EMERGING CONTAMINANTS UNDER THE MICROSCOPE: EXPLORING MICROPLASTICS IN THE NORTH SASKATCHEWAN RIVER

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October 17, 2024

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WORLD ECONOMIC FORUM

NATURE AND BIODIVERSITY

Microplastics: Are we facing a new health crisis – and what can be done about it?

Sep 3, 2024

People

Microplastics Are a 'Big Time Bomb,' Says Researcher Who Found That 57 Million Tons of Plastic Are Produced Annually

By Angel Saunders | Published on September 4, 2024 08:13PM EDT

Reuters

Baby bottle maker says microplastics inescapable, health risks unproven, in bid to toss lawsuit

By Diana Novak Jones

September 9, 2024 2:44 PM MDT · Updated 20 hours ago

The Guardian Int

Microplastics found in every human testicle in study

Damian Carrington
Environment editor

Mon 20 May 2024 15.34 BST

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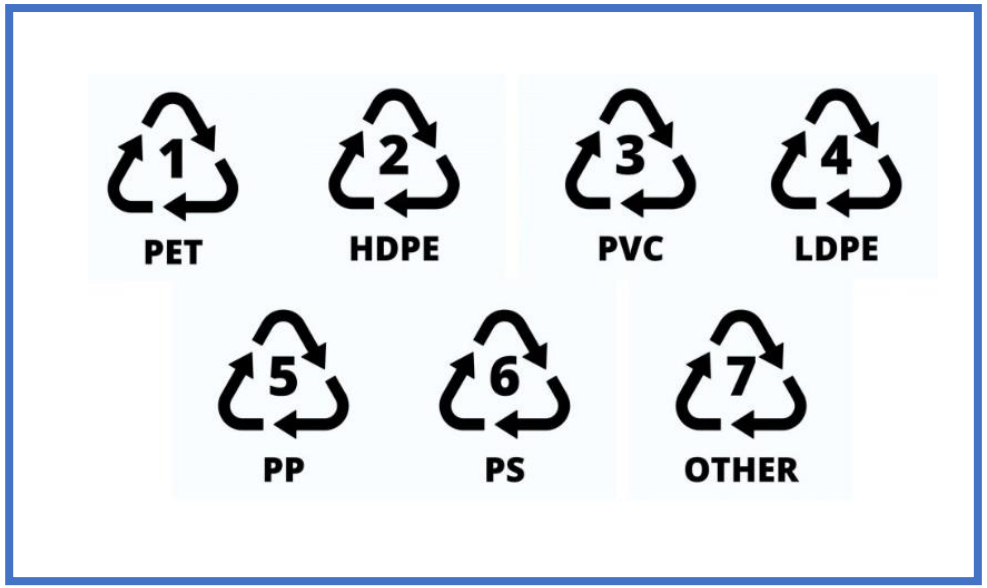
>5mm
1–5mm
300µm
<100µm

MICROPLASTICS OVERVIEW

- Small plastic particles in the size range of 1 µm to 5 mm

- Come in all shapes and sizes – fragments, fibers, spheres, films, etc.
  - *Government of Canada. https://www.dfo-mpo.gc.ca/science/environmental-environnement/microplastics-microplastiques/index-eng.html*

- All types of microplastics have been found – Polypropylene, Polyethylene, Polyvinyl Chloride, rubber, etc.
  - *UN environment programme. Report: Microplastics*. **May 2019.**



PET: Polyethylene terephthalate **HDPE:** High-density polyethylene **PVC:** Polyvinyl chloride **LDPE:** low density polyethylene **PP:** Polypropylene **PS:** Polystyrene

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DISTRIBUTION OF MICROPLASTICS

- Microplastics are found to be ubiquitous throughout the world

- Found to be present in all oceans, lakes, rivers, soils, atmosphere, and many organisms, including humans
  - *A review on the occurrence, distribution, characteristics, and analysis methods of microplastic pollution in ecosystems.* ***2021****.*
  - *Freshwater Microplastics.* ***2018****.*
  - *Microplastic Contamination in Freshwater Environments: A Review, Focusing on Interactions with Sediments and Benthic Organisms.* ***2020****.*
  - *Discovery and Quantification of Plastic Particle Pollution in Human Blood.* ***2022****.*

The Great North Saskatchewan River. Edmonton AB. **2022**. Photo by Sachin Pundir

- Present in consumer products and drinking water
  - *Microplastic contamination of drinking water: A systematic review.* ***2020.***
  - *Occurrence of Microplastics in Tap and Bottled Water: Current Knowledge.* ***2022.***

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MICROPLASTICS SOURCES

Degradation and fragmentation of plastics

- *Microplastic Contamination in Aquatic Environments.* ***2018****.*

Laundry can cause the shedding of microfibers

- *Microfiber Masses Recovered from Conventional Machine Washing of New or Aged Garments..* ***2016.***

Wastewater treatment plants discharge and storm water runoff

- *Microplastics in Wastewater Treatment Plants: Sources, Properties, Removal Efficiency, Removal Mechanisms, and Interactions with Pollutants.* ***2023.***
- *Microplastics in Urban and Highway Stormwater Retention Ponds.* ***2019****.*

Tire and road wear particles

- *Environmental Risks of Car Tire Microplastics Particles and Other Road Runoff Pollutants.* ***2021.***

Accidental discharge

- *The Unaccountability Case of Plastic Pellet Pollution.* ***2018.***

Plastic Litter

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MICROPLASTIC RESEARCH AT NAIT

- Began work in 2020 in collaboration with Heartland Polymers, through **PRIA** (*Plastics Research in Action*), in partnership with Dow Canada

- **Goal:** To develop, adapt, and apply methodology to sample, isolate, and analyze microplastics in the North Saskatchewan River (NSR) within the Edmonton Municipal region (EMR)

  1. Advance methodology in a practical way
  2. Improving precision and accuracy
  3. Develop a robust baseline of microplastic concentrations within the EMR

NSERC CRSNG

Mitacs

DOW®

heartland polymers

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NEEDLE IN A HAYSTACK

- Microplastics exist within a mixture of microparticles within the environment
- They are elusive and challenging to measure. A strategic approach is necessary
- A standardized approach is best

Scenic Plains

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STRATEGIC AND HIGH THROUGHPUT APPROACH

- The project team has made significant progress in method development, enhancing their robustness and applicability to the NSR and improving our understanding of microplastics in the region.

