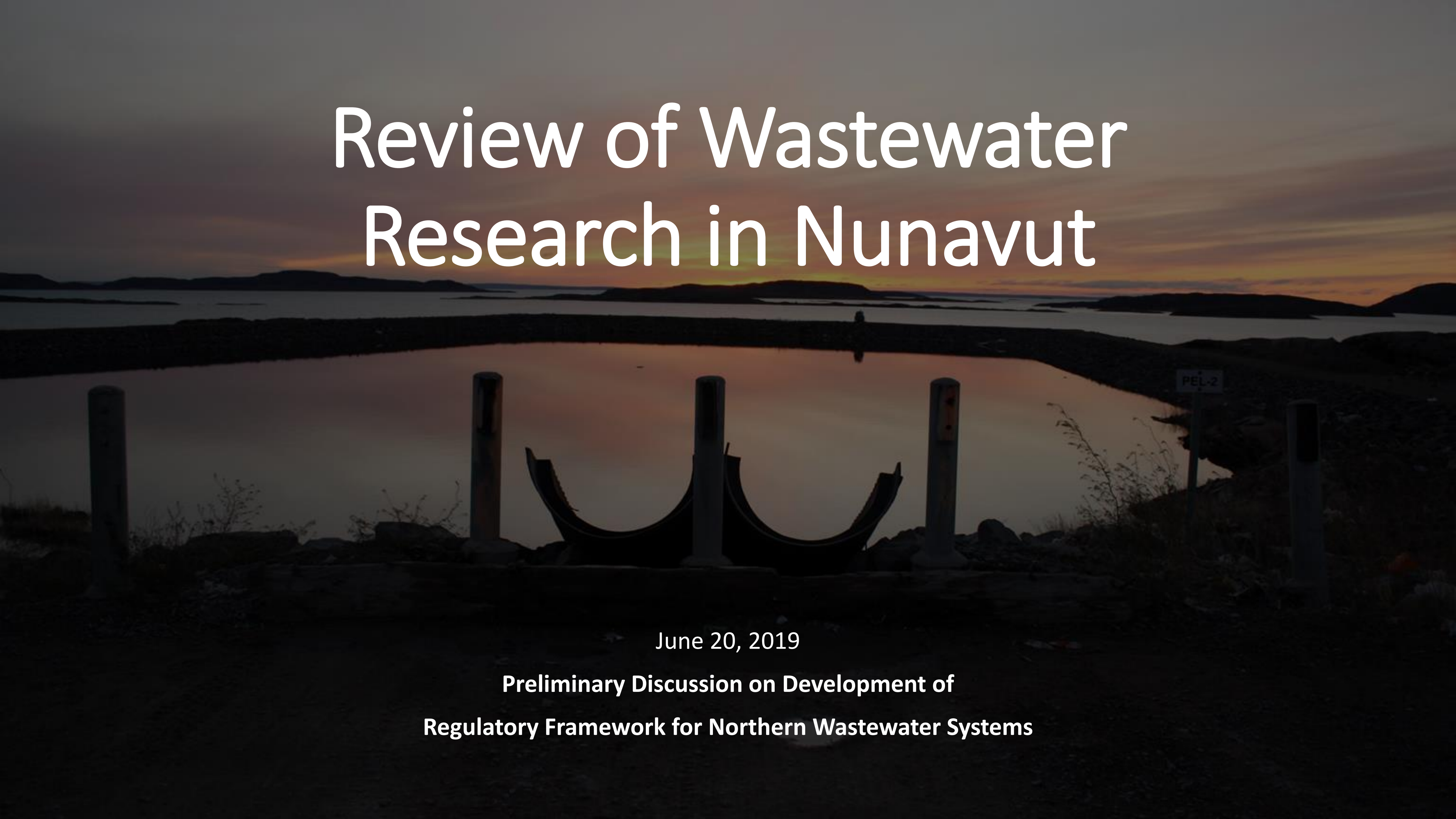


Review of Wastewater Research in Nunavut

June 20, 2019

Preliminary Discussion on Development of

Regulatory Framework for Northern Wastewater Systems

2009

- CCME endorsed the Municipal Wastewater Effluent (MWWE) Strategy
- The Inuit Tapririit Kanatami (ITK) responded to the CCME MWWE
- The Arctic Wastewater Workshop was sponsored by Environment Canada

2010

- The Northern Research Working Group 2007-2010 Summer Sampling Program
- CCME Northern Working Group
  - Risk-level criteria and timelines for implementation (Hutchinson Environmental Sciences Ltd)
  - Northern Working Group Workshop (Lara Consulting)
  - Financial Implications of capital, design and operation impacts (exp)

2014

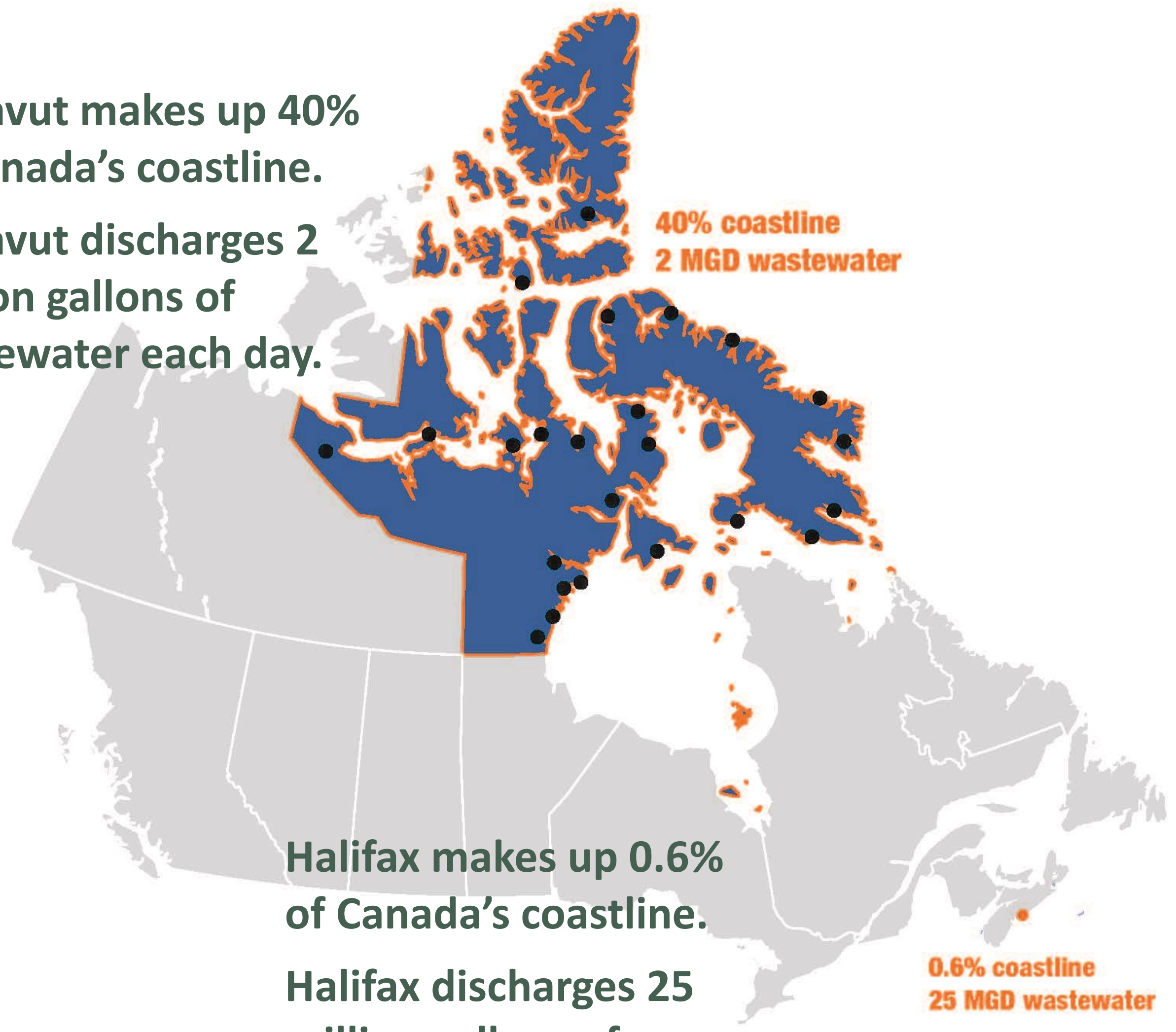
Nunavut – Unique Considerations

- receiving environment

Nunavut makes up 40% of Canada's coastline.

