

Mitigating Inputs of Tire Wear Toxins to Protect Salmonid Habitat on Vancouver Island

Community Watershed Monitoring Network Results Session Event

Nanoose Place

Nanoose Bay, B.C., July 9, 2024



Haley Tomlin, BC Conservation Foundation Aquatic Research & Restoration Centre

Photo: D. Swainson



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Mitacs



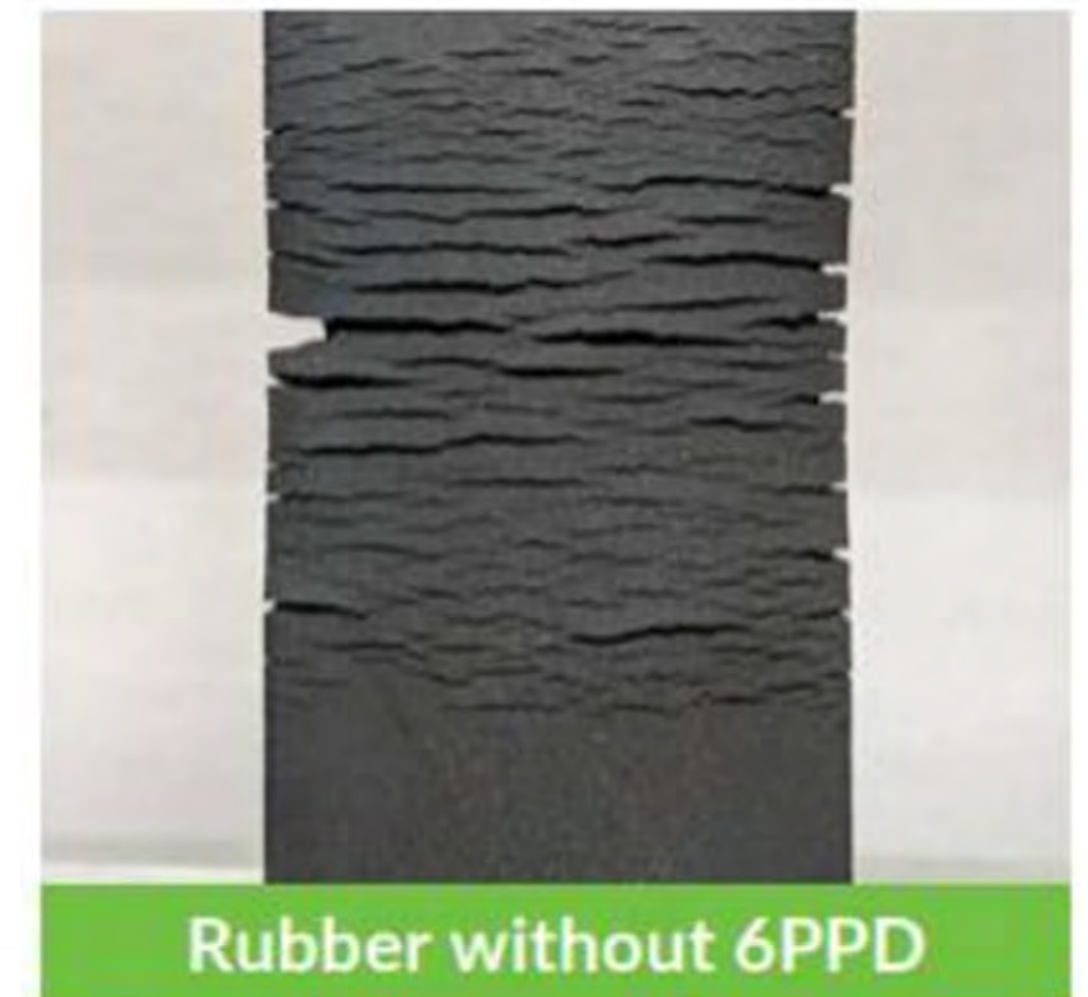
REGIONAL
DISTRICT
OF NANAIMO



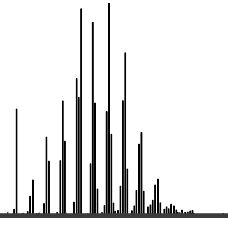
What is 6-PPD (The Parent Compound)?

6-PPD is a tire preservative that's been used since the mid-1960s, it:

- an antiozonant that makes up approximately 1-2% of all tires, by weight (~1lb per 100lbs of tire); and,
- as the tire wears away, more 6-PPD is exposed at the surface.



What is 6-PPDQ?



When exposed to ozone in atmosphere (oxidized), 6-PPD transforms into 6-PPD Quinone (6-PPDQ), which is the compound we're concerned about.

6-PPD

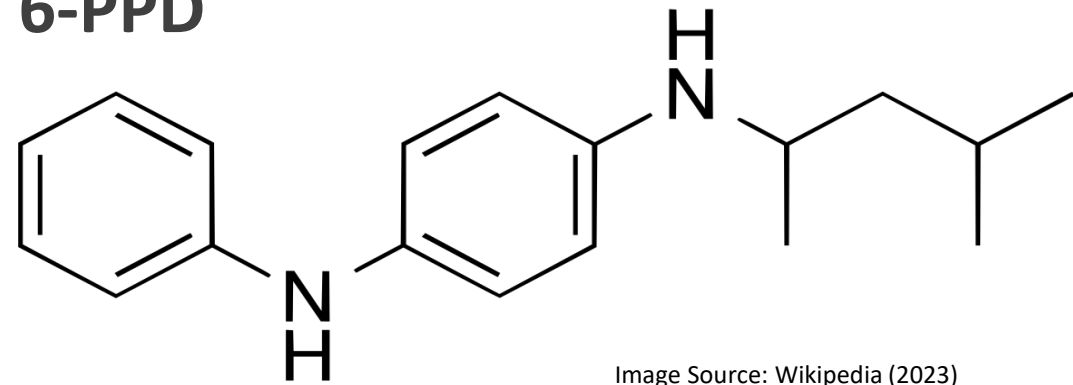


Image Source: Wikipedia (2023)

N-(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine



6-PPDQ

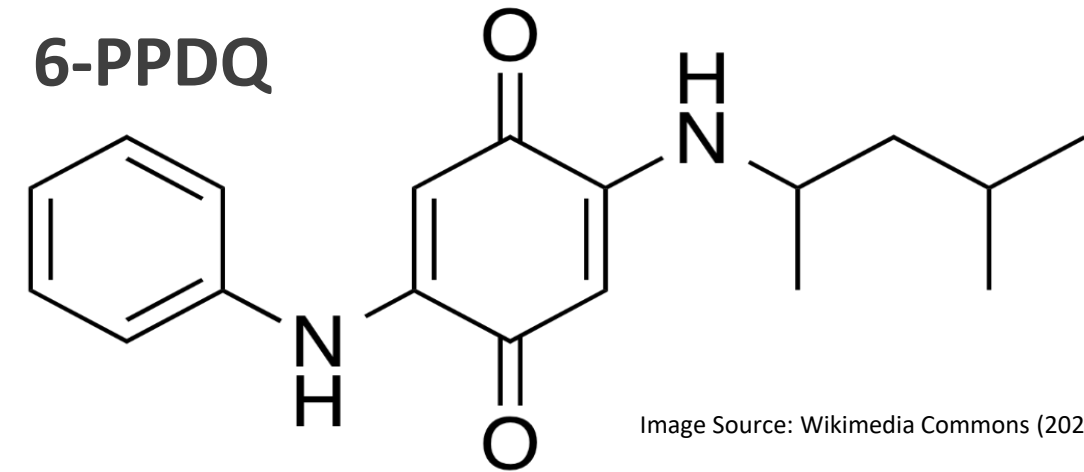


Image Source: Wikimedia Commons (2023)

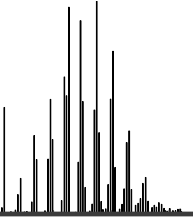
N-(1,3-dimethylbutyl)-N-phenyl-p-phenylenediamine-quinone