1. Sampling

2. Laboratory Isolation

3. Identification and Quantification

icons created by Freepik - Flaticon

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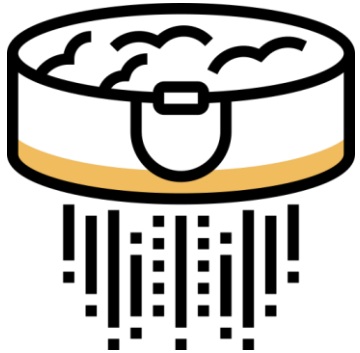
MICROPLASTIC SAMPLING OPTIONS

- Selecting the appropriate sampling technique is critical in ensuring a robust and representative approach

1. Grab Method

2. Net Method

3. Pump & Sieve Method



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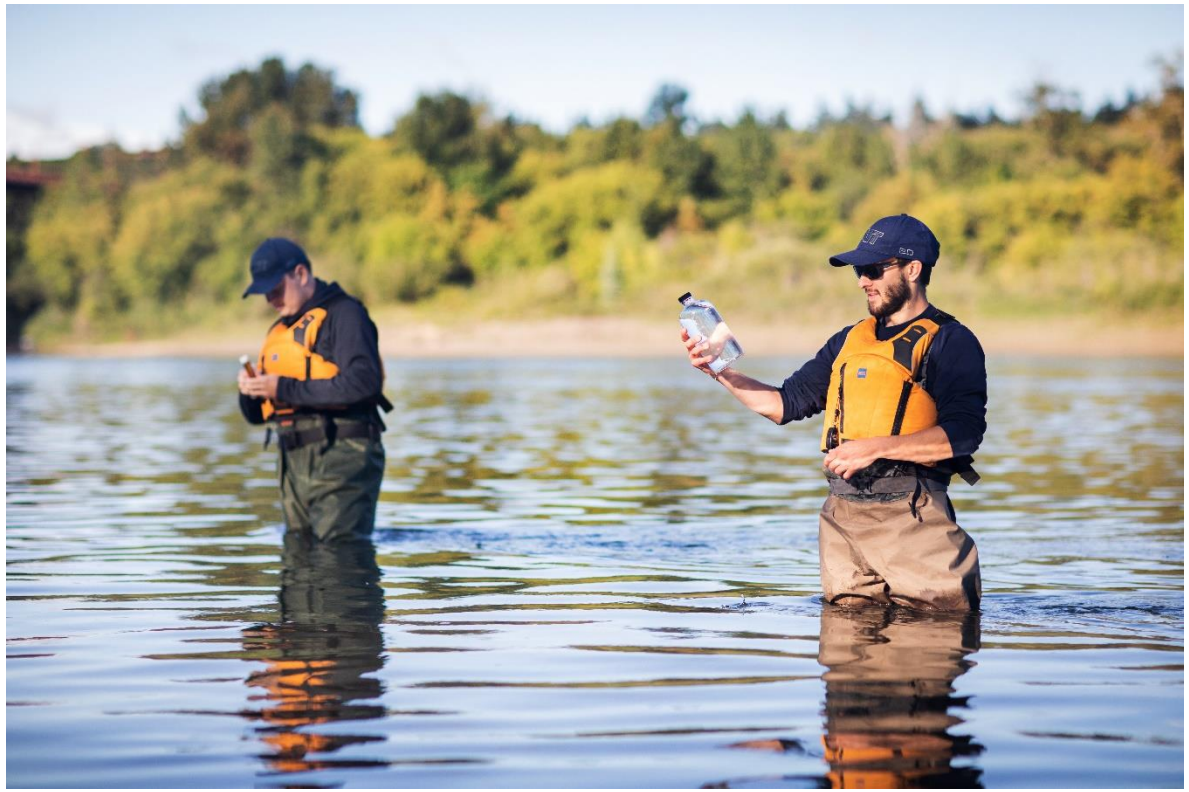
MICROPLASTIC SAMPLING OPTIONS



Left to Right. Patric McGlashan & Jeremiah Bryksa, Water Sampling. ***2020.*** *Photo by Leigh Kovesy*

Grab Sampling

- Simple and straight forward method to collect environmental samples for laboratory analysis
- Commonly used for water chemistry analysis
- Low sample volume can limit ability to detect microplastics

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MICROPLASTIC SAMPLING OPTIONS

Microplastic Abundance in Volga River: Results of a Pilot Study in Summer 2020. ***2020.***

Nets or Mantra Trawls

- Commonly used in microplastic marine studies
- Large volume samples
- Can be static or towed
- Mesh size can be limiting
- Can rip, tear, or clog in fast moving water with high suspended solids

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MICROPLASTIC SAMPLING OPTIONS

Pumping Method

- Use a series of sieves with different mesh sizes to filter particles from the river
- Large volumes of water to be sampled with minimal clogging
- Standardized method, published 2020

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RIVER BEAUTY

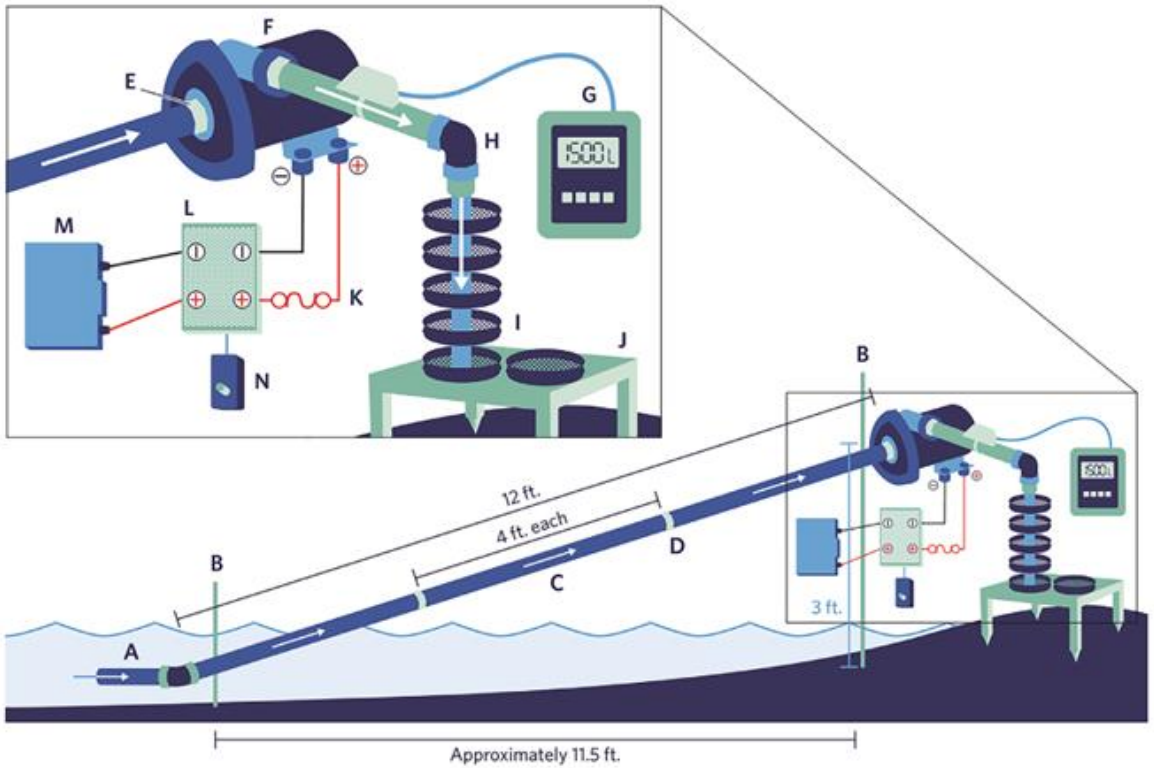

Fig. 1. Freshwater pumping system designed and fabricated in this work. **A** = river inlet $\frac{3}{4}$-inch stainless steel tube; **B** = metal clamps with stands; **C** = 4-foot $\frac{3}{4}$-inch stainless steel tubing sections; **D** = compression fittings; **E** = $\frac{3}{4}$-inch national pipe thread (NPT) fittings; **F** = centrifugal pump; **G** = clamp-on doppler flow sensor (optional); **H** = sample outlet (90° bend) $\frac{3}{4}$-inch stainless steel tubing; **I** = cascade sieve stack with field blank; **J** = aluminum sieve table with mounting spikes; **K** = 10 A fuse; **L** = variable speed controller; **M** = 12 V DC battery; and **N** = speed controller knob.