Nunavut discharges 2 million gallons of wastewater each day.

- 40% of Canada's coastline
- 0.1% of Canada's wastewater geneartion
- 24 communities scattered along the coastline
- 1 inland community – Baker Lake
    - 320 km inland from Hudson Bay
    - Baker Lake is 1,887 square km

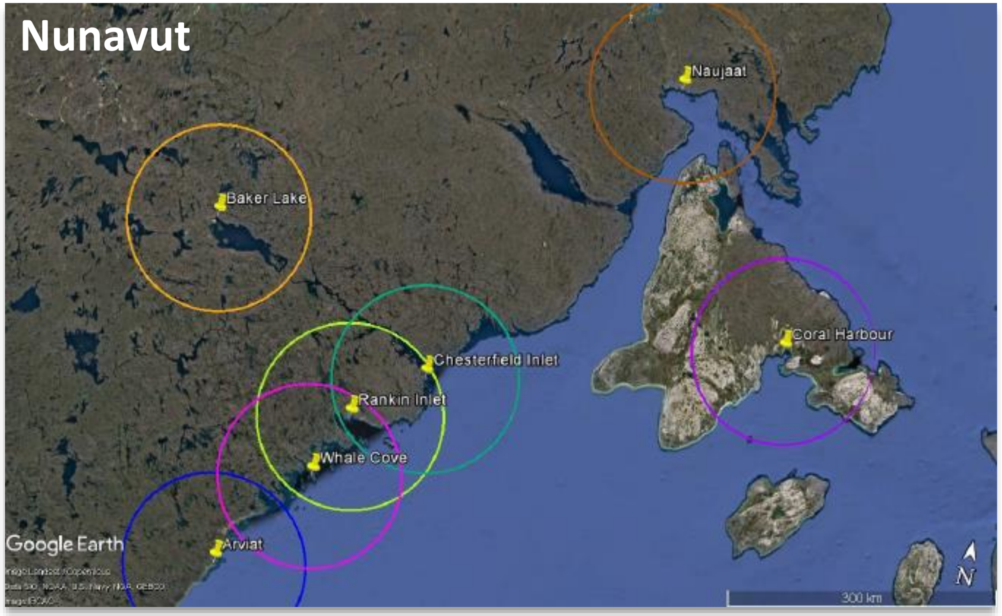


Halifax makes up 0.6% of Canada's coastline.

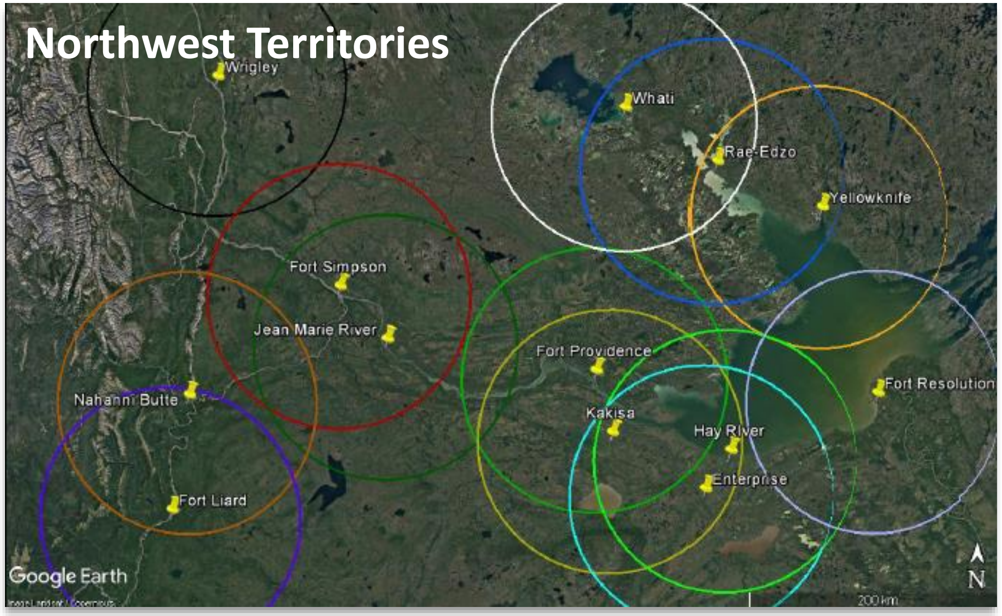
Halifax discharges 25 million gallons of wastewater each day.

Nunavut – Unique Considerations
- assimilative capacity and cumulative effects

- Population density:
  - NU: 0.017
  - NWT: 0.031
  - Nanvik:0.027
  - Labrador: 0.090
- The two closest Nunavut communities have 175 km of coastline between them.



100 km radius



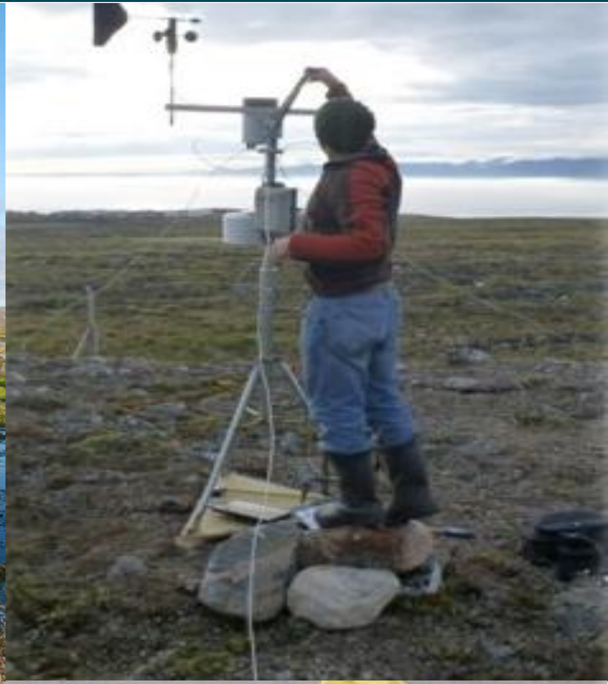
Nunavut – Unique Considerations

- wastewater characteristics

	Southern Canada		Nunavut	
Volume of water used	300 lpd/person		100 lpd/person	
	cBOD (mg/L)	TSS (mg/L)	cBOD (mg/L)	TSS (mg/L)
raw	210	190	475	380

GN and Dalhousie University Led Research

- GN-CGS entered into a long-term research contract with Dalhousie University in response to the CCME MWWE.
- The research studied wastewater systems in six Nunavut communities (2010-2014).
- The contract was extended to study an additional three wetland systems (2014-2016).
- Eleven technical papers were produced for the GN in addition to numerous journal articles.



