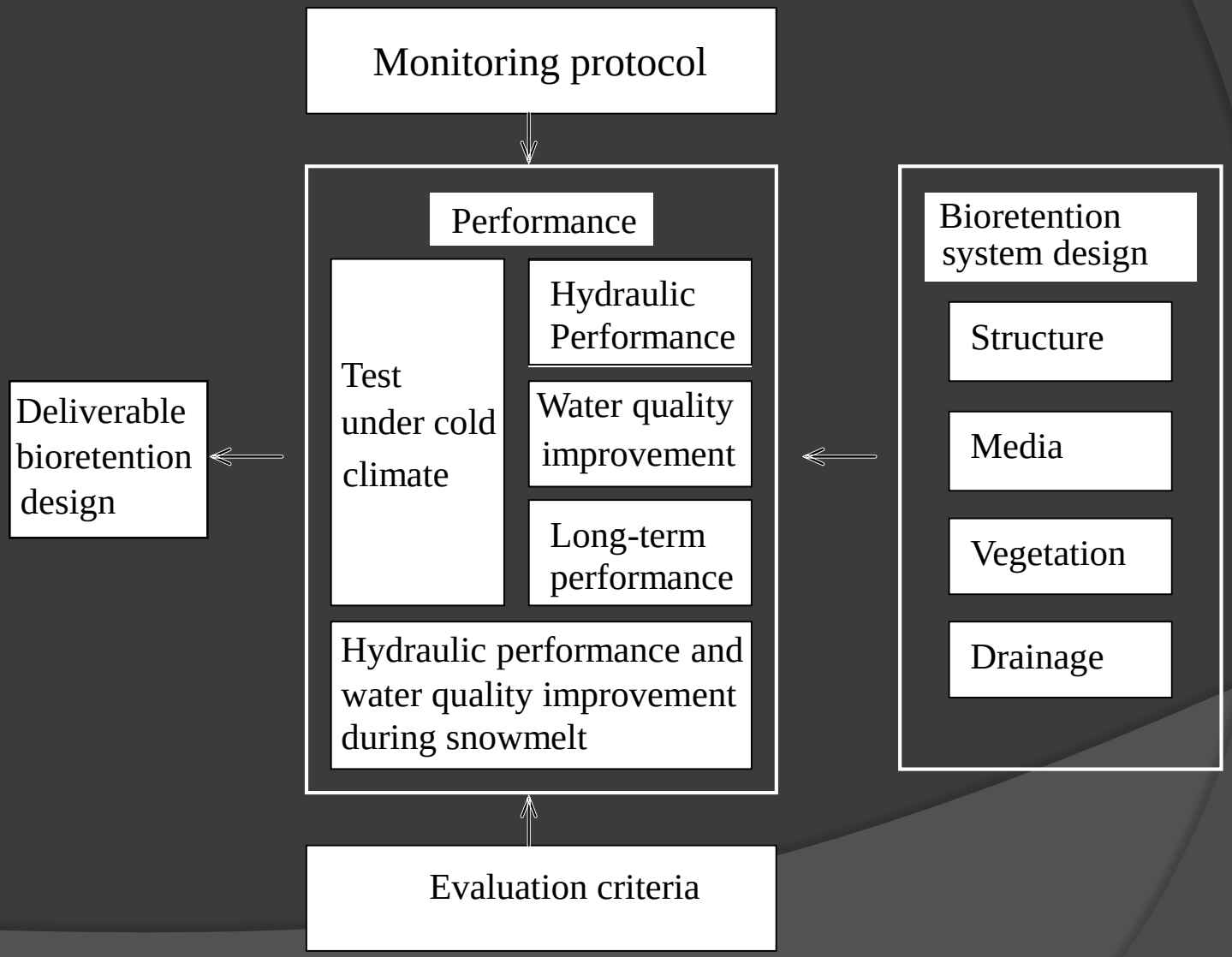
Objectives (NSERC-CRD w/ City of Edmonton)

3. To evaluate long-term performance of the bioretention system with focus on hydraulic performance, long-term removal and accumulation of pollutants in bioretention system
4. To understand the fate and transport mechanism of major pollutants in the system and assess interrelationship among major components of the media (soil, water and plant).