High throughput application of ASTM D8332: Detailed prototype design and operating conditions for microplastic sampling of riverine systems. ***2024***

- Plastic free, battery powered, portable sampling system
- Capable of pumping large volumes of water
- Very practical for challenging water matrixes (NSR)
- One of the first teams so demonstrate a practical application of **ASTM D8332** in freshwater

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LABORATORY ISOLATION

- Within the laboratory, we must concentrate our target analyte (microplastics) by isolating them from other microparticles and removing as much excess background as possible

1. Separation

2. Digestion

3. Deposition

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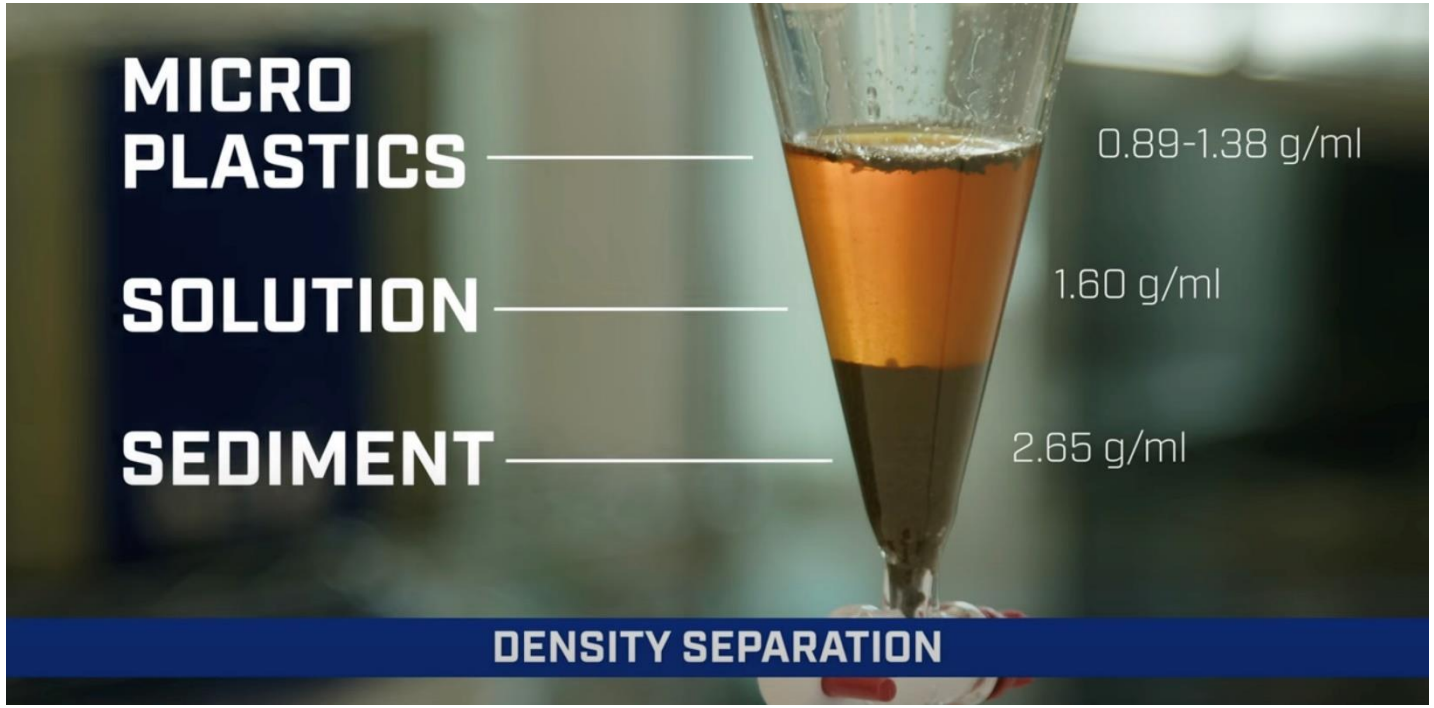
SEPARATION BASED ON PHYSICAL PROPERTIES



- Utilize saturated **Sodium Iodide (NaI)** to separate & remove inorganic material
- Removes the majority of non-analyte microparticles

Microplastics in the North Saskatchewan River. The Challenge of Finding Microneedles in a Haystack. ***2023.*** *https://www.youtube.com/watch?v=KqrZwpJ0fYA*

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CHEMICAL AND BIOLOGICAL DIGESTION

Microplastics in the North Saskatchewan River. The Challenge of Finding Microneedles in a Haystack. ***2023.*** *https://www.youtube.com/watch?v=KqrZwpJ0fYA*

Peroxide Oxidation (Fenton reaction)

- Removes Natural Organic Material (NOM)

Biological Digestion (Ammonium Hydroxide)

- Removes Cellulose

Enzymatic Digestion

- Removes lipids and proteins

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DEPOSITION ONTO 2-DIMENSIONAL SURFACE

NAIT Single Drop Deposition Technique. ***2024.*** *Photo by Sachin Pundir*

- Particles are dispersed on a 2-dimensional laser reflective microscope slide
- Challenging step
- Can be completed at NAIT or Dow
- At NAIT, we use ethanol and a swing bucket centrifuge to pelletize and transfer microparticles

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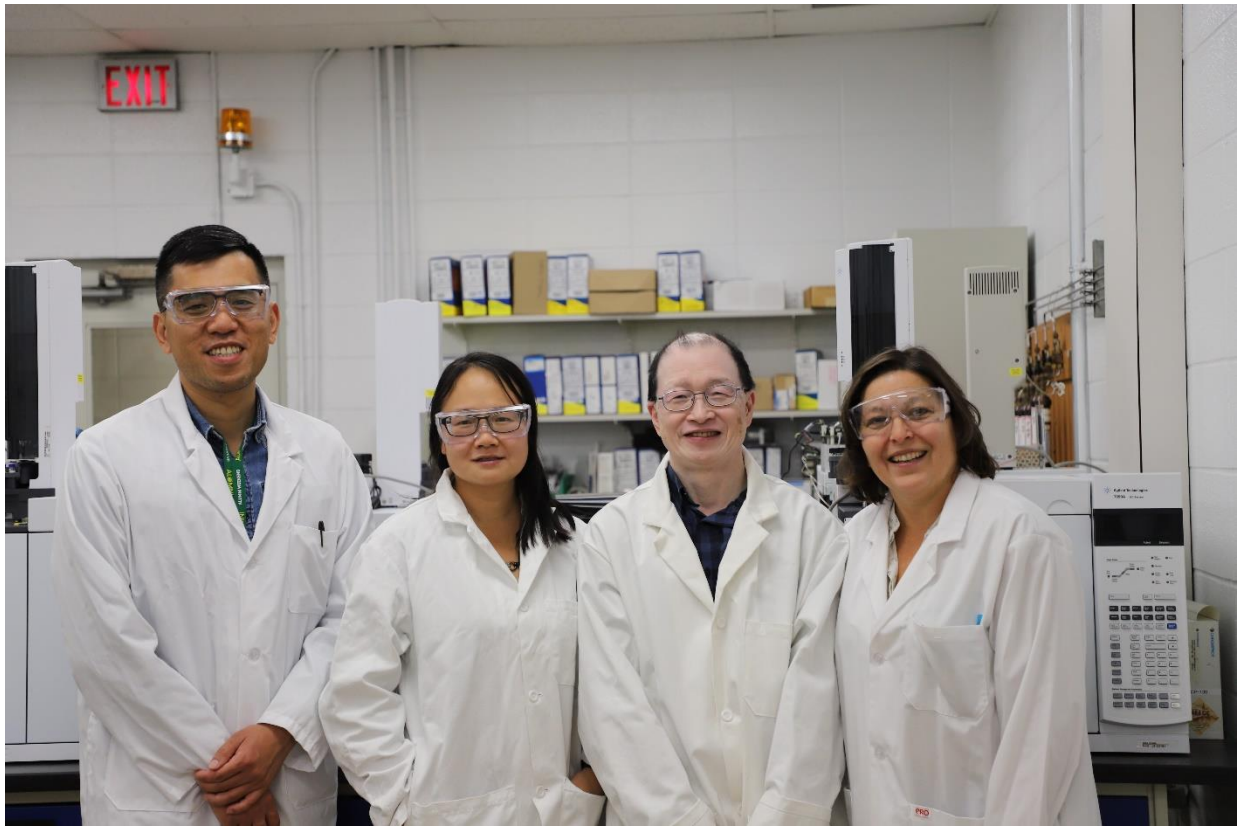
DOW FORT SASKATCHEWAN R&D TEAM