Municipal Wastewater Impacts on Marine Benthic Invertebrates

Communities studied:

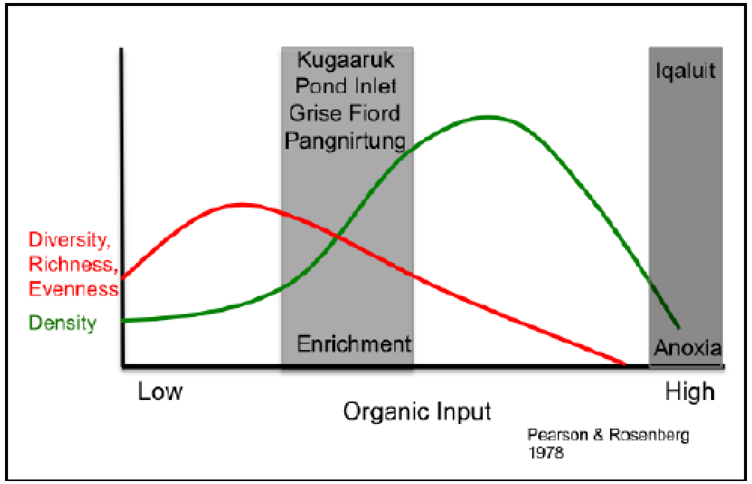
- Grise Fiord, Kugaaruk, Pangnirtung, Pond Inlet and Iqaluit

Objective:

- Determine impacts to benthic invertebrates in sediments in near shore areas of the effluent discharge point.

Municipal Wastewater Impacts on Marine Benthic Invertebrates

- Spatial impacts for communities are less than 250 m and characterized as enrichment.
- Spatial impact for Iqaluit was 580 m and is characterized as anoxic.
- This spatial impact for larger municipalities of Canada are scales of 1000 m to 4000 m.



Treatment Performance on Municipal Wastewater Stabilization Ponds

Communities studied:

- Pond Inlet, Clyde River, Kugaaruk, and Grise Fiord

Objectives:

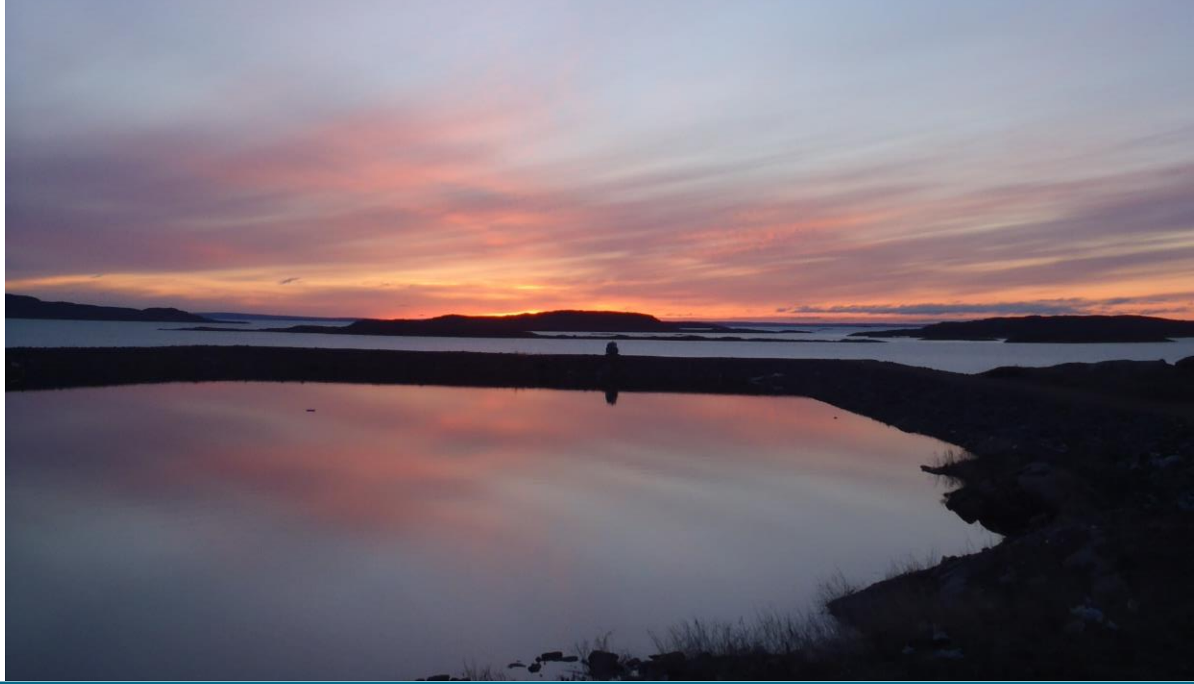
- To better understand the treatment mechanisms of cold-region lagoons.

Treatment Performance on Municipal Wastewater Stabilization Ponds

- The study found lagoons removed progressively more cBOD over the course of the treatment season.
- At the start of the season cBOD reduction is a result of settling.
- As the lagoon warms cBOD is removed via settling and biological activity.

Expected effluent quality based on lagoon depth

Parameter	Shallow (<2.2 m)	Deep (>2.5 m)
cBOD (mg/L)	80 – 120	120 – 160
TSS (mg/L)	50 – 100	25 – 50
NH_3-N (mg/L)	<1.25	<1.25



Impacts on Receiving Water

Communities studied:

- Pangnirtung, Kugaaruk, and Pond Inlet

Objectives:

- Better understand the factors affecting and influencing water quality impacts upon discharge to the marine environment.

Impacts on Receiving Water

Key factors which affect the water quality impacts associated with wastewater discharges into the receiving environments include:

- ambient characteristics of the receiving environment
- discharge rates
- timing of the discharges in relation to tidal regime

For existing systems:

- optimizing timing of the discharges
- community education

For new systems:

- siting the system based on:
    - discharge location
    - wind action
    - ambient current

Community	Initial Mixing Zone
Kugaaruk	50 m
Pangnirtung	>150 m
Pond Inlet	>350 m

Site-Specific Studies on Tundra Wetland Areas

Communities studied:
- Coral Harbour, Kugaaruk and Grise Fiord

Objectives:
- Develop a model to predict treatment capacity for existing and proposed wetlands
- Determine rate constants derived for northern systems to apply in modelling

Communities studied:
- Sanikiluaq, Naujaat, Cape Dorset

Objectives:
- To calibrate and validate models

Site-Specific Studies on Tundra Wetland Areas

- Dilution is a major contributor to reduced concentrations through wetlands, however treatment is also occurring
- Rate constants fell within the low percentiles compared to literature for cold (non-arctic) climates
- A modified tanks-in-series mass balance modeling approach is most appropriate model for northern systems
- Site-specific treatment performance studies are recommended

Summary of Site Research findings

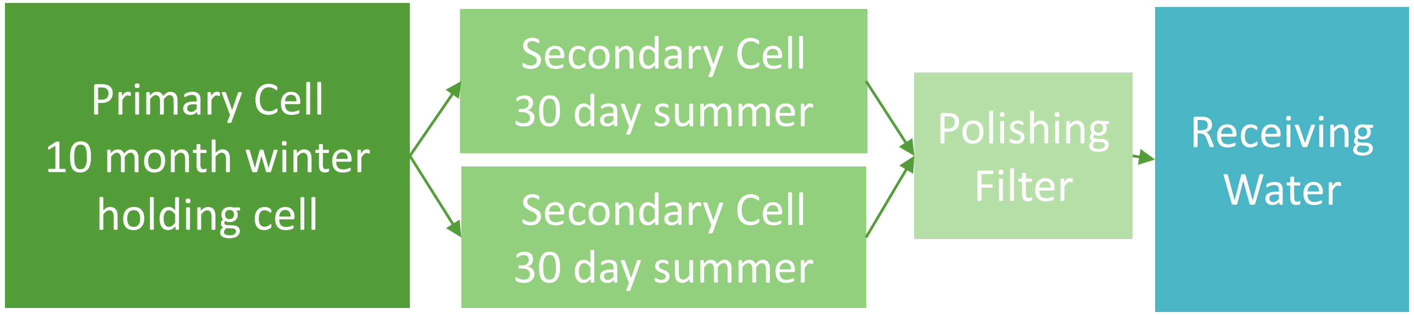
	Receiving	Decant	Volume of waste water	Loading Rate	Leaving lagoon		Entering receiving water			Impact
			(m^3 annually)	<22 kg/ha/d recommended	CBOD (mg/L)	TSS (mg/L)	CBOD (mg/L)	TSS (mg/L)	NH_3 (mg/L)	(m)
Pangnirtung*	Fiord (marine)	continuous	46,810	not applicable			104	253	0.8	75-225
Kugaaruk	Small marine bay	2 -3 weeks	25,330	28	150	25	12	3	0.42	70-100
Grise Fiord	Fiord (marine)	1 week	4,270	25	Insufficient data		75	280	0.52	20-150
Iqaluit	Large Bay (marine)	continuous	552,600	not applicable	Insufficient data		620	310	0.3	580
Pond Inlet	Open Marine	2-3 weeks	80,880	15	118	86	47	77	1.85	0-75