Objectives (NSERC-CRD w/ City of Edmonton)

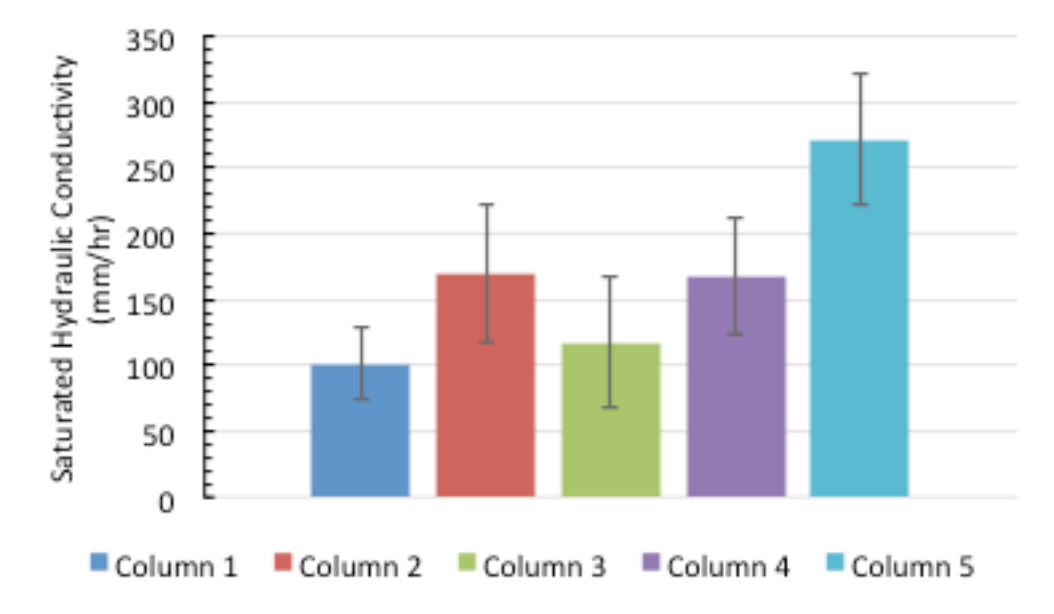
5. To evaluate applicability of bioretention system to the snow melt with focus on the impacts of salts, freezing-thaw cycle and snow melt runoff.

Experimental Approach



Lab Small Column Cells

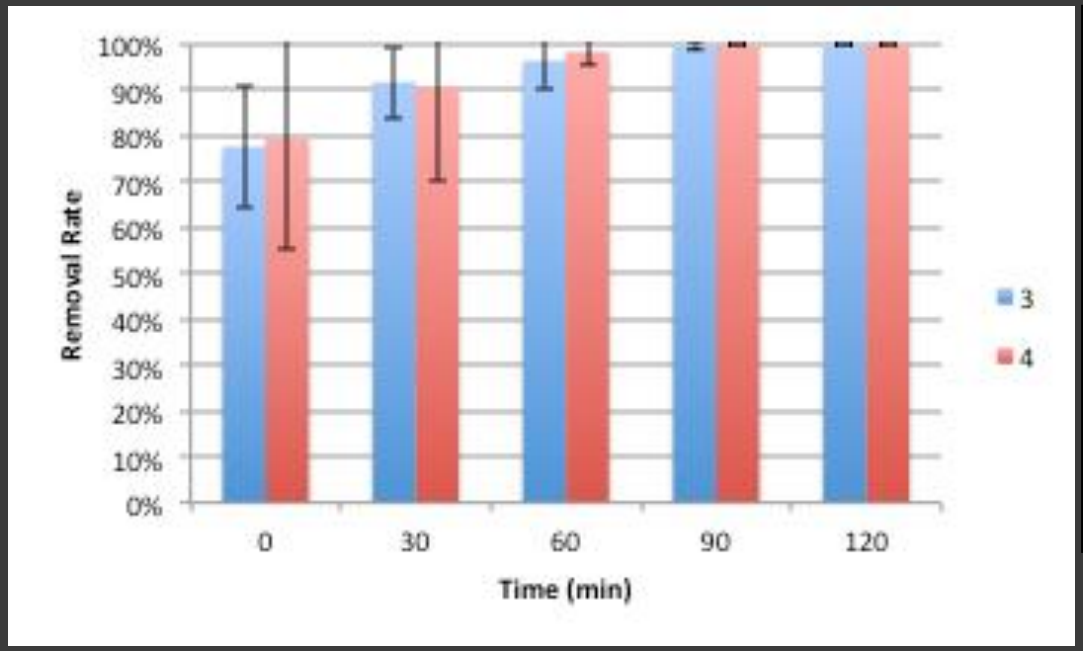
Preliminary Results (Soil Media)