Left to Right. Dr. Guangyu Liu, Dr. Yujuan Hua, Dr. Jim Luong, Dr. Ronda Gras.
Photo provided by Dow

- Partnering with Dow to deliver advanced analysis of microplastics using Laser Direct Infrared Imaging System (LDIR)
- LDIR offers advanced analytical measurement capabilities such as particle size, particle shape, and chemical composition of the particles with high throughput
- Dow is a leader in measurement science

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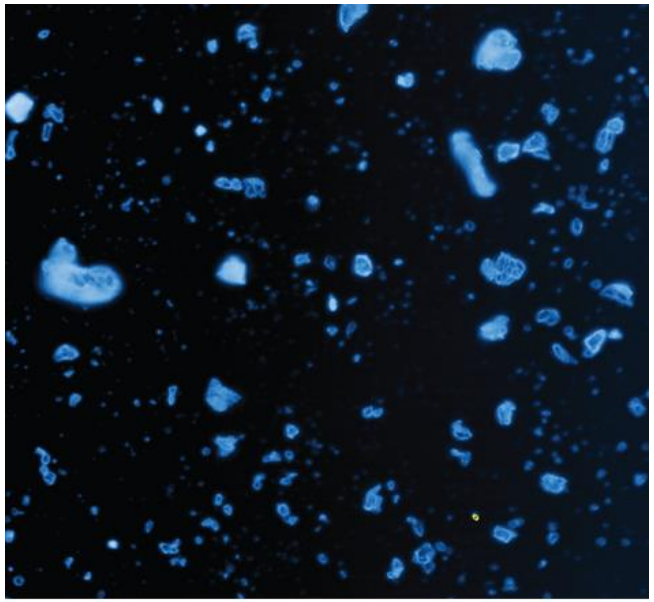
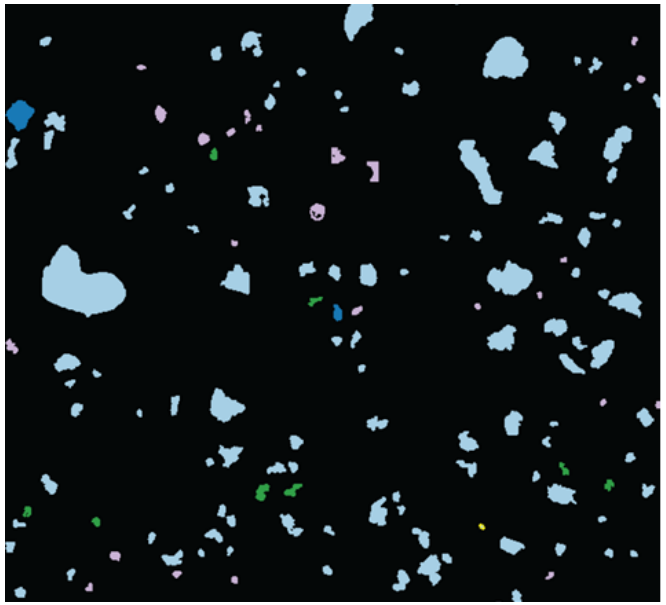
LDIR CHEMICAL IMAGING SPECTROSCOPY





- Utilize a Quantum Cascade Laser (QCL) source to perform particle-by-particle **high throughput** analysis to identify microplastics from other microparticles
- Engineered materials (like plastics) have a distinctive chemical profile when they interact with infrared (IR) light, which can be detected using vibrational spectroscopy
- The deployment of the 8700 LDIR represents the **first in Canada** and is a **corner stone** for project success due to its advanced capabilities

Characterization of Microplastics in Environmental Samples by Laser Direct Infrared Imaging and User-Generated Libraries. ***2022****.*