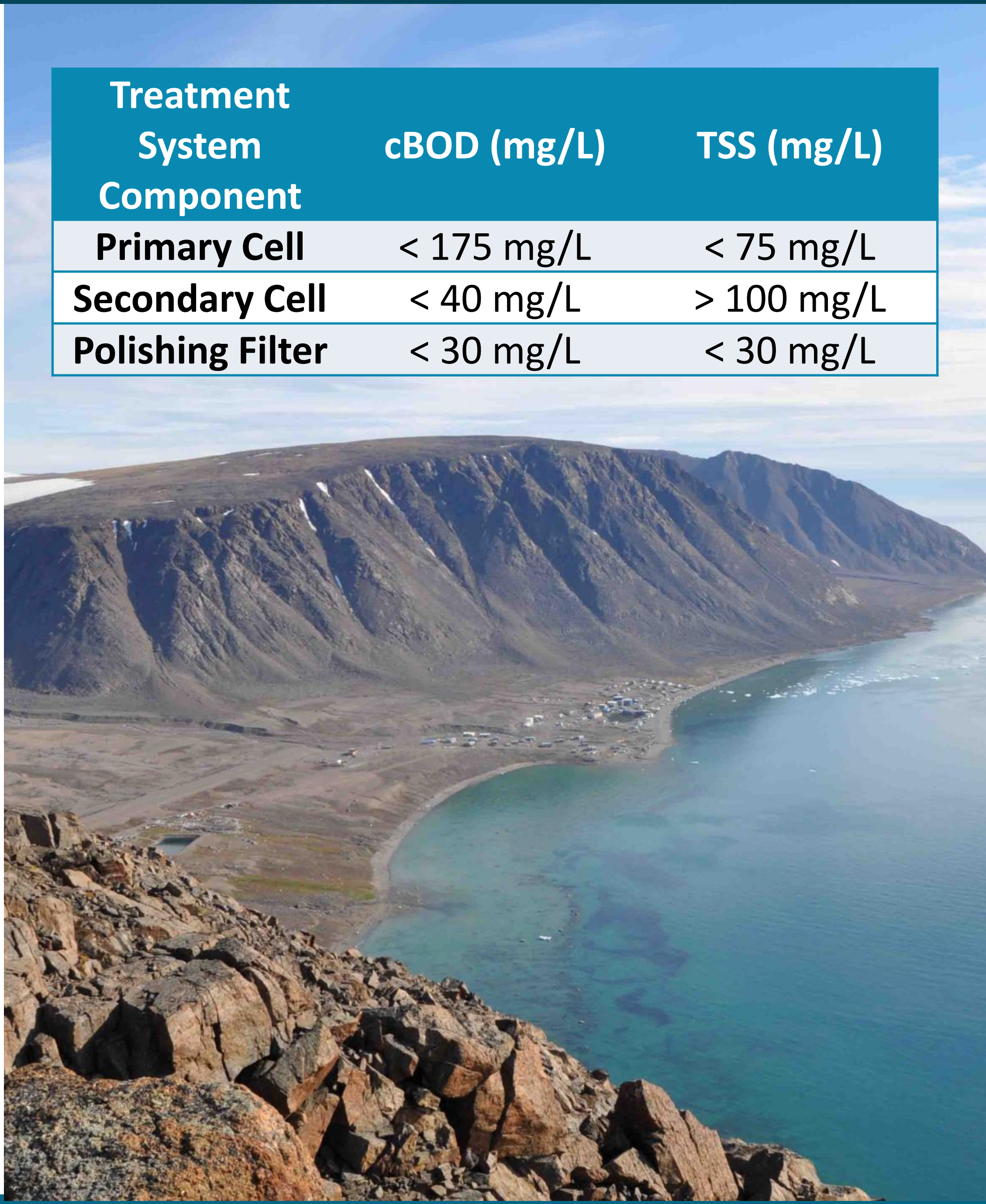
*The Pangnirtung Wastewater Treatment plant has been upgraded since the study period.

Guidelines for the Process Design of Wastewater Stabilization Ponds

Objective:

- Propose a multi-component system design for northern lagoons.





Treatment System Component	cBOD (mg/L)	TSS (mg/L)
Primary Cell	< 175 mg/L	< 75 mg/L
Secondary Cell	< 40 mg/L	> 100 mg/L
Polishing Filter	< 30 mg/L	< 30 mg/L

Proposed Revision to Regulatory Criteria for Risk Assessment

Objectives:

- Propose an approach for conducting semi-qualitative risk assessments for lagoons
- Review the WSER risk framework in the context of its applicability to Nunavut

Proposed Revision to Regulatory Criteria for Risk Assessment

Recommended criteria to be retained or discarded

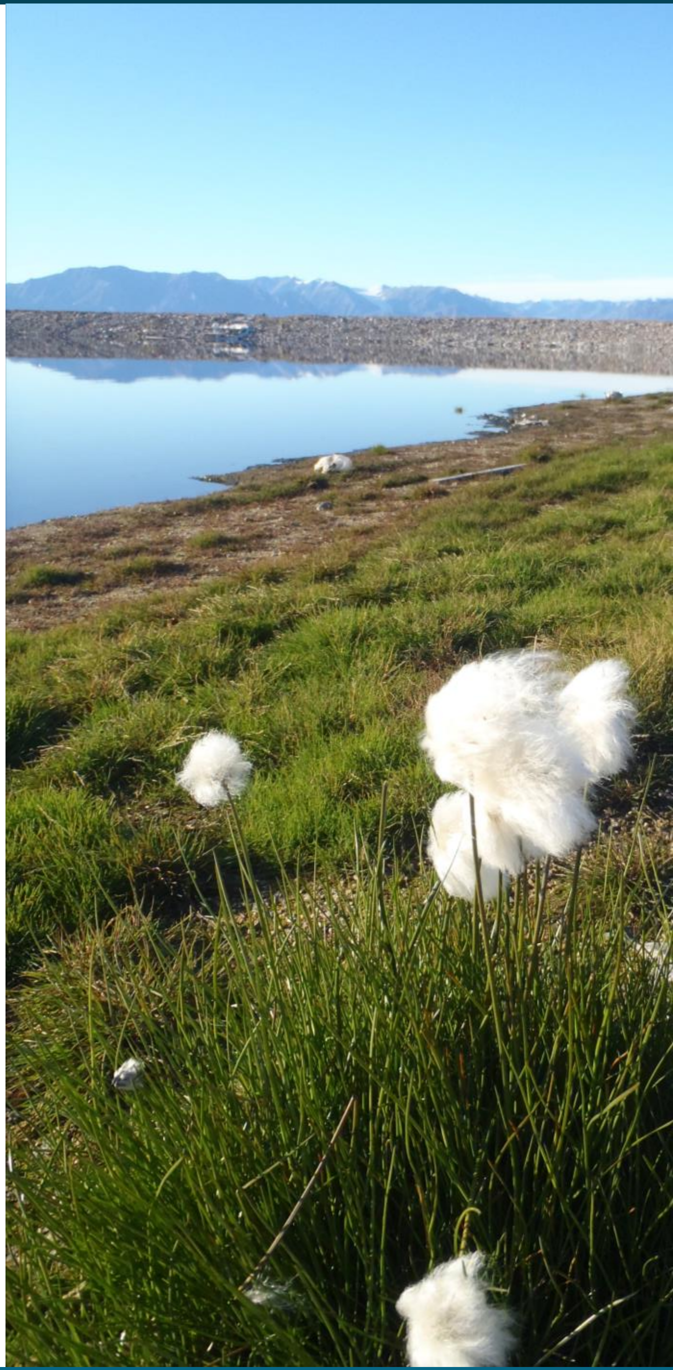
- Retain: facility size (flow) retained
- Retain: un-ionized ammonia nitrogen (NH_3-N)
- Discard: total residual chlorine