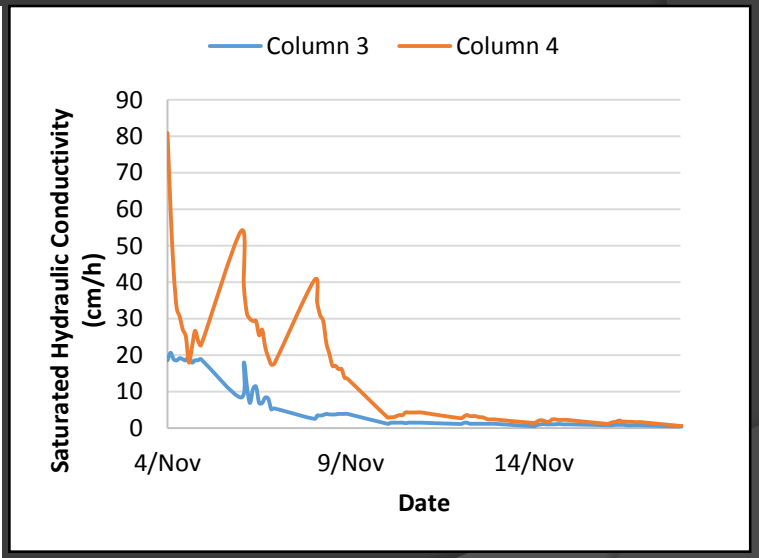


Soil media	topsoil: sand: amendment ratio (weight)	Amendments
#1	50%:50%	N/A
#2	30%:50%:20%	Sawdust
#3	50%:30%:20%	Compost
#4	30%:50%:20%	Compost
#5	10%:70%:20%	Compost

Preliminary Results (Soil Media)

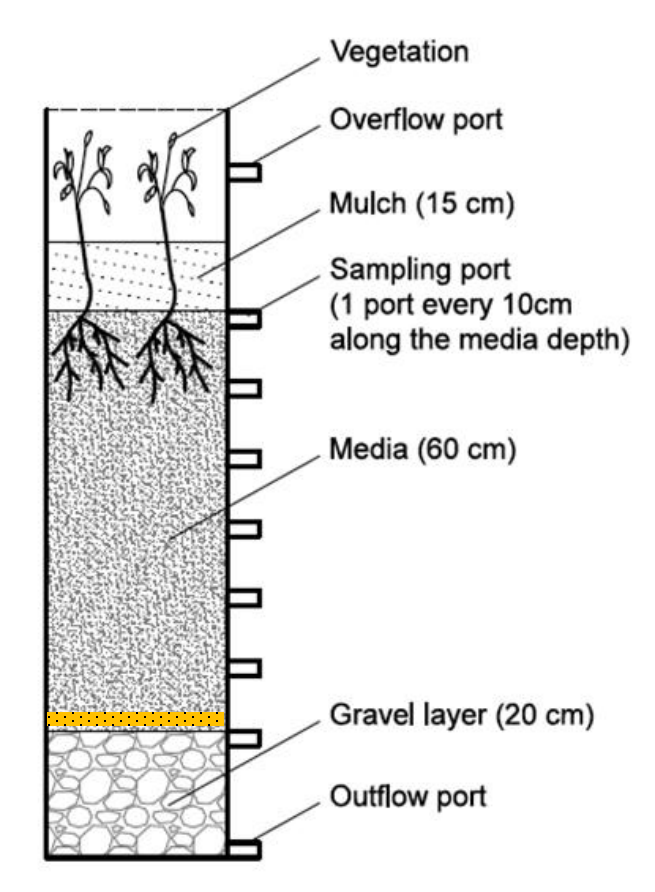
Soil media	topsoil: sand: amendment ratio (weight)	Amendments
#3	50%:30%:20%	Compost
#4	30%:50%:20%	Compost