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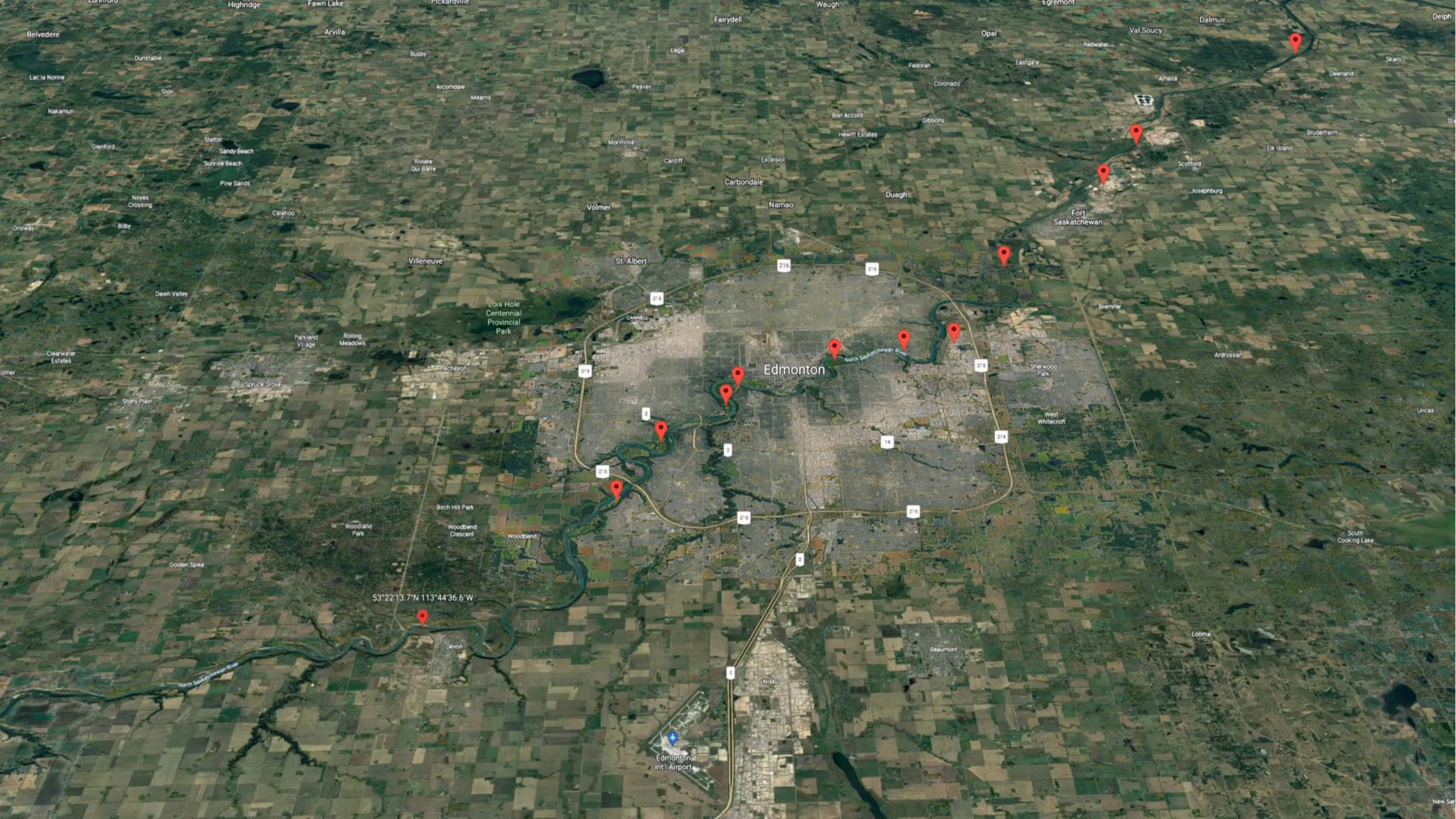
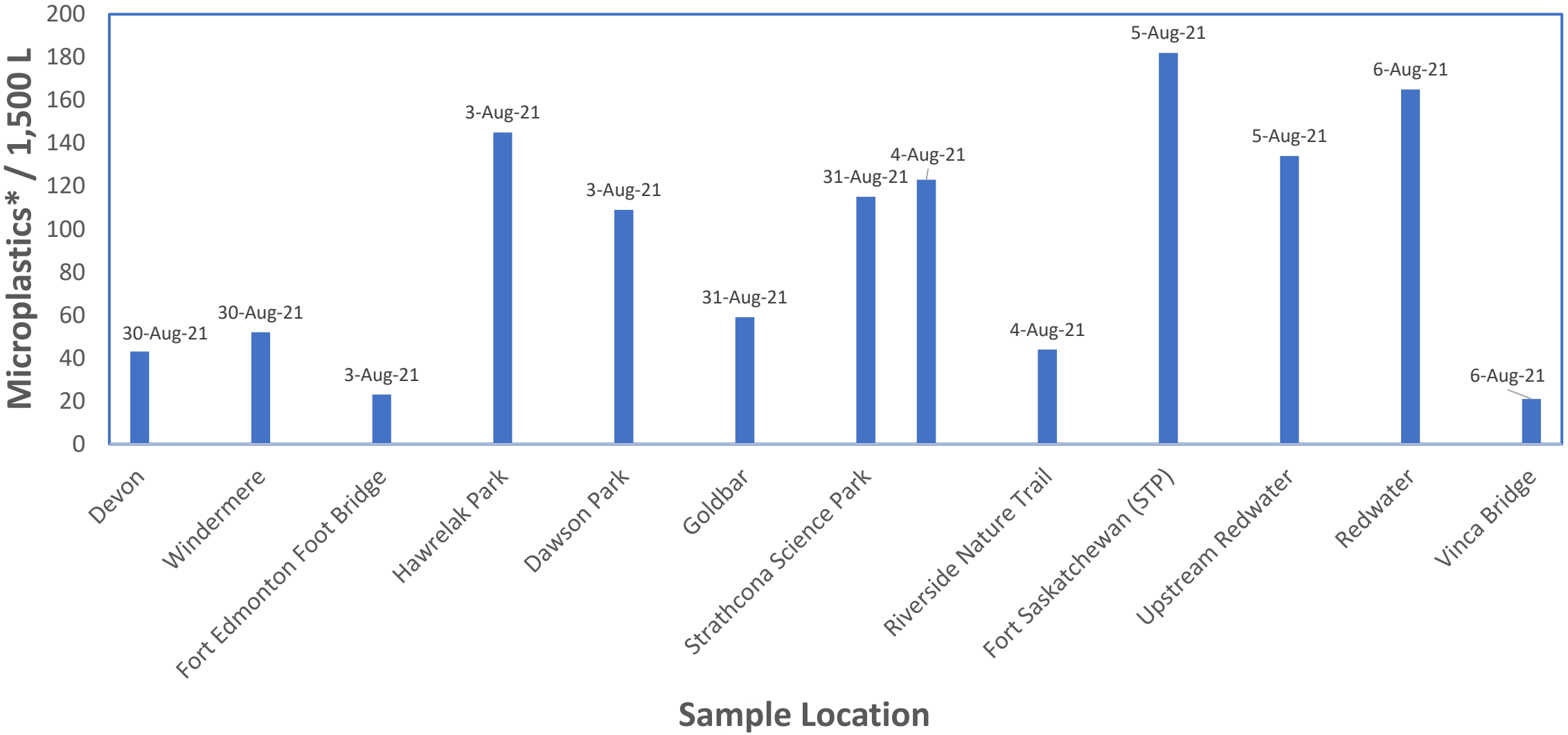

Edmonton
St. Albert
Fort Saskatchewan
Villeneuve
Lois Hole Centennial Provincial Park
Edmonton Int'l Airport
53°22'13.7"N 113°44'36.6"W
North Saskatchewan River
Devon
Stony Plain
Spruce Grove
Acheson
Beaumont
Sherwood Park
Ardrossan
Carbondale
Namao
Volmer
Duagh
Bremner
Scotford
Josephburg
Elk Island
Bruderheim
Deerland
Val Soucy
Dalmuir
Opal
Fairydell
Waugh
Egremont
Belvedere
Arvilla
Fawn Lake
Highridge
Lac la Nonne
Dunstable
Busby
Legal
Peavey
Aicomdale
Mearns
Sion
Nakamun
Glenford
Stettin
Sandy Beach
Sunrise Beach
Pine Sands
Noyes Crossing
Onoway
Bilby
Calahoo
Dawn Valley
Clearwater Estates
Parkland Village
Rolling Meadows
Birch Hill Park
Woodland Park
Woodbend Crescent
Woodbend
Golden Spike
Looma
South Cooking Lake
Uncas
West Whitecroft
Nisku
Cardiff
Morinville
Rivière Qui Barre
Excelsior
Hewitt Estates
Bon Accord
Gibbons
Fedorah
Coronado
Eastgate
Redwater
Ameila
Skaro
Delph
CANNELL