Recommended revisions to criteria

- Assess the risk based on the type of treatment systems, and associated level of treatment expected, rather than the concentration-based metric (cBOD/TSS)
- Receiving environment should represent conditions observed in Nunavut

Recommended new criteria

- Frequency and timing of discharges
- Consider surrounding land and water uses by human activities
- Consider the risk reducing merit of community education and engagement, such as consultation, and signage



Risk criteria	Description	Points
Treatment system type	Secondary treatment (passive)	5
	Secondary treatment (active)	10
	Primary treatment passive (WSP only)	15
	Primary treatment active (WWTP only)	20
	Screening pre-treatment only	25
	Direct discharge (outfall)	35

Criteria	Description		Points
Type of receiving environment or affected use	Water where effluent is deposited via the final discharge point (highest value that applies)	Open marine waters low current (< 0.1 m/s)	5
		Open marine waters strong current (≥ 0.1 m/s)	25
		Exposed marine intertidal zone	25
		Lake, natural wetland, reservoir, estuary, enclosed bay	20

Risk criteria	Description	Classification	Points
Frequency and timing of discharge	Decanted systems are those which are manually discharged typically with a pump and generator.	End of season decant (August -October)	5
	Continuous discharges are those from mechanical treatment plants, passive exfiltration structures and subsurface discharge.	Continuous steady (June – October)	10
		Continuous variable (June –October)	20
		Start of season decant (June-July)	25
	Steady indicates maximum flow fluctuations of ± 50 m^3/d.	Continuous year-round	25

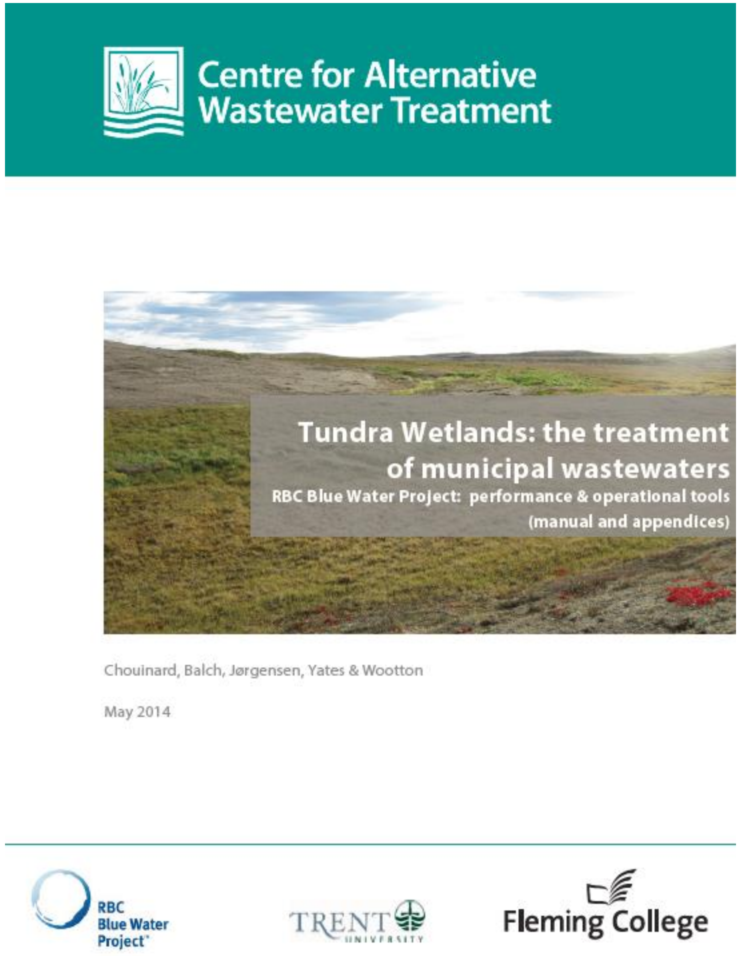
Risk criteria	Activities	Points
Surrounding land and water uses	Commercial shipping (<500 m)	5
	Recreational boating (<100 m)	10
	ATV and/or snowmobile (<100 m)	10
	Mining and/or craving rock collection (<100 m)	15
	Walking (<100 m)	15
	Fishing (<100 m)	20
	Hunting and harvesting (<100 m)	20
	Swimming (<500 m)	25
	Drinking water collection (<500 m)	30
	Shellfish harvesting (<500 m)	30

Risk criteria	Interactive measures	Points
Community education and engagement	No posters in hamlet and Hunters and Trappers offices showing location of discharges	10
	No communication of proper waterfowl and game handling at Hunters and Trappers offices	15
	No consultation on radio and in-person	25
	No signage near outfall area	30

Risk level	Risk characterization	Timeline for upgrades
< 50	Low	30 years
50 – 100	Low to medium	20 years
100 – 150	Medium to high	15 years
150 – 200	High	10 years

Centre for Alternative Wastewater Treatment

- The research funded through the International Polar Year included site investigations of 13 northern wetlands including six Nunavut communities: Arviat, Baker Lake, Chesterfield Inlet, Coral Harbour, Naujaat (Repulse Bay) and Whale Cove.
- The report confirms past resources that have described natural wetlands as natural open and diffuse systems, often with poorly defined boundaries, flow patterns and permeable boarders.
- The research findings are comparable with those of Dalhousie University.
- Wetlands provide treatment and treatment performance of is improved when decants are extended over the summer season rather than over a short period at the end of the summer.