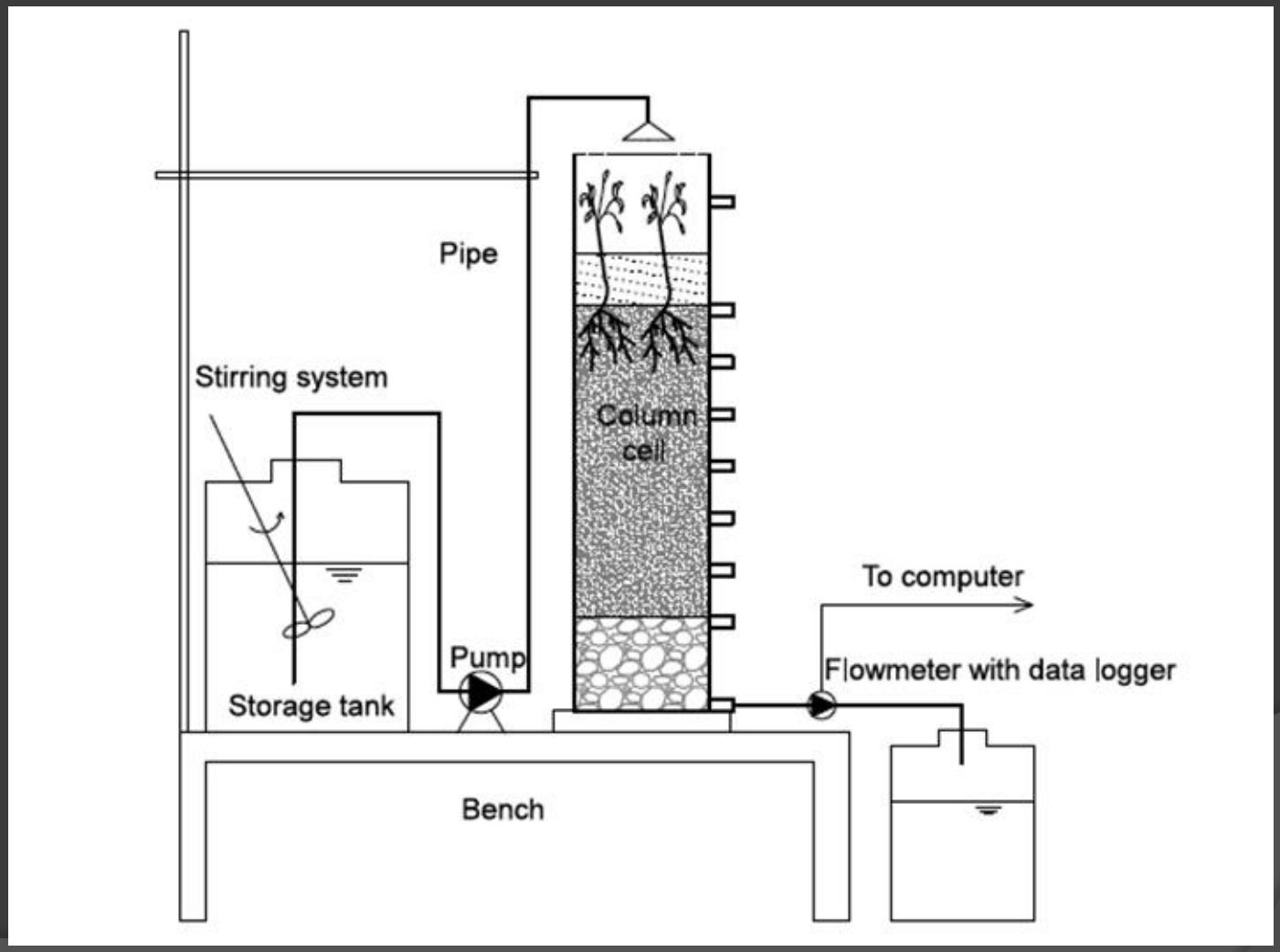


Lab Large Column Cells

- The large column cell has been designed, based on our expertise and the literature study
- Four (4) columns are in the process of being fabricated and tested
- Diameter is 40 cm
- Ponding depth is 30 cm
- Operated in controlled environment (temperature-controlled room)