North Saskatchewan River Microplastic Quantitation - August 2021



* > 40 µm

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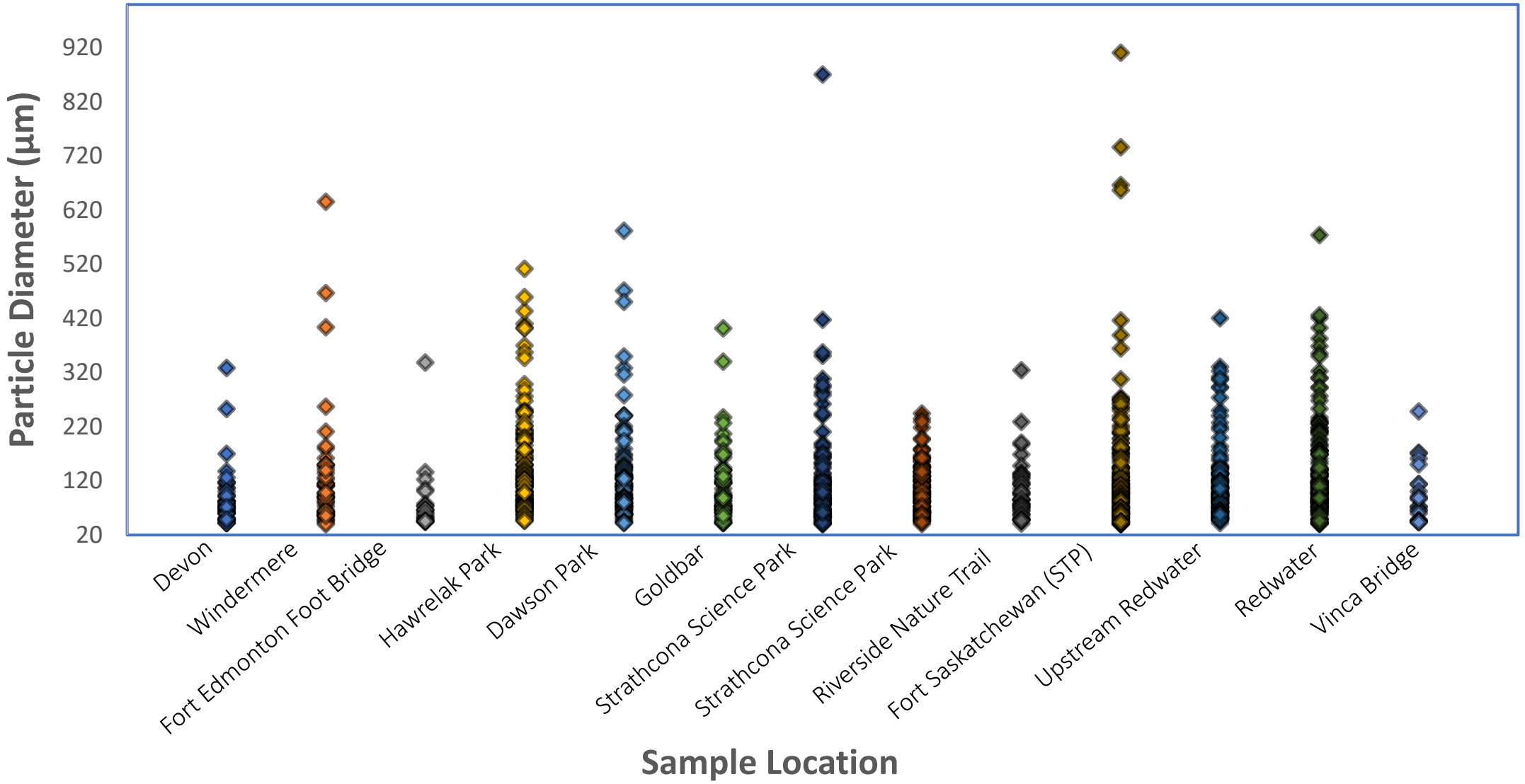
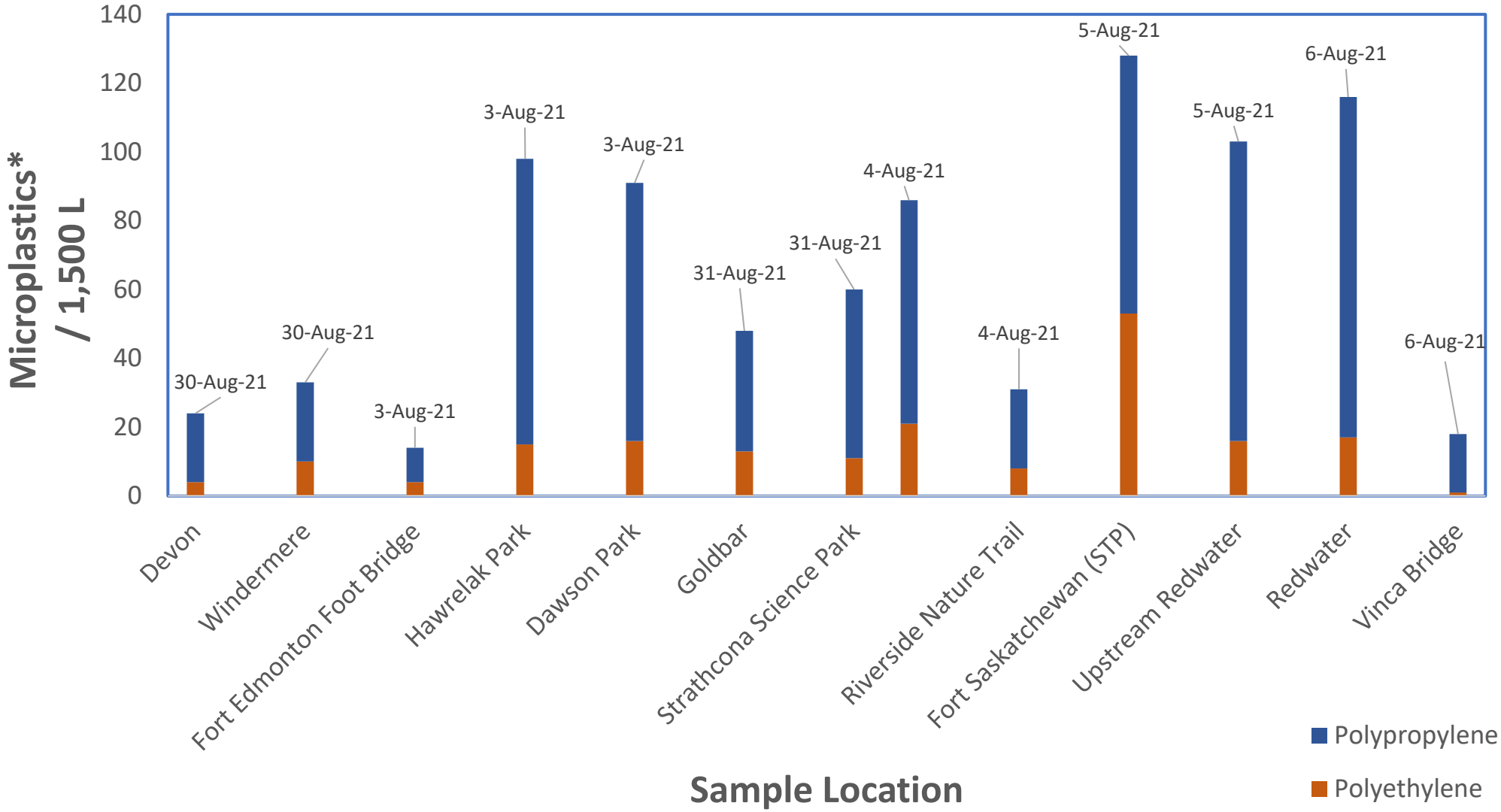
North Saskatchewan River Microplastic Quantitation - August 2021