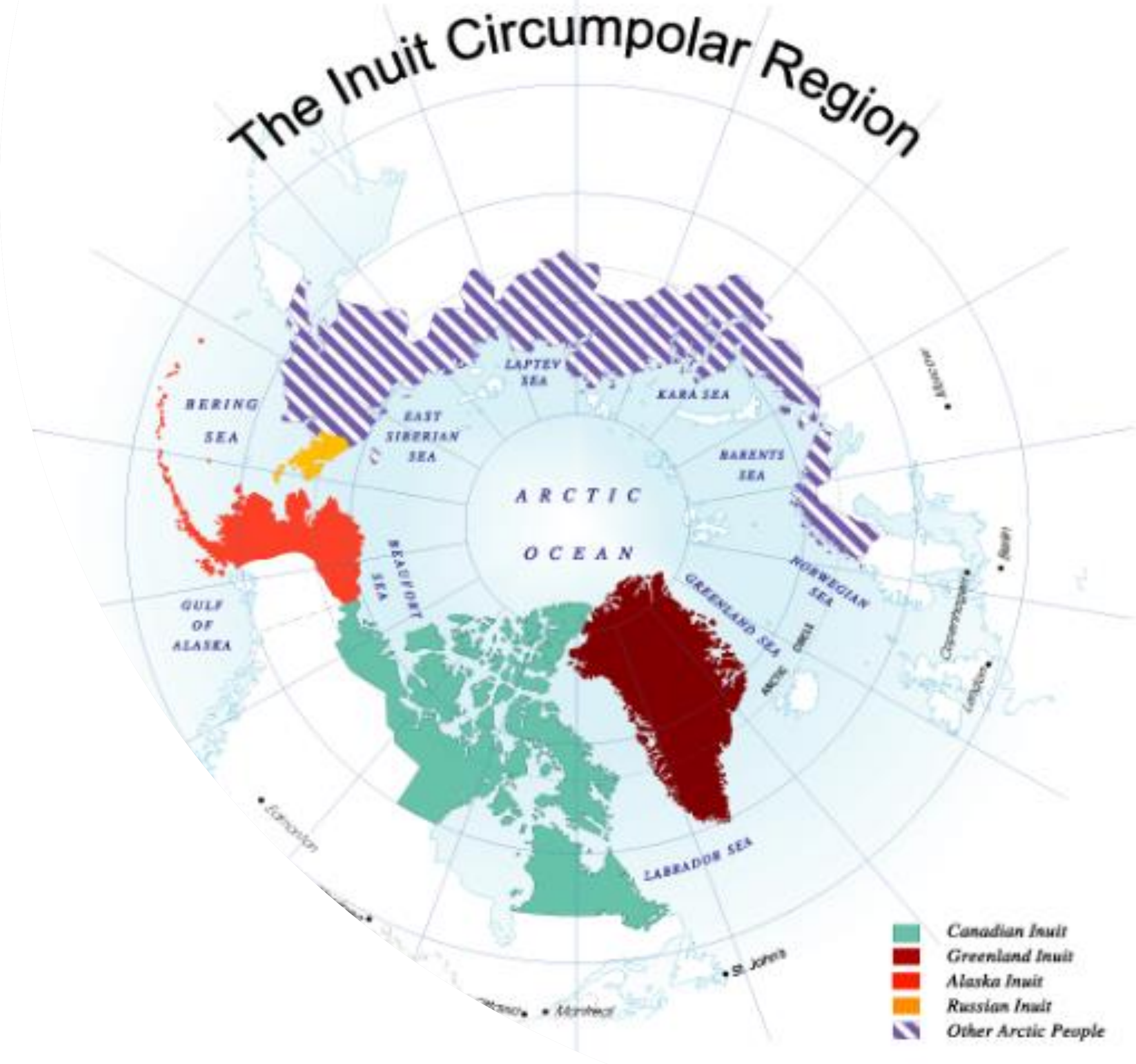
National Standard of Canada

- Developed a national standard for wastewater treatment in northern communities using lagoon and wetland systems.
- Provides a resource for consulting engineers.
- Technical Committee comprised of leads from Dalhousie and Fleming College research teams.

"this standard specifically addresses the planning, design, operation and maintenance of intermittent/seasonal discharge lagoon and wetland systems that are most appropriate for use in Northern regions, where effluent discharge is either difficult, or not possible in colder months." CSA

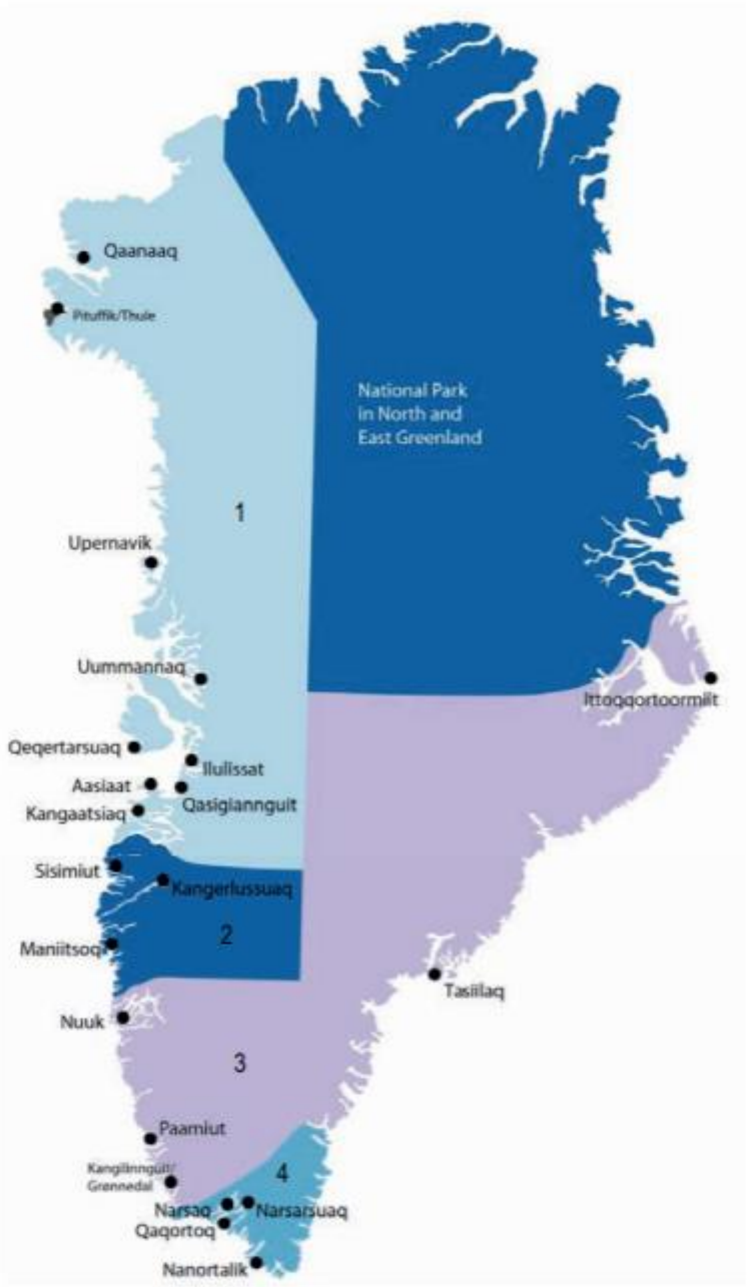
Jurisdictional Research – Wastewater Treatment in Alaska and Greenland

In addition to looking to Southern Canada the research also looked to Canada's northern neighbours



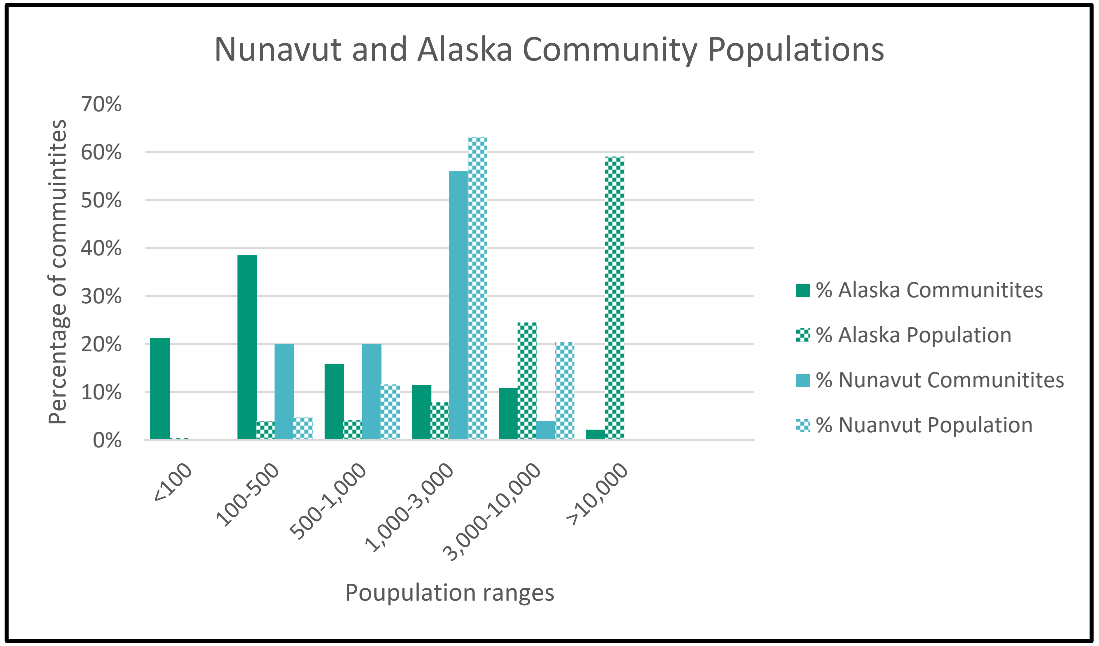
Wastewater Treatment in Greenland

- Greenland introduced a new disposal of wastewater legislation in 2015.
- The Regulation refers to developing wastewater plans for receiving environment however, there are no parameters or timelines associated.
- There are no standard effluent objectives in Greenland
- At present dilution is still heavily relied upon.
- The new legislation offers the possibility for the municipality and government to implement restrictions if environmental issues arise.