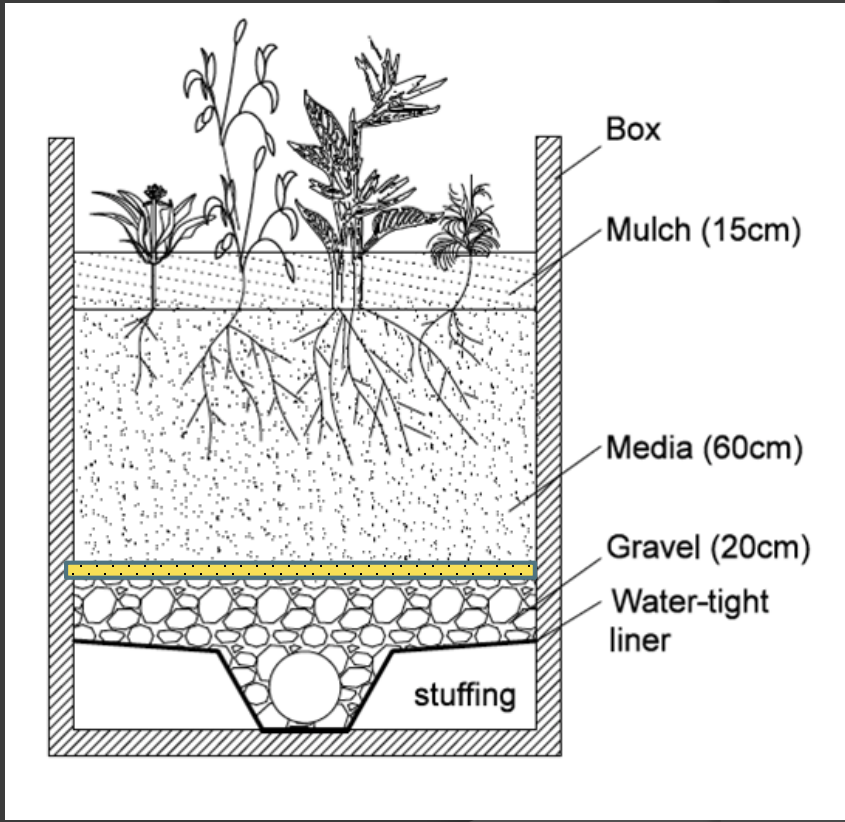


Large Column Cell Setup

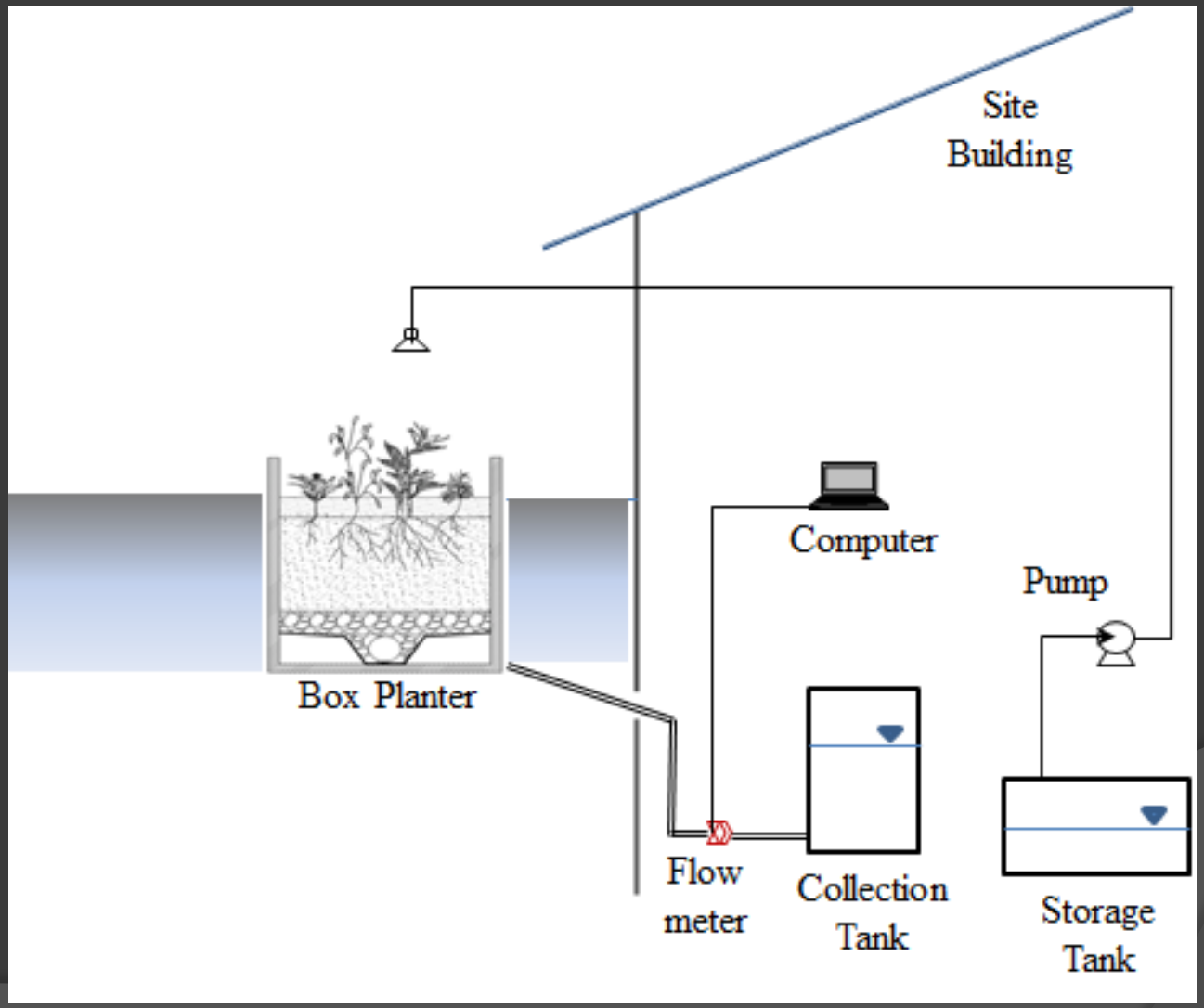


Field Pilot Box Planters

- The design is completed
- Four (4) box planters will be built at a selected site in Edmonton
- Diameter is 1 m
- Ponding depth is 30 cm
- Operated in natural environment (ambient temperature)
- Water-tight liner at the bottom for defined volume and mass balances



Box Planter Setup



Hydraulic Loading & Water Quality

- Simulation of rainfall/snowmelt events based on historical rainfall data of Edmonton
- Water quality parameters:

  TSS, COD, TN, NH_4^+, NO_3^-, TP, Cl^-, Metals, pH,

Lessons Learned

1. For research, we need to address the capacity of a bioretention cell (in unit volume or area) in cold climate. Therefore, we need to study a controlled system; i.e., controlled volume as well as controlled input and measured output on both water quantity and quality.

Lessons Learned

2. We expect a bioretention cell to have multiple functions; therefore, should view it as one with multiple components. Studies of the relationships, sometimes conflicting, between the components and functions are needed.

Lessons Learned

2. The multiple functions include:
   - Flow reduction
   - Solids removal
   - Pathogen removal / reduction
   - Organic carbon removal
   - Nitrogen removal
   - Phosphorus removal
   - Metal removal
   - Inorganic salts removal

Lessons Learned

2. The multiple components include:
   - Pretreatment
   - Local soil media amendments
   - Porosity control
   - Submerged anoxic zone
   - Microbial communities
   - Vegetation
   - Adsorbent materials
   - Precipitating materials

Lessons Learned

3. The long-term (10-15 years) performance and maintenance of bioretention in cold climate are to be carefully studied. A method to study them within a reasonable time frame is needed.

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