North Saskatchewan River Polyolefins Quantitation - August 2021



* > 40 µm

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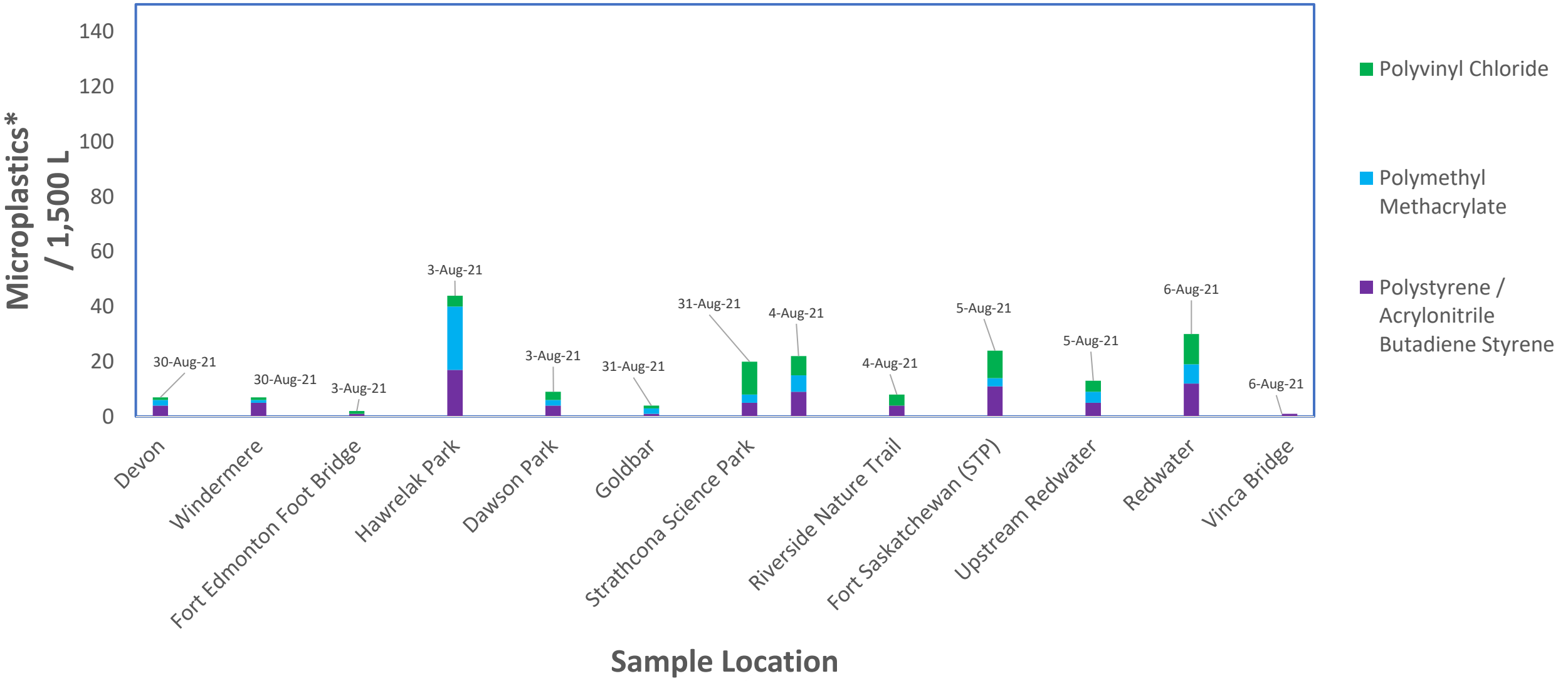
North Saskatchewan River Trace Microplastic Quantitation - August 2021



* > 40 µm

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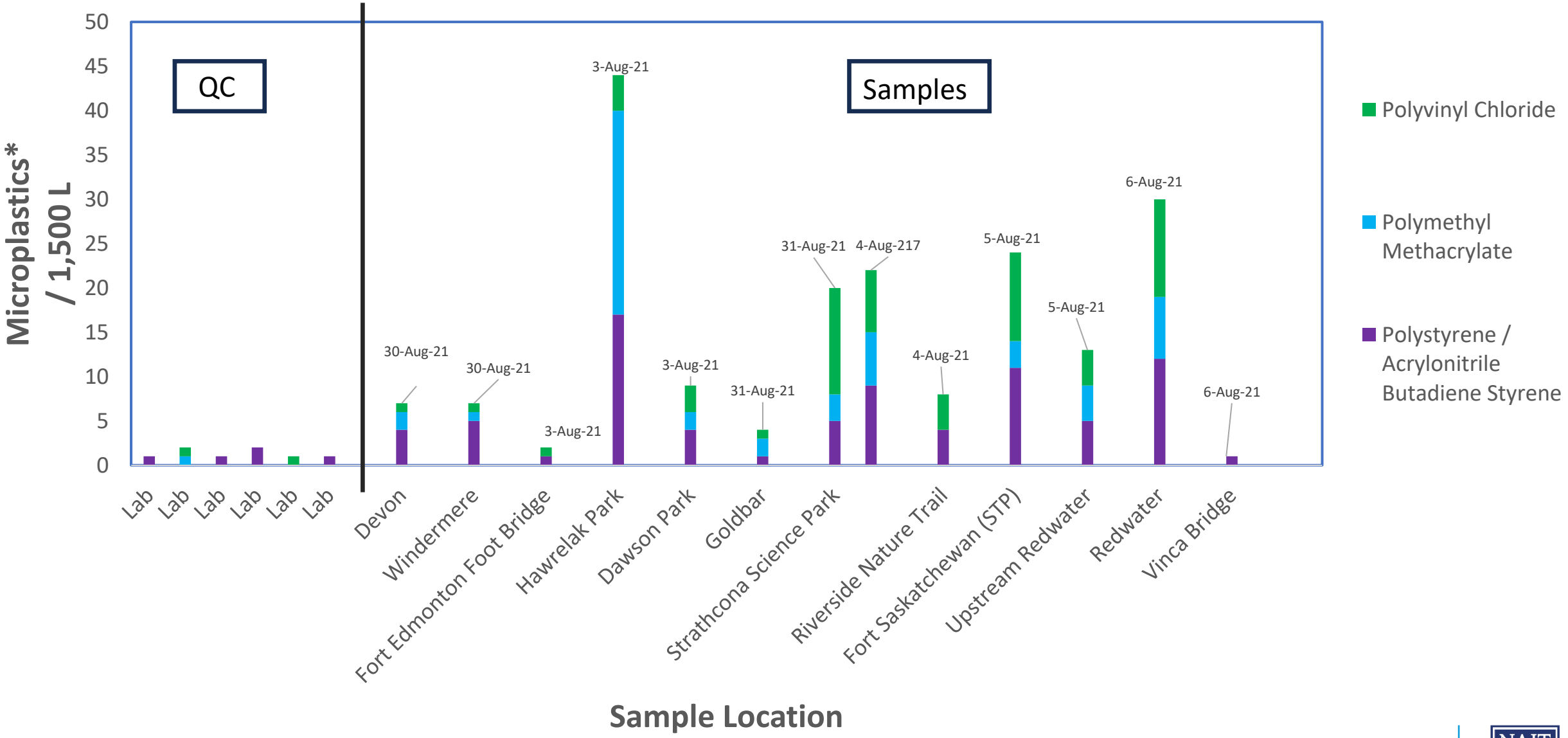
North Saskatchewan River Trace Microplastic Quantitation - August 2021