Wastewater Treatment in Alaska

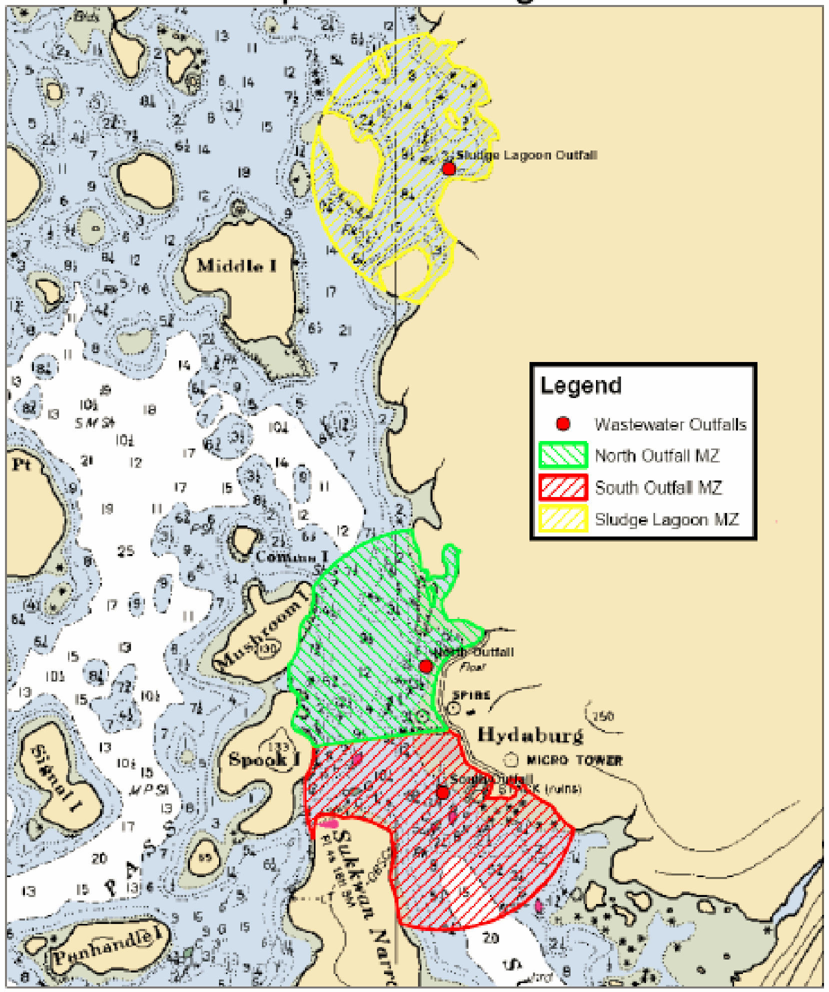
- Effluent discharge limits are the same for all systems regardless of flow.
- BOD and TSS average weekly limit is 45 mg/L.
- The Regulation includes clauses for case-by-case reduced levels of treatment if the applicant can prove protection of public health, public private waters systems, and the environment.



Wastewater Treatment in Alaska

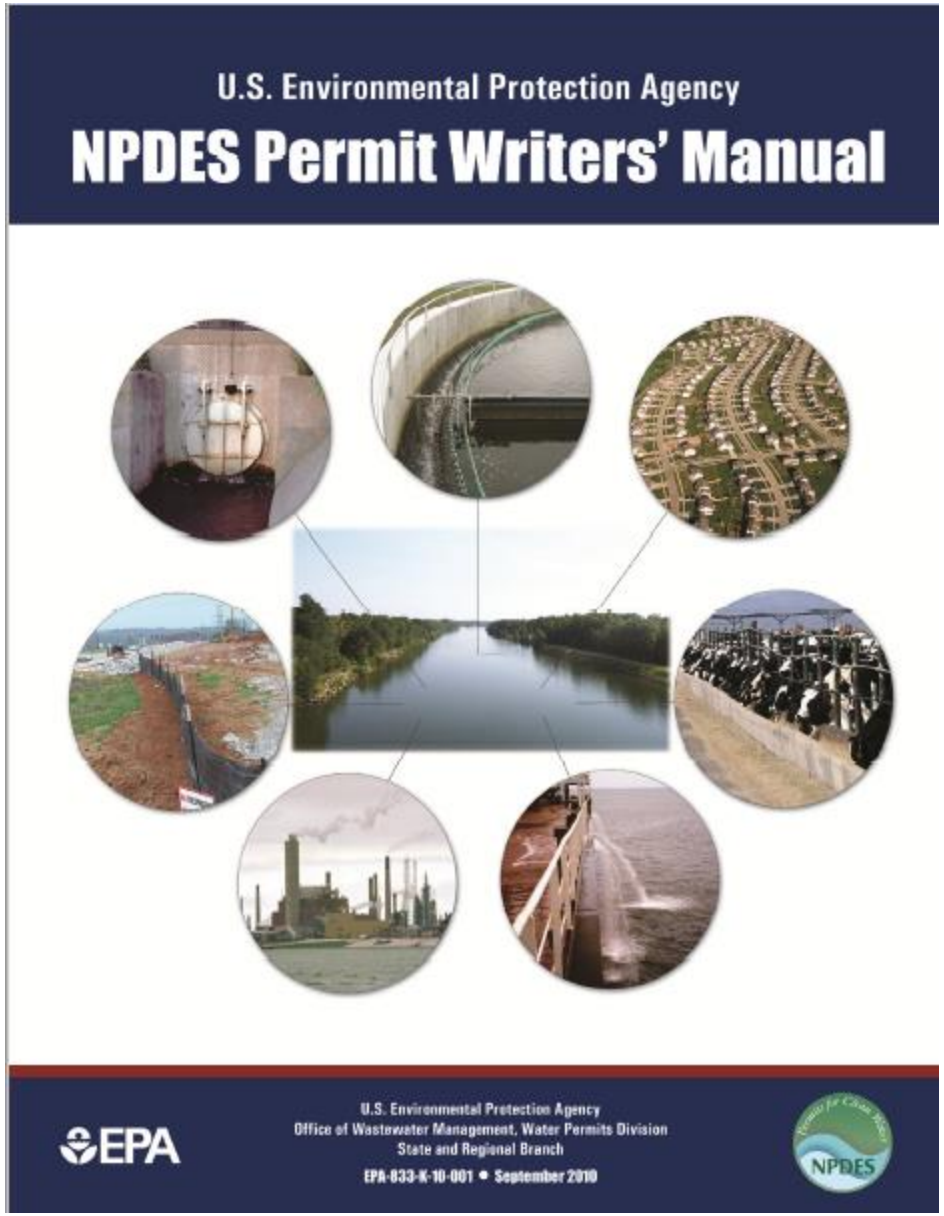
- Alaska’s wastewater discharge permits are similar to a water licenses.
- Discharge permits identify discharge criteria and monitoring requirements.
- Mixing zones are supported in permits with varying defined zones and parameters.
- Faecal coliforms often had differing criteria at the outside edge and the shoreline edge of the mixing zone.