4

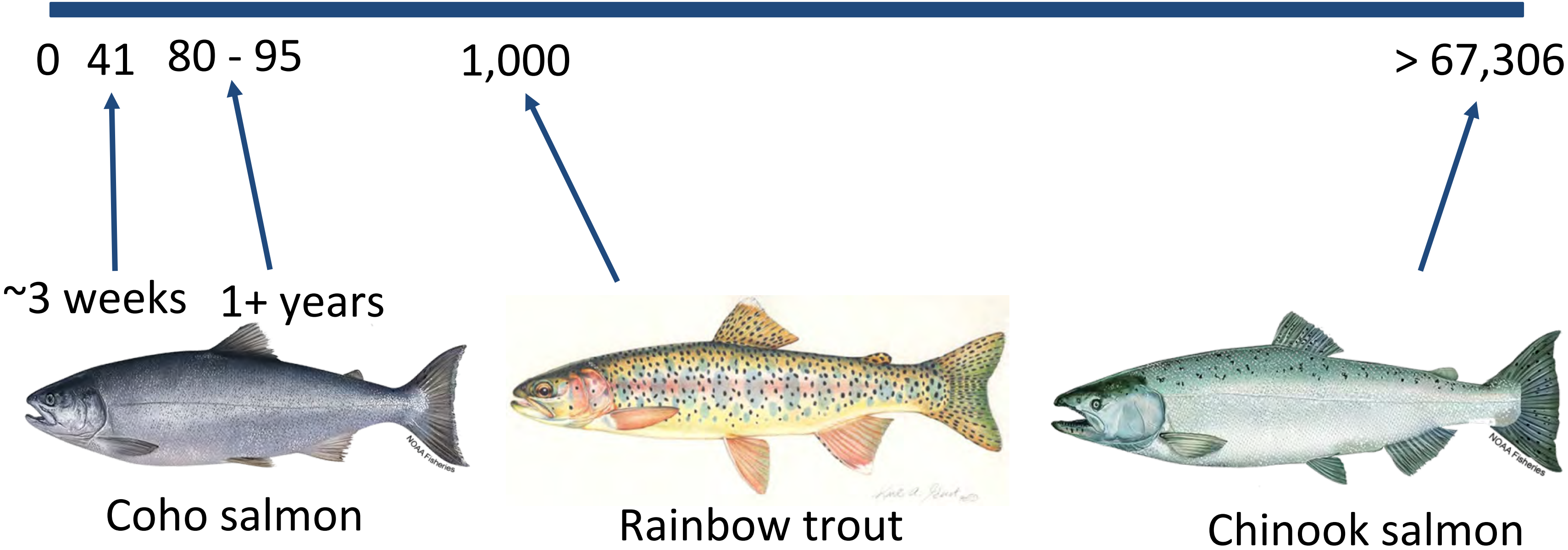
Discovered as the cause of 'urban runoff mortality syndrome' at sub-parts-per-trillion (ppt) levels in numerous fish species; first discovered in 2020.



Locally Impacted Fish Species



Lethal Concentration of 6-PPDQ (ng/L)



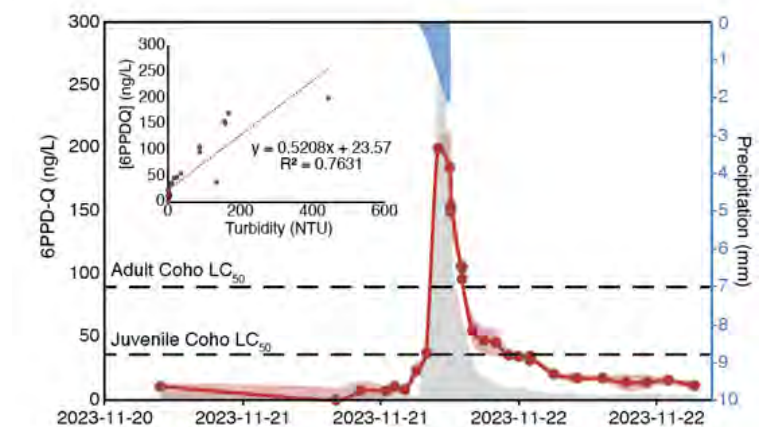
Mitigating Tire Wear Toxins to Protect Salmon

Project Objectives

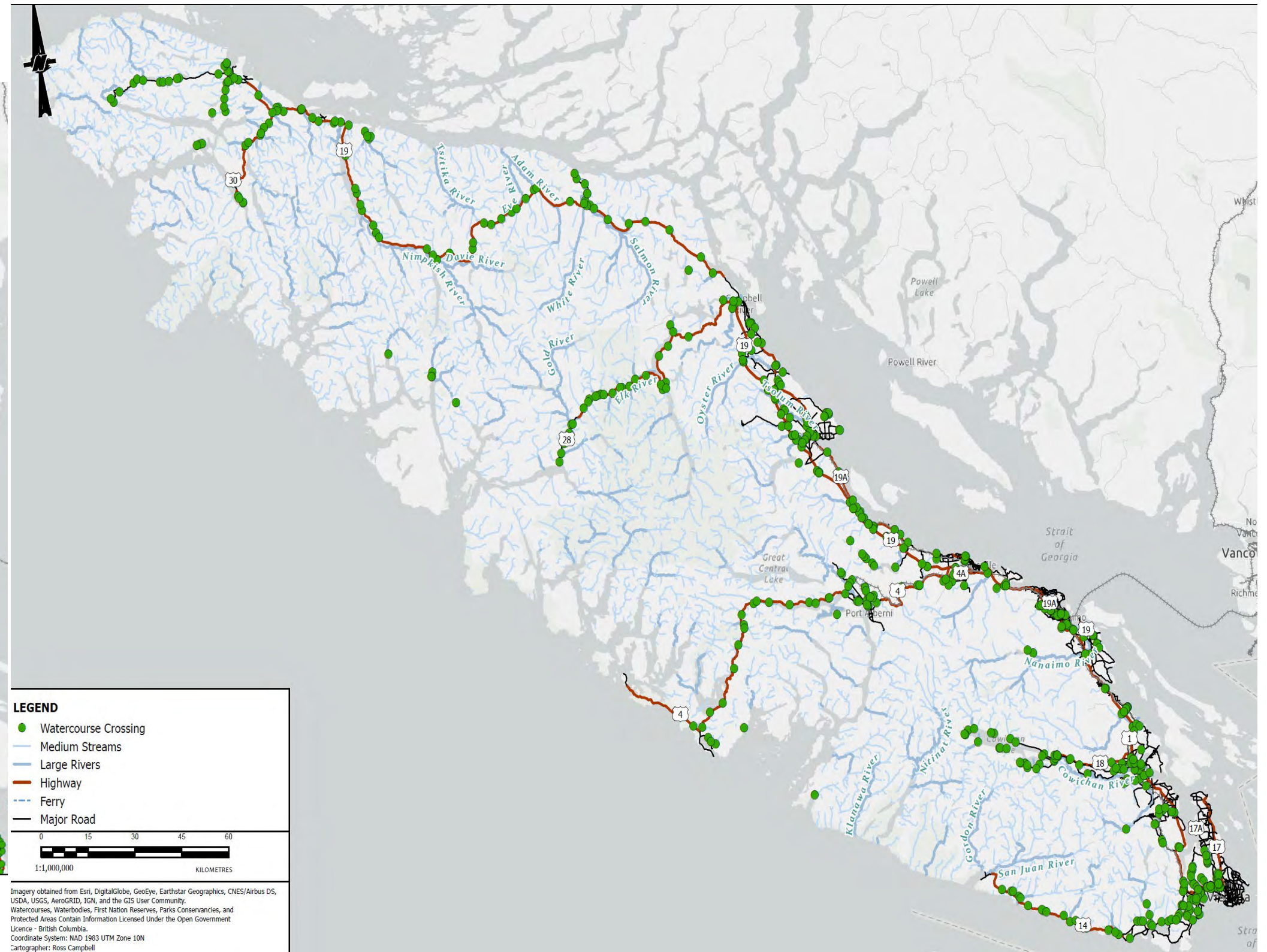
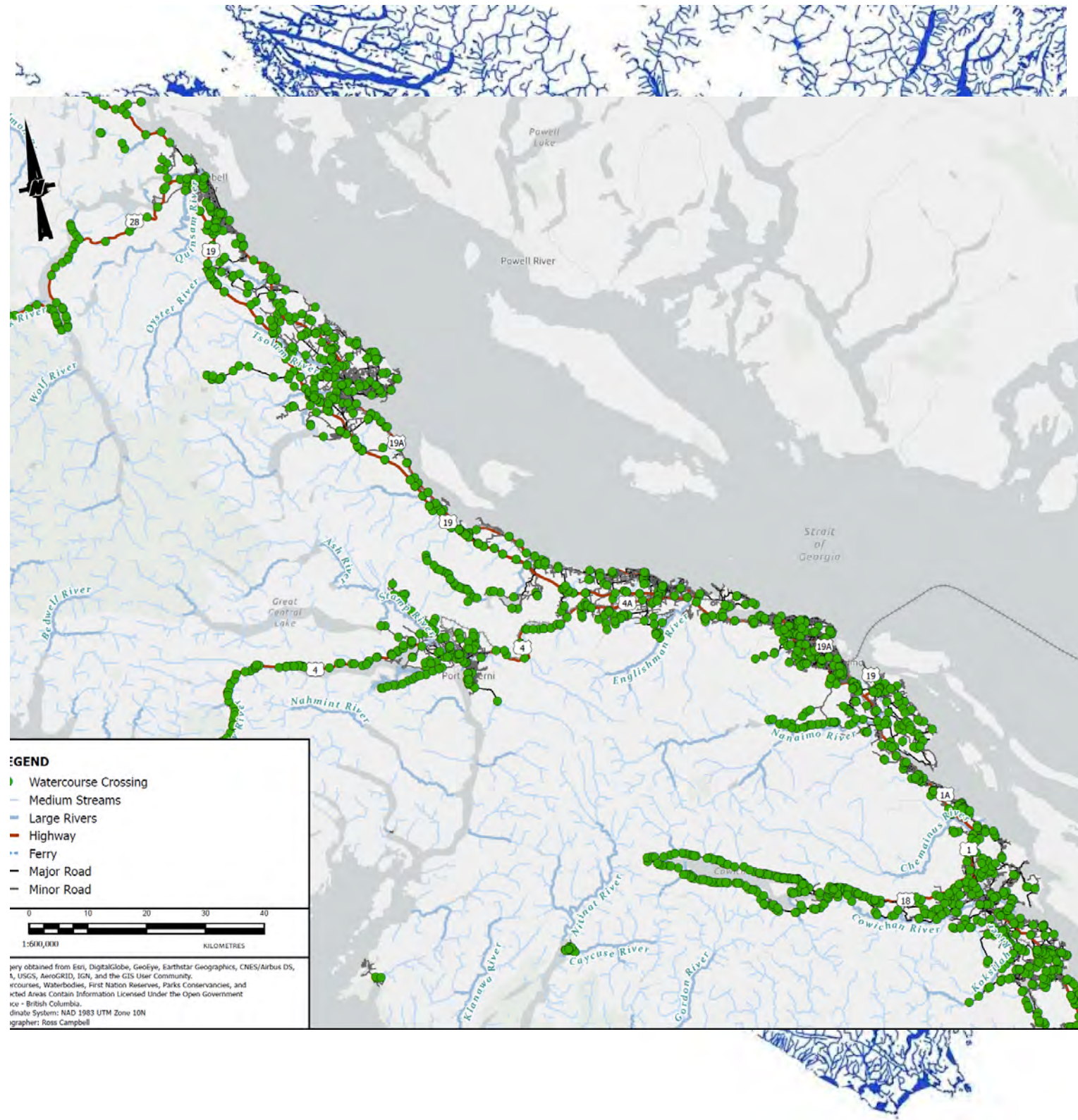
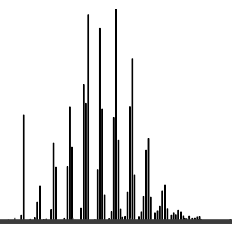
What and where are the major sources of tire wear toxins inputs on Vancouver Island?

How do concentrations change over time and space?

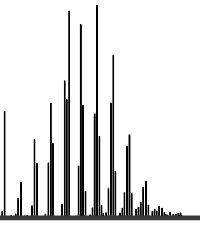
How can low-cost nature-based solutions protect urban streams from tire wear toxins?



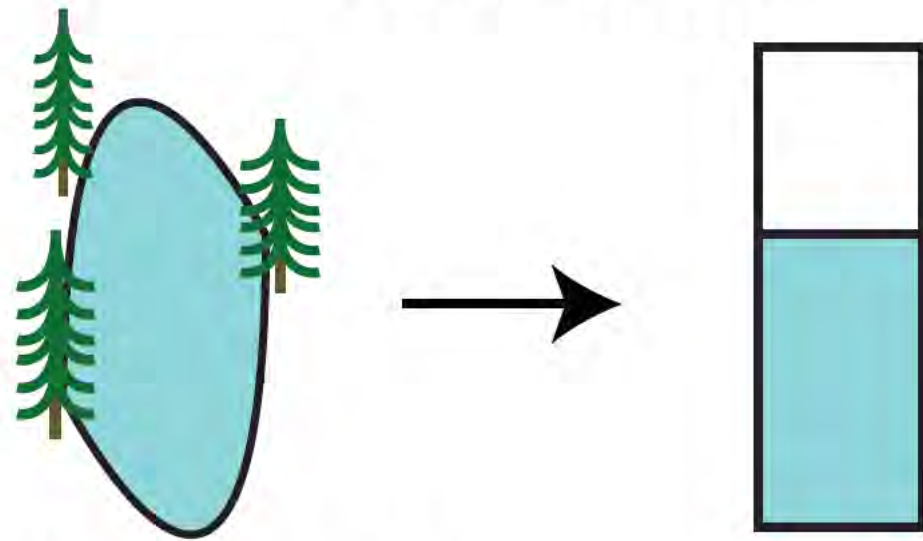
What and where are the major sources of tire wear toxins



Updates to Accommodate Large Sample Quantities

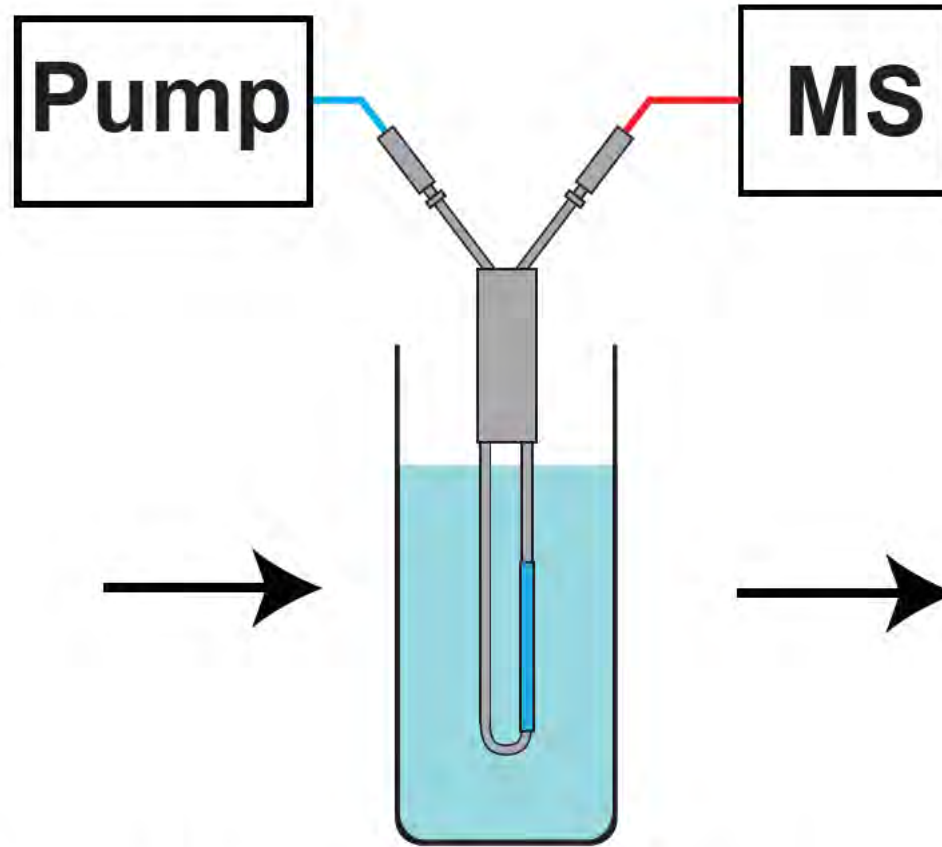


Sample Collection



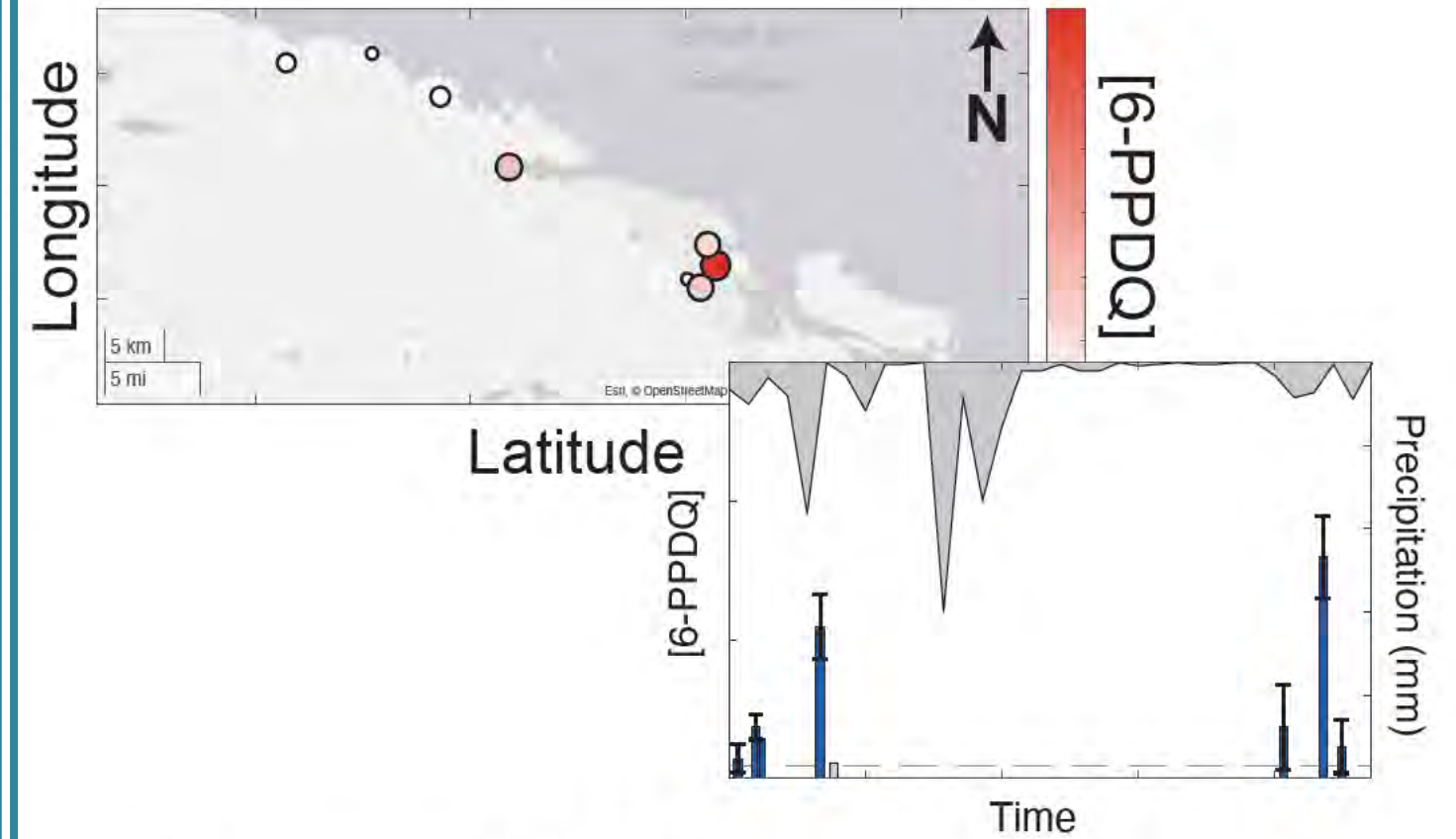
Environment

1



Intake & Analysis

2

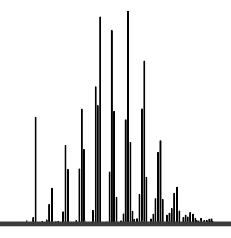


Workup & Interpretation

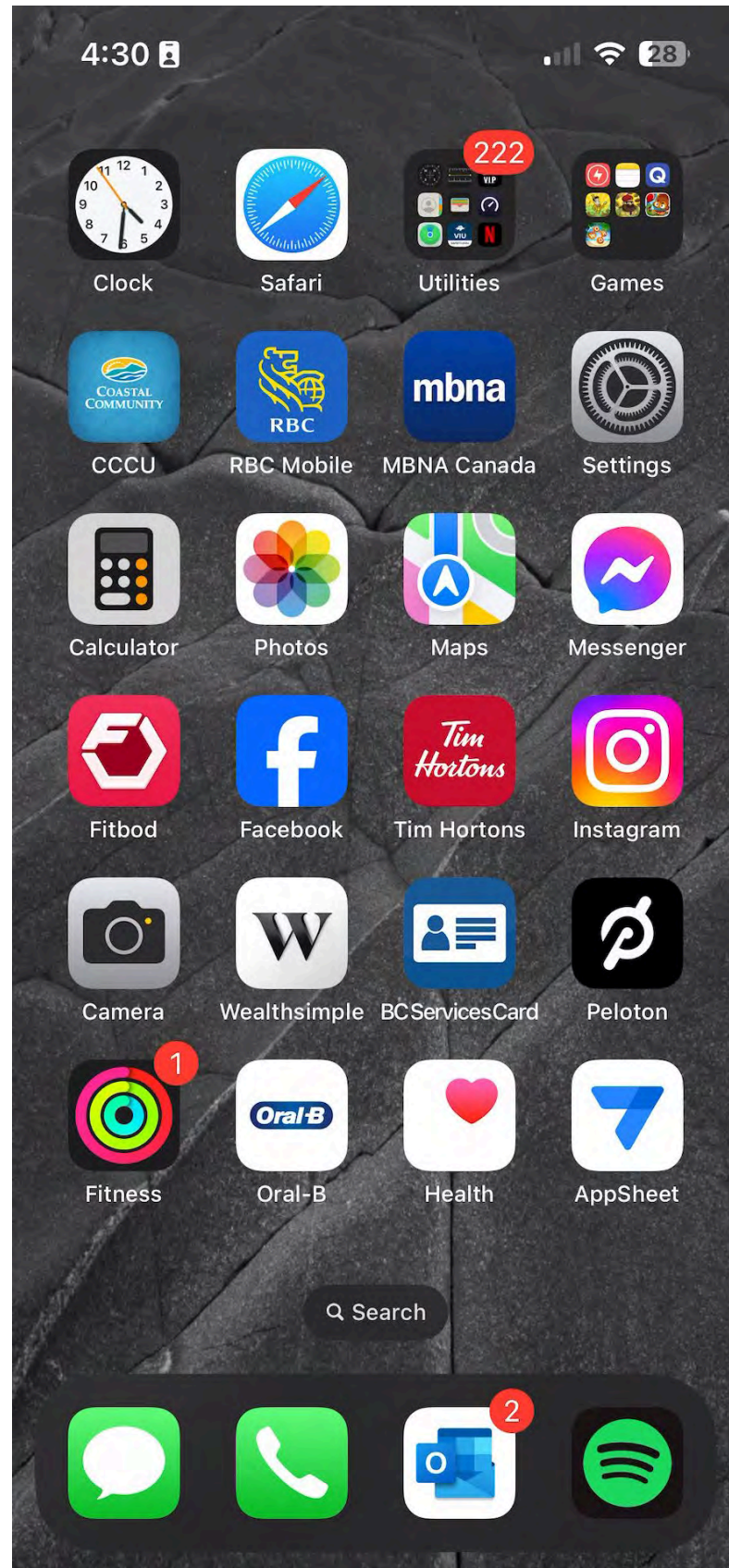
3



Sample Collection Smartphone App



QR-coded Sample Bottles



Public Form.xlsx

Home Insert Draw Page Layout Formulas Data Review View Automate Tell me

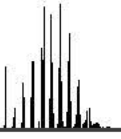
Open recovered workbooks? Your recent changes were saved. Do you want to continue working where you left off?

111 Sample Database_Images/JMHT_BetaTestSample_023.Site Photo.214959.jpg

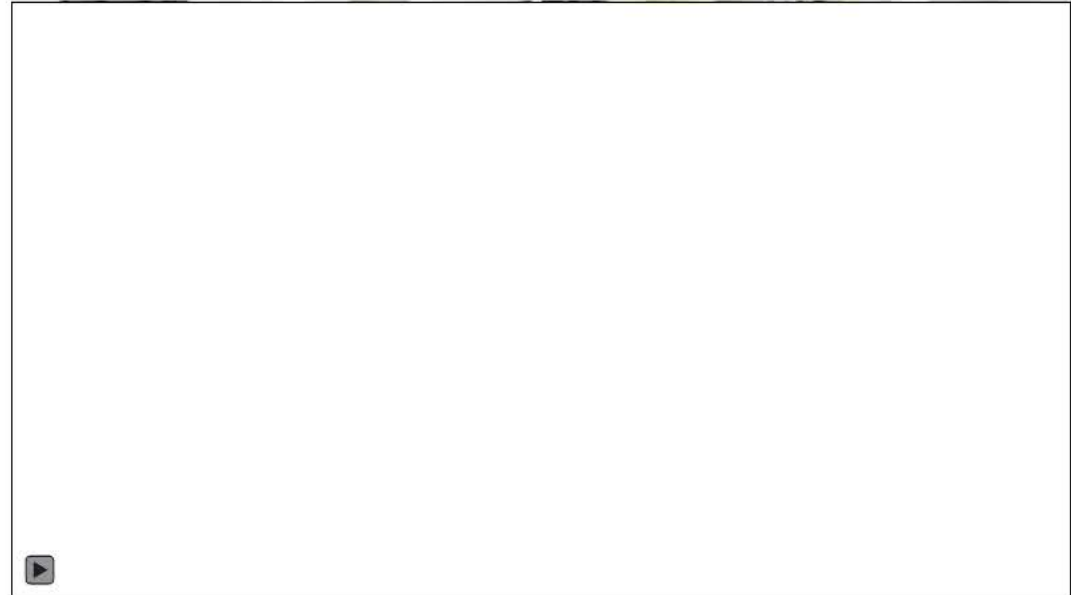
	A	B	C	D	E	F	G	H	I	J
1	Sample ID	Sample Kit	Sampler	Sample Type	Fish Visible?	Date Time	Location	Comments	Site Photo	Additional WQ?
2	JMHT_BetaTestSample_034	JMHT	JMHT	Other	No	7-17-2023 9:42:00	49.149909, -123.943501		Sample Database	TRUE
3	JMHT_BetaTestSample_037	JMHT	JMHT	Other	No	7-17-2023 9:48:00	49.149958, -123.943431		Sample Database	TRUE
4	JMHT_BetaTestSample_025	JMHT	JMHT	Other	No	7-17-2023 10:07:00	49.146645, -123.943861		Sample Database	TRUE
5	JMHT_BetaTestSample_026	JM_HT_July17	JMHT	Other	Unsure / NA	7-17-2023 10:23:00	49.150436, -123.952557		Sample Database	TRUE
6	JMHT_BetaTestSample_032	JM_HT_July17	JMHT	Other	Yes	7-17-2023 10:34:00	49.149950, -123.955623		Sample Database	TRUE
7	JMHT_BetaTestSample_027	JM HT	HT	Before	No	7-17-2023 9:52:00	49.150289, -123.943691		Sample Database	TRUE
8	JMHT_BetaTestSample_029	JM_HT_July17	JMHT	Other	No	7-17-2023 11:33:00	49.090772, -124.108531	Offline test	Sample Database	TRUE
9	JMHT_BetaTestSample_038	JM_HT_July17	JMHT	Other	No	7-17-2023 11:36:00	49.090747, -124.108522	Offline test	Sample Database	FALSE
10	JMHT_BetaTestSample_028	JM_HT_July17	JMHT	Other	No					FALSE
11	JMHT_BetaTestSample_023	HT - test	HT - test	During	No					FALSE
12	JMHT_BetaTestSample_040	Ravenswood dr	Chris J	Other	No					FALSE
13	JMHT_BetaTestSample_035	Ravenswood dr	Angelina Jaeger	Other	No					FALSE
14	Sample_BCCF_AERL_00001	Location_Cottle	HT	During	No					FALSE
15	Sample_BCCF_AERL_00002	Location_Depar	HT	During	No					FALSE
16	Sample_BCCF_AERL_00003	Location_North	HT	During	No					FALSE
17	Sample_BCCF_AERL_00004	Location_Millsto	HT	During	No					FALSE
18	Sample_BCCF_AERL_00005	Location_Cat S	HT	During	No					FALSE
19	Sample_BCCF_AERL_00006	Location_Chase	HT	During	No					FALSE
20	Sample_BCCF_AERL_Test	Location_Rosev	Shaun	During	No					FALSE
21	Sample_BCCF_AERL_Test_lise	Location_Wilfr	Lise	After	No					TRUE
22	Sample_BCCF_AERL_Test - HT	Location_Wilfr	Haley	Before	No					FALSE
23	Sample_BCCF_AERL_Test Test	Location_Wilfr	Ulrika	During	Yes					FALSE



Auto-sampling and Data Processing



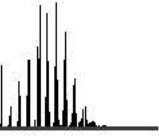
3D printer
\$400



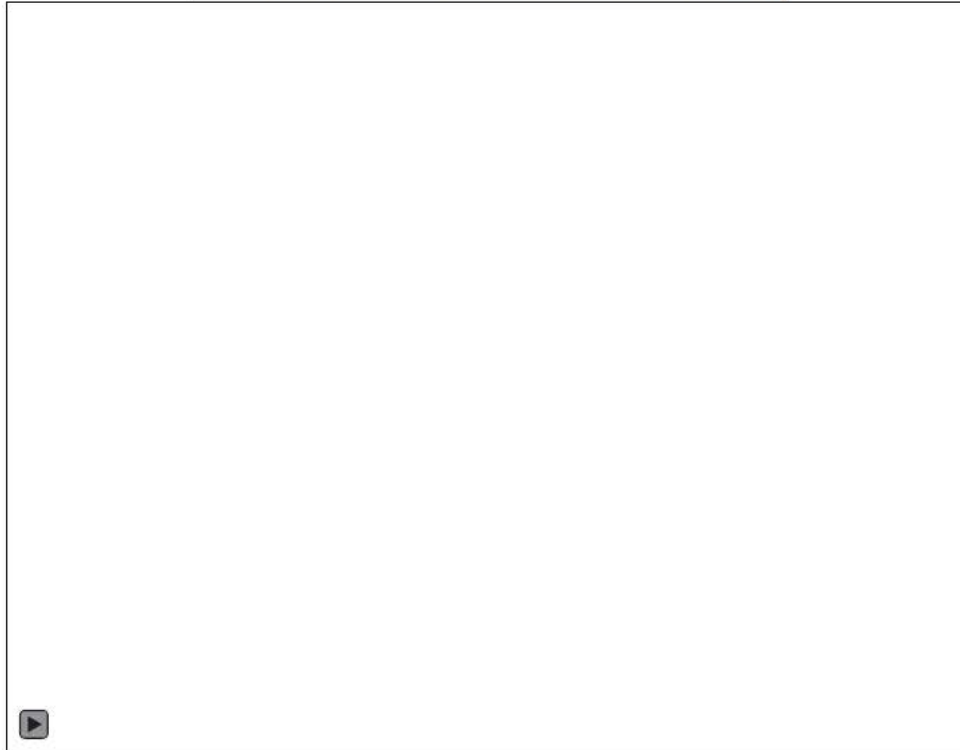
Precise xyz positioning
Stirring
Open source
Low cost!



Data Processing & Visualization



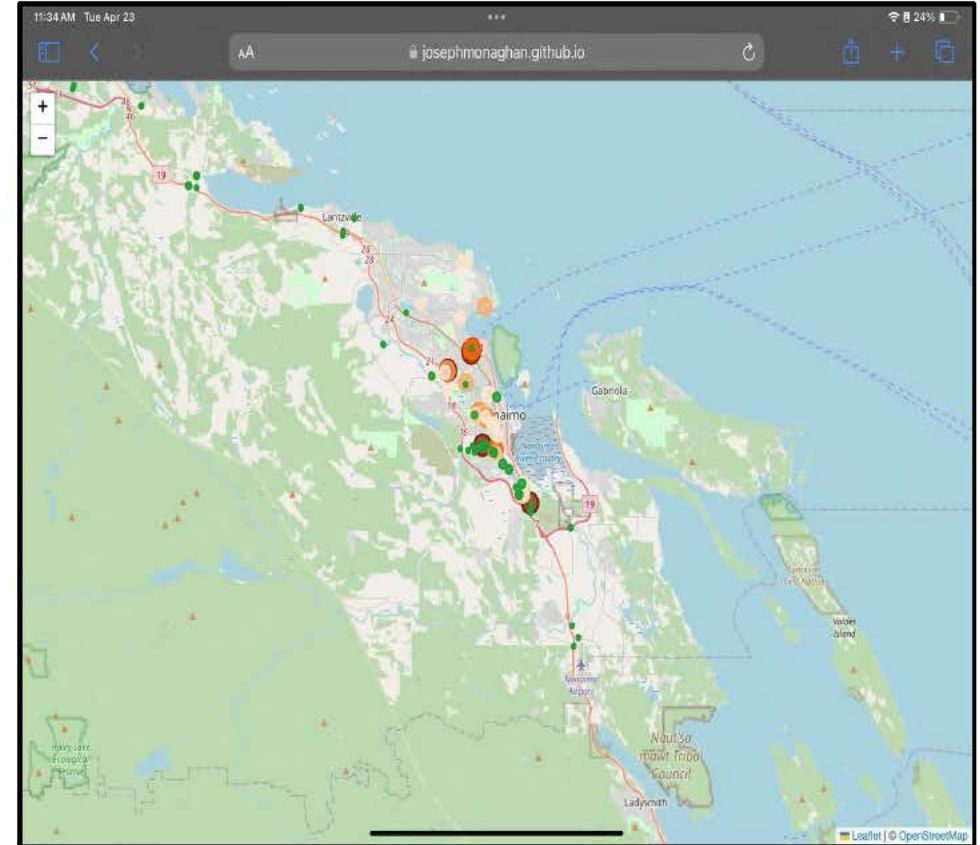
Data Processing



MatLab GUI for signal processing
& quantitation

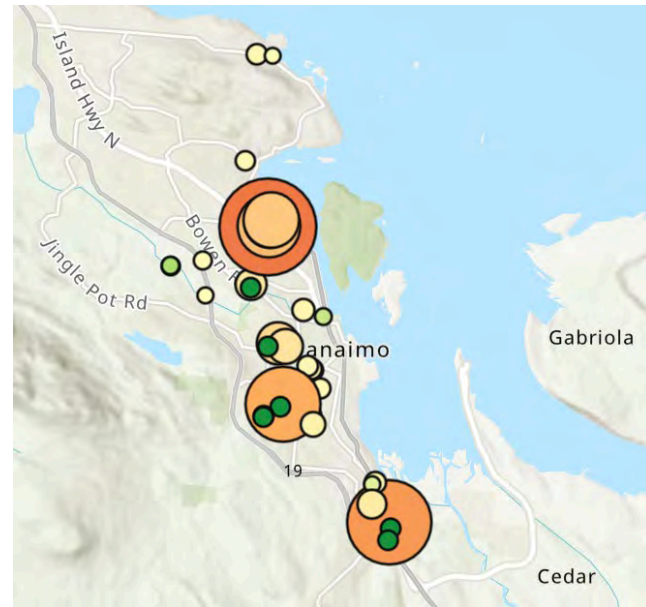
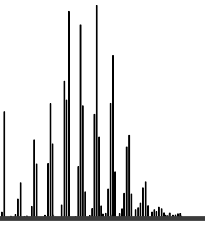


Data Exploration

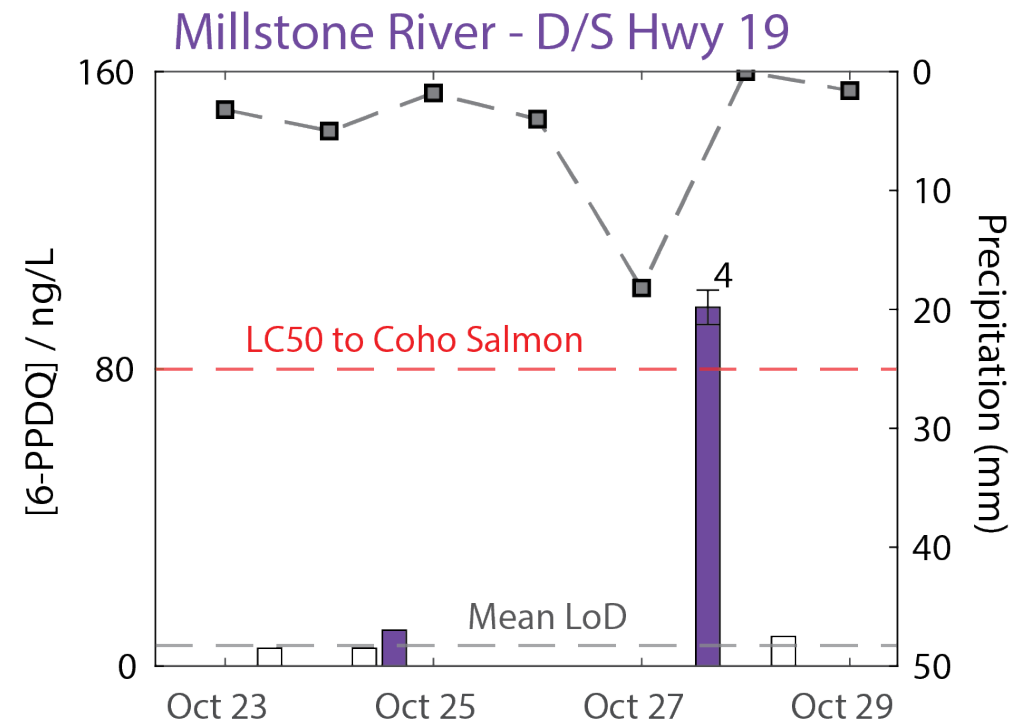


Interactive map for hotspot
identification

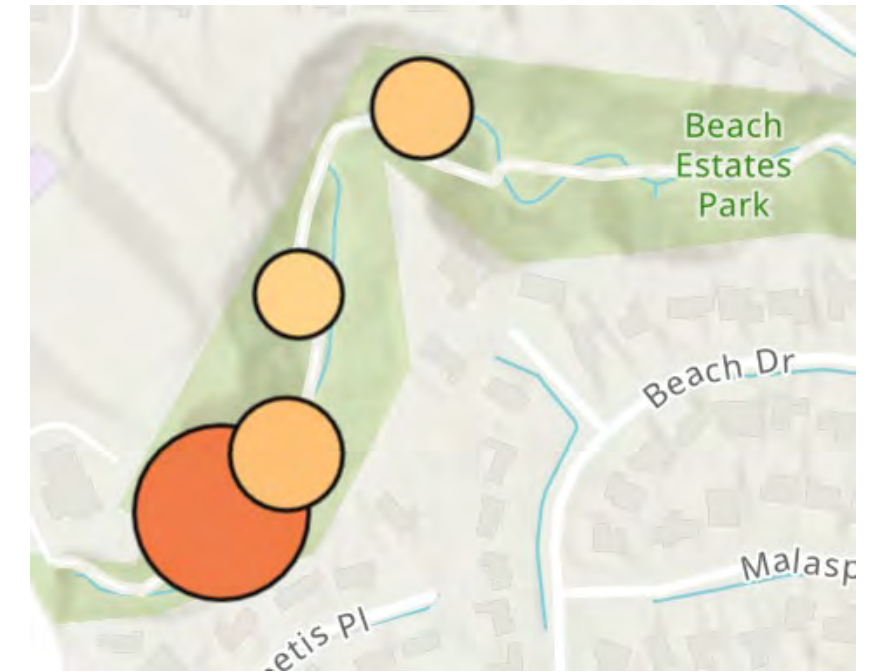
Leveraging High Throughput Analysis



Where are we seeing 6-PPDQ on Vancouver Island?



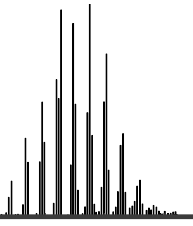
When to collect samples that best represent a rain 'event'?



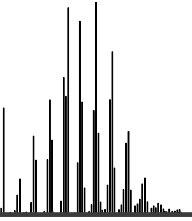
Where to collect samples that best represent impacts to urban waterways?



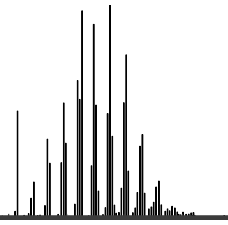
Wide Scale Surveillance – Driven by Indigenous/Local knowledge



Stream Sampling



Sample Collection (2022-2024)

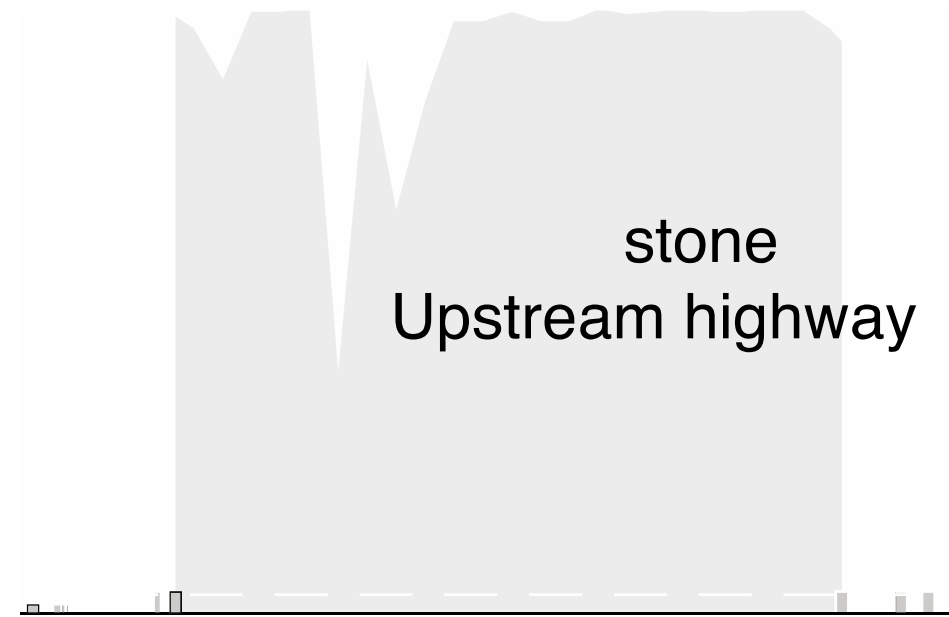


Before-during-after
rainfall

Increased engagement and
sampling efforts throughout the
study years

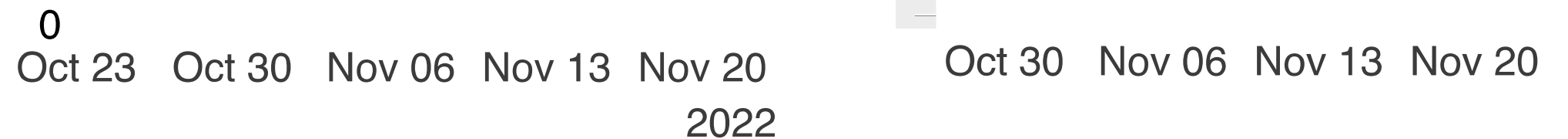
Distinct
site-to-site behavior

Several sites exceed coho
LC50
(41 – 95 ng/L)



Site C
Northfield

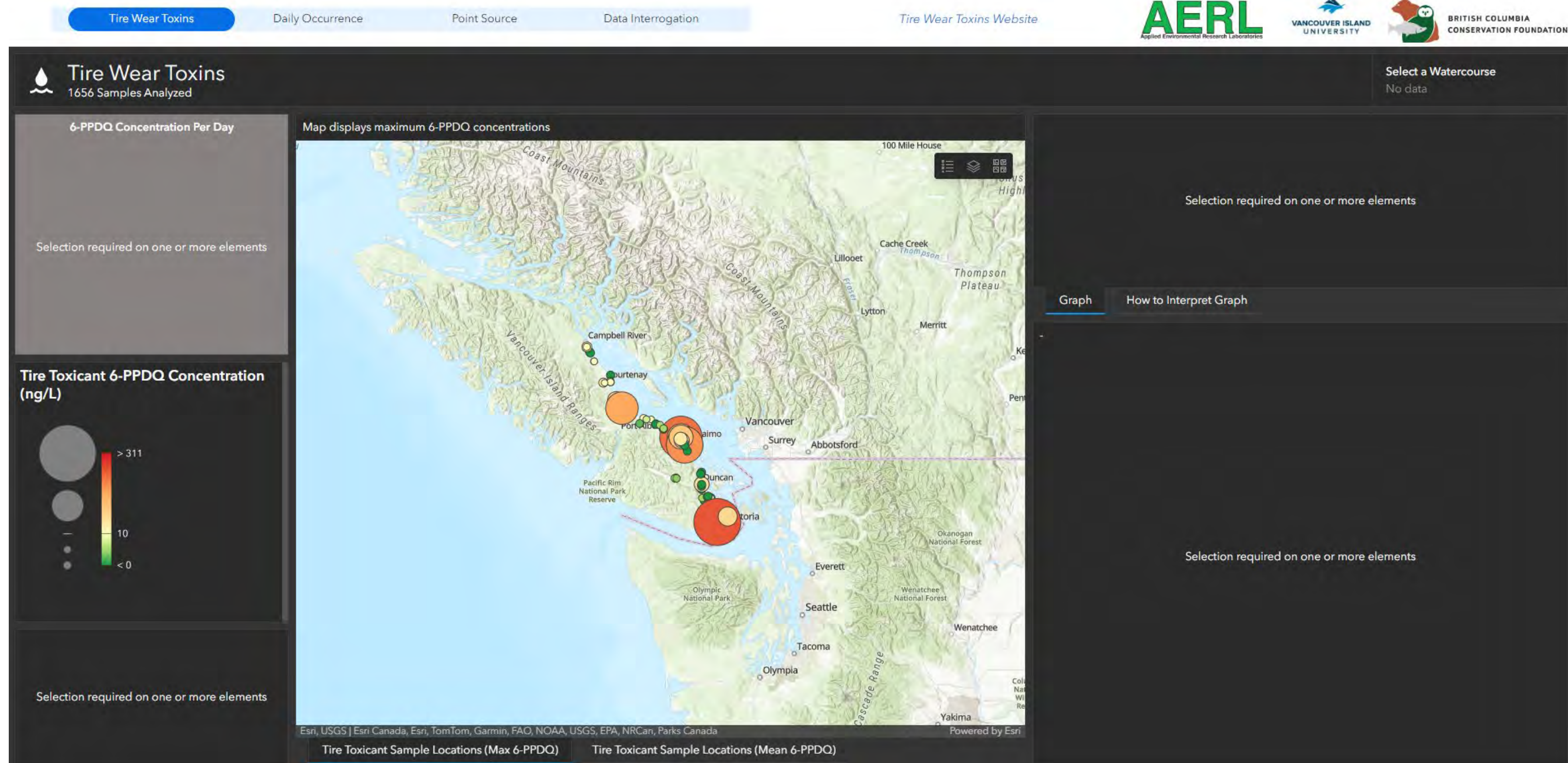
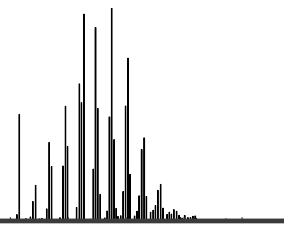
Site D
Cougar Creek



Gray shading = 6-PPDQ not detected

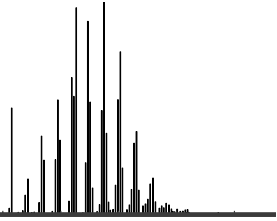


Interactive Data Dashboard



...For those interested, we could explore after presentations!

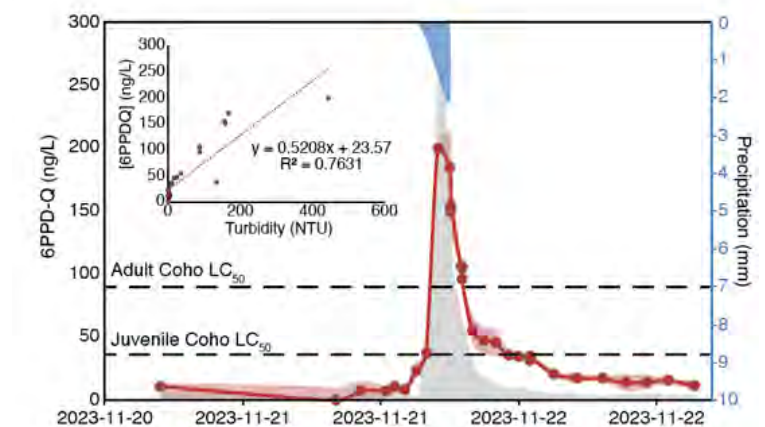
Project Objectives



What and where are the major sources of tire wear toxins inputs on Vancouver Island?



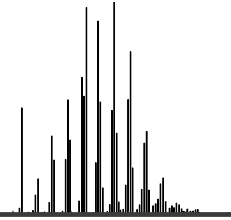
How do concentrations change over time and space?



How can low-cost nature-based solutions protect urban streams from tire wear toxins?



Investigate Variation Over Time & Space

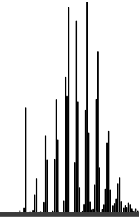


Collect grab samples over increased time/space to assess residence time and changes over time.

Ultimately, aim to deploy VIU's mobile lab creekside and monitor rain event(s) in real time from start to finish.



Increased Time Interval Sampling



We have conducted high-interval sampling at two occasions in mid- and late-November.

First event:

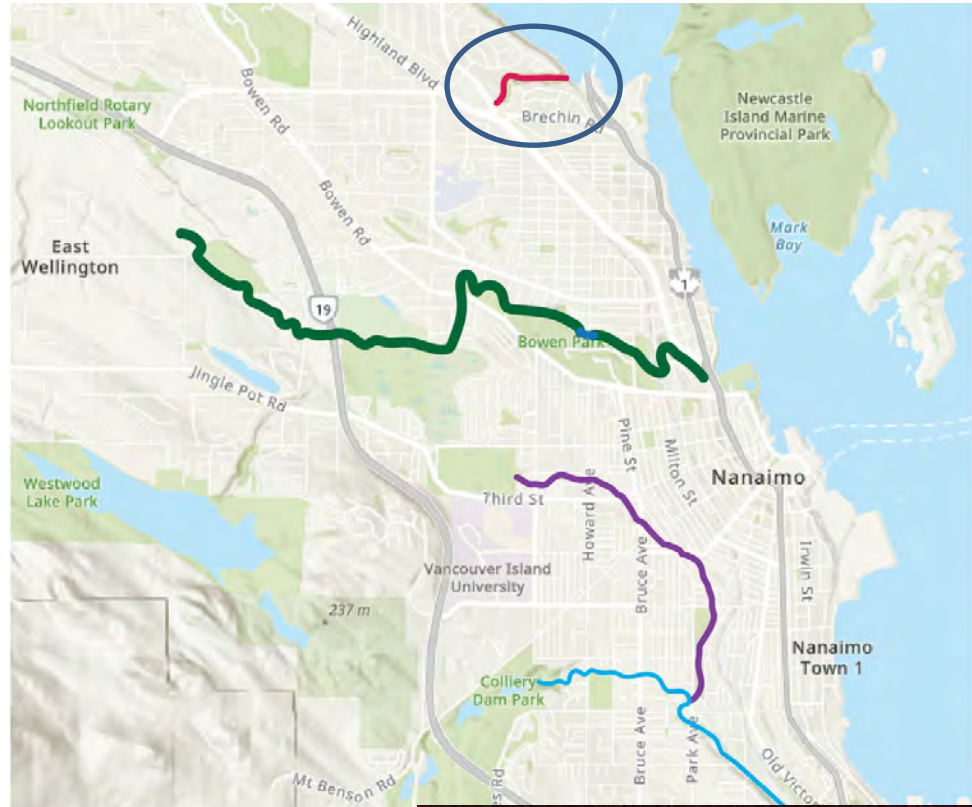
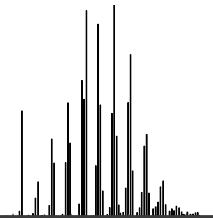
- 1 system
- 1 rainfall (4 – 5 mm)
- ~ 24 hours – sampling every 1 – 2 hours (28 samples)

Second event:

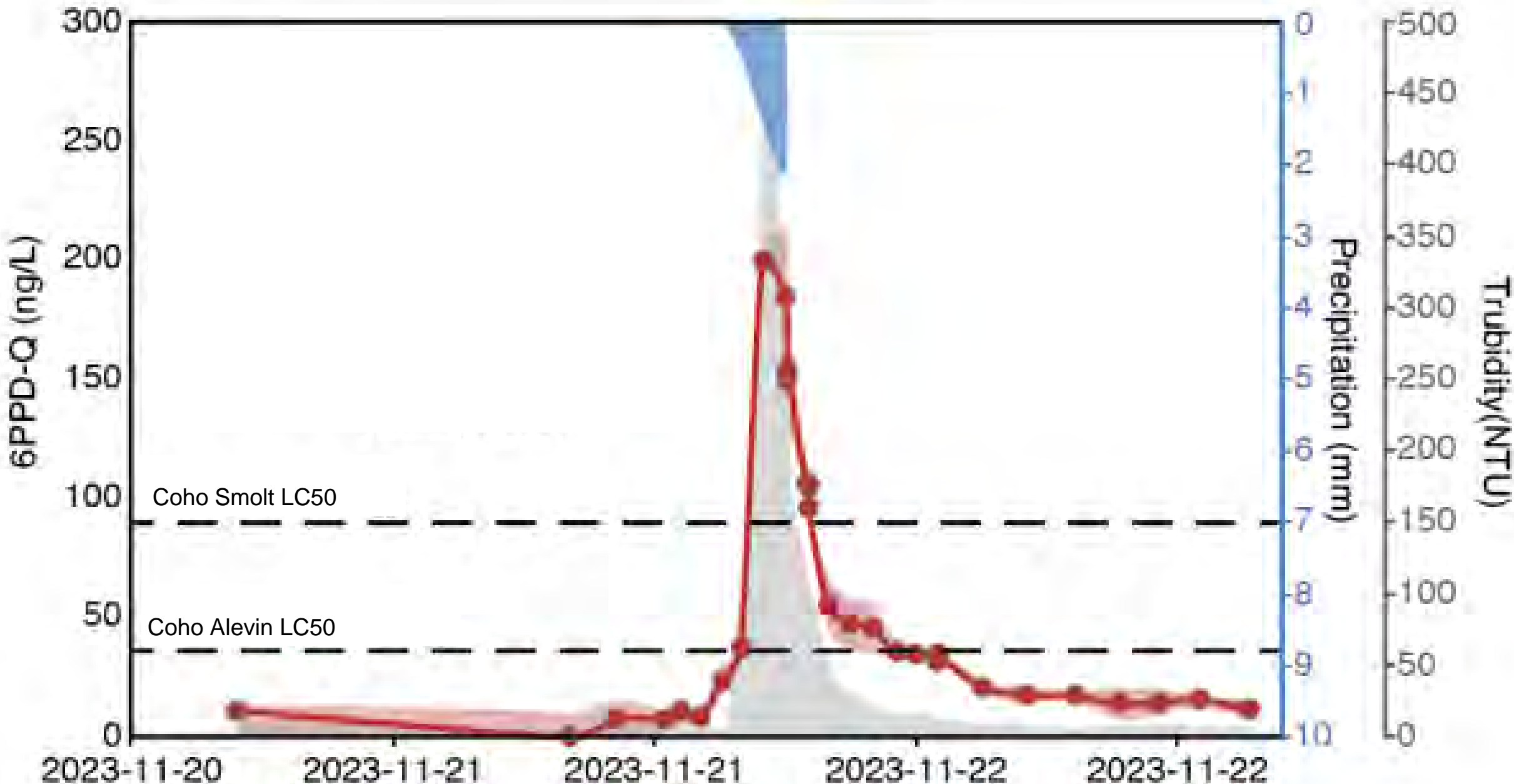
- 3 systems
- Several smaller rain events (2 – 5 mm) + 1 large rainfall (25 mm)
- ~120 hours – sampling every 1 – 6 hours (244 samples)



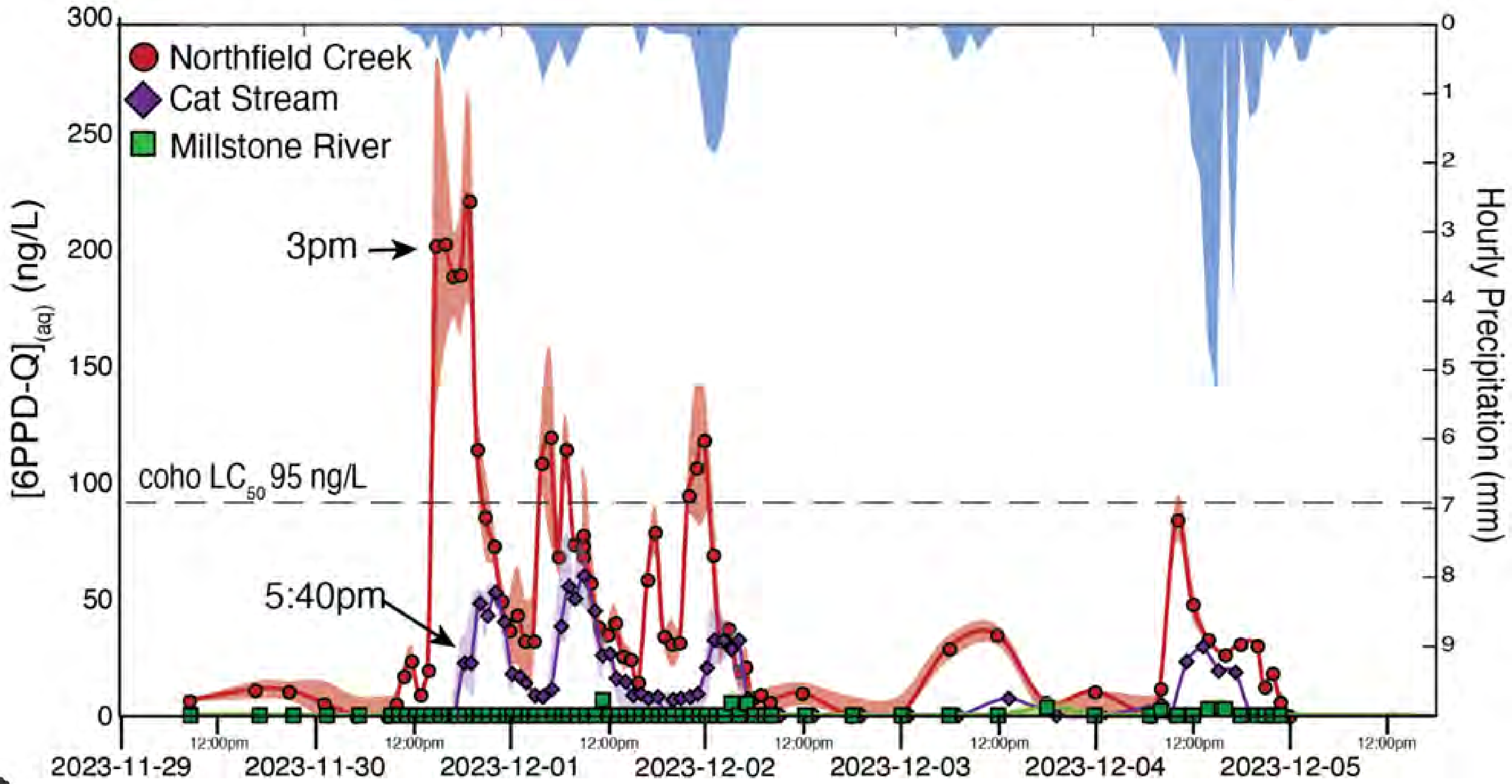
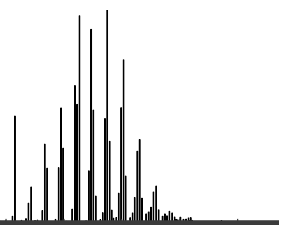
First Increased Interval Efforts



Northfield Creek - Hourly Sampling (Nov 21 – 22nd, 2023)



In-stream Concentration Dynamics



Increased Spatial Sampling

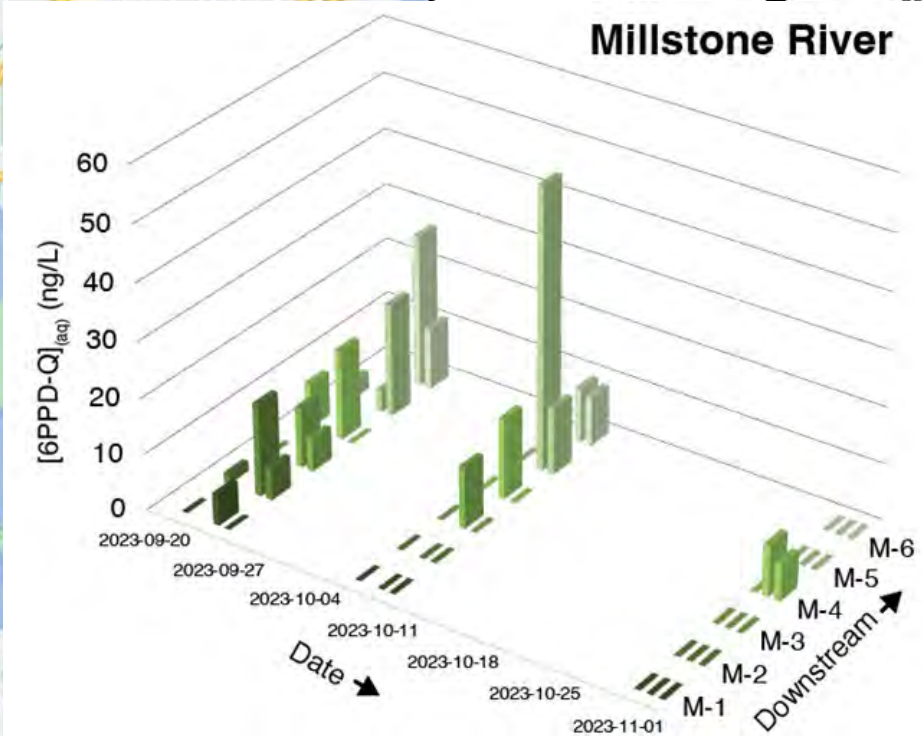