* > 40 µm

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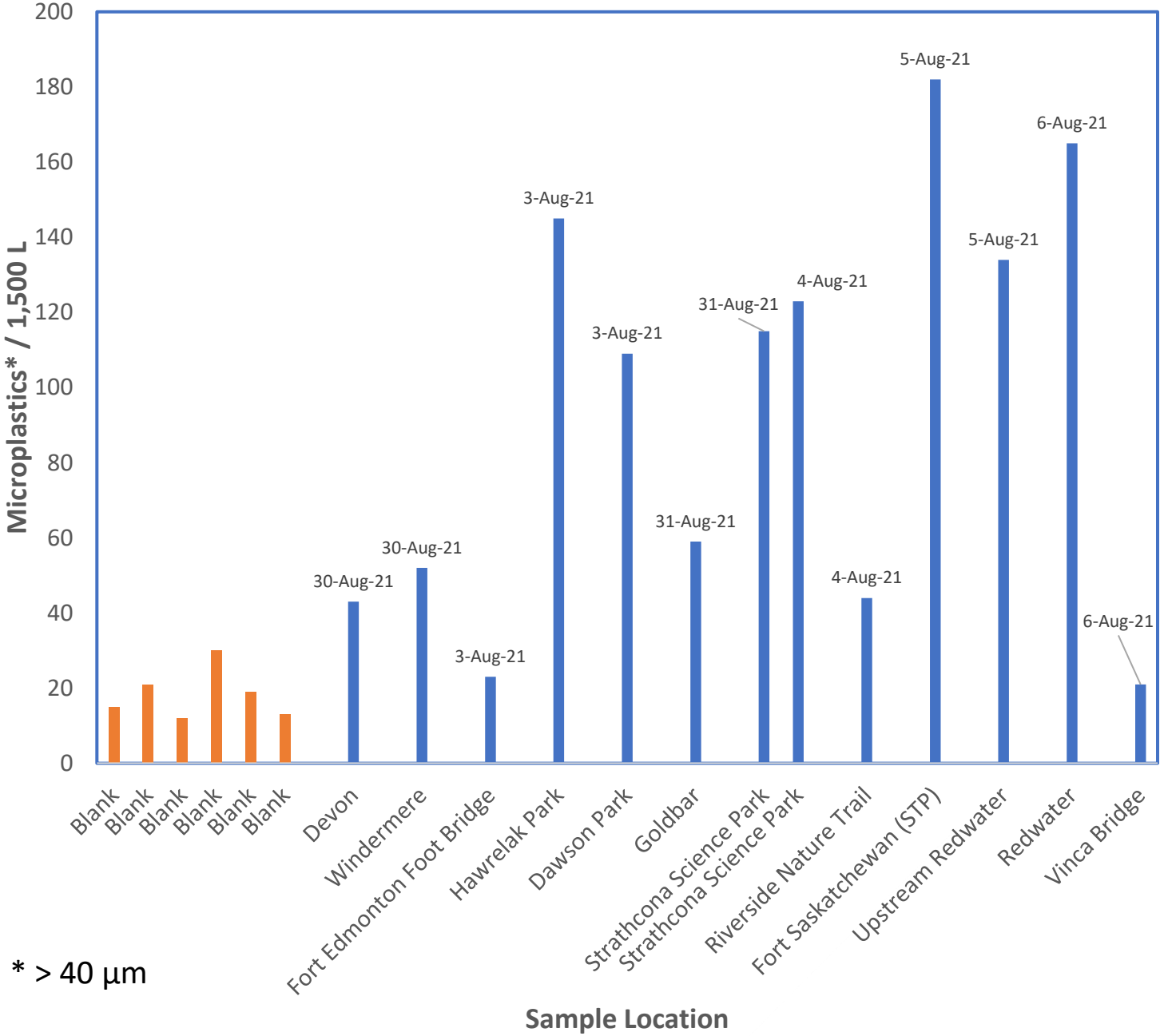
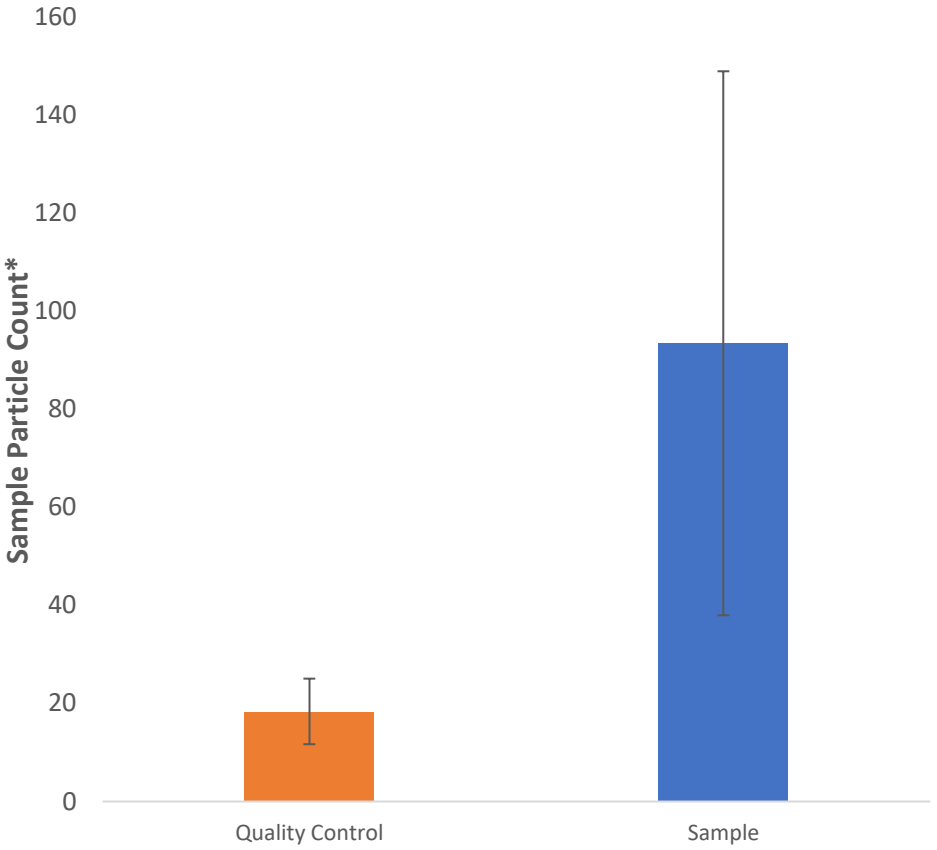
North Saskatchewan River Microplastic Quantitation - August 2021



* > 40 µm

Average Microplastic Quantitation Quality Control and Results



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CONCLUSIONS

- August 2021 sample results ranging from **21-182 microplastic particles per 1,500 L** (NSR)
  - NOTE: Depending on site location

- Average of **93 microplastics per 1,500 L** (n=13; 19,500L total)

- Average of **0.06 microplastics per L (>40 µm)**

- Approximately **70%** of the microplastics were **PP** + **PE**

- Trace plastics like **PS**, **ABS**, **PMMA** and **PVC** are each <10% of the sample composition (by particle number)

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FUTURE WORK

- Completion of study in 2025
- Peer reviewed publications:
  - Extraction Methodology
  - NSR Microplastic Results
- Continue collaboration with microplastic researchers to advance methodology, improving accuracy, precision and throughput
- Continue engagement with industry and government bodies to enhance microplastic research within Canada

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ACKNOWLEDGMENTS

- Heartland Polymers
- Dr. Jim Luong, Dr. Ronda Gras, and Dow Canada R&D Team
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- Centre for Sensors and System Integration at NAIT
- Students on project: Patric McGlashan, Nadia Stelck, Jon Wong, Aldo Fumagalli, Katrina Gonzales, Kailyn Gibbons, Divyanshu Chawla, Sachin Pundir, Danielle Charrois, LeeAnne Johnston, Hannah Prinsen

Questions?

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