Hydaburg Wastewater Outfalls and Proposed Mixing Zones



A Closer Look at the US Permit System

- Regulations are under the Clean Water Act.
- Regulations are technology-based secondary treatment standards that are federally regulated.
- A National Pollutant Discharge Elimination System (NPDES) permit is required for any wastewater discharged to waters of the United States.



A Closer Look at the US Permit System

- Section 301 (h) of Clean Water Act provides a variance from meeting secondary treatment standards for facilities that discharge into well-flushed marine waters. Majority of small Alaskan communities are under this modified permit.
- Impact monitoring is required with the modified permit. The monitoring results are used to evaluate applications for permit renewal.
- 301 (h) requirements:
  - Attain or maintain water quality that allows recreational activities in and on the water;
  - Attain or maintain water quality that allows protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife;
  - Meet water quality standards (or federal guidance values for pollutants without standards);
  - Establish a monitoring program to assess impacts;
  - Provide a minimum of primary or equivalent treatment;
  - Have an approved pretreatment program and establish toxics controls;
  - Provide enhanced urban area pretreatment, for systems serving greater than 50,000 population;
  - Prohibit variances in stressed estuaries; and
  - Protect water supplies.

A Closer Look at the US Permit System

		30-day average	7-day average
TSS	Concentration (mg/L)	30	45
	SS removal (concentration)	Not less than 85%	
	TSS Technology Based Equivalent to Secondary		
	Concentration (mg/L)	45	65
	SS removal (concentration)	Not less than 65%	
BOD(cBOD)	Concentration (mg/L)	30 (25)	45 (40)
	Removal (concentration)	Not less than 85%	
	BOD and cBOD Technology Based Equivalent to Secondary		
	Concentration (mg/L)	45 (40)	65 (60)
	Removal (concentration)	Not less than 65%	

Upward adjustments for TSS are made on a case-by-case basis:

- 21 states TSS limitation are >75 and < 90
- 7 states are >90 and <120

Applying Concentration Reductions to Canada

	Southern Canada		Nunavut	
Volume of water used	300 lpd/person		100 lpd/person	
Wastewater characteristics	cBOD (mg/L)	TSS (mg/L)	cBOD (mg/L)	TSS (mg/L)
raw	210	190	475	384
85% reduction	29	32	71	58
65% reduction	67	74	166	134

Recommendations Based on the Research

	Receiving	Decant	Volume of waste water	Loading Rate	leaving lagoon		entering receiving water			Impact
			(m^3 annually)	<22 kg/ha/d recommended	CBOD (mg/L)	TSS (mg/L)	CBOD (mg/L)	TSS (mg/L)	NH_3 (mg/L)	(m)
Pangnirtung	**Fiord (marine)**	continuous	46,810	not applicable			104	253	0.8	75-225
Kugaaruk	**Small marine bay**	2 -3 weeks	25,330	28	150	25	12	3	0.42	70-100
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Iqaluit	**Large Bay (marine)**	continuous	552,600	not applicable	Insufficient data		620	310	0.3	580
Pond Inlet	**Open Marine**	2-3 weeks	80,880	15	118	86	47	77	1.85	0-75

Reduction in Concentration

	Southern Canada		Nunavut	
Volume of water used	300 lpd/person		100 lpd/person	
Wastewater characteristics	CBOD (mg/L)	TSS (mg/L)	CBOD (mg/L)	TSS (mg/L)
raw	210	190	475	384
85% reduction	29	32	71	58
75% reduction	52	47	118	96
65% reduction	67	74	166	134

75% reduction from raw waste water results in effluent strength similar to current Nunavut Water License

This strength is also similar to the measured values in Pond Inlet which confirmed protection of the receiving environment

Pond Inlet – Setting the baseline

- Population: 1,600
- Loading Rate: 15 kg/ha-da
- Design: Lined with controlled decant
- Decant period: 21 days
- Impact zone: 75 m
- No wetland

plusArctic's Recommendations for Consideration

- 2590 m^3/day (risk averse)
- 15 day decant assumption (risk averse)

Discharge period (days)	Population
	125 lpc
15	766
20	1,022
30	1,533

16 Nunavut communities are < 1,533

plusArctic's Recommendations for Consideration

- All municipal facilities should be regulated
- Technology-based effluent criteria

Mechanical systems

- 25 mg/L cBOD; 25 TSS mg/L

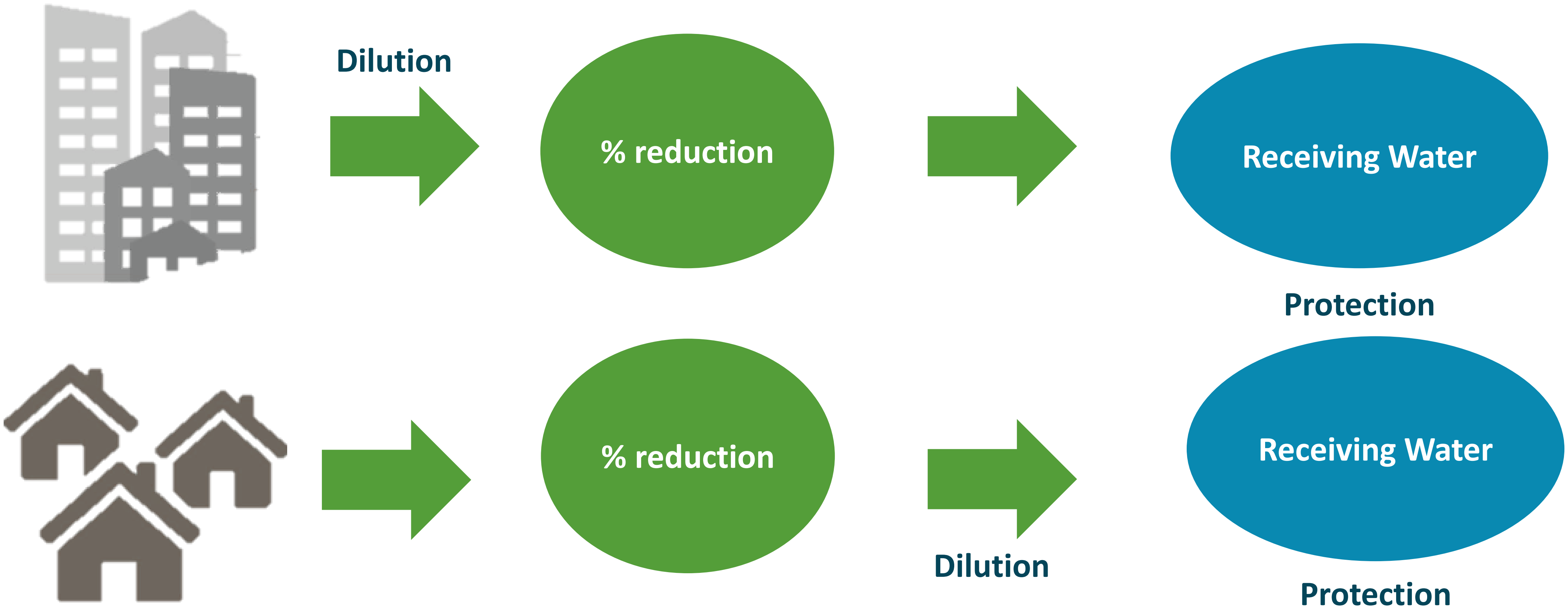
Lagoon/Wetland Systems

- Tiered regulation depending on volume of WW released per day to environment
- Flow < 2,500 m^3/day: cBOD 100 mg/L; TSS 120 mg/L
- Flow >2,500 m^3/day: cBOD 40 mg/L; TSS 100 mg/L or site specific study

A waiver for less stringent criteria supported by environmental studies and monitoring

- Water-quality based effluent criteria
  - Site specific criteria may be more stringent if required to protect public and environmental health

Summary – Treatment Train to Impact



Designing to meet stringent standards equates to roughly 2 times increase in cost for diminishing return on environmental protection

Thank You

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plusArctic
for the north, with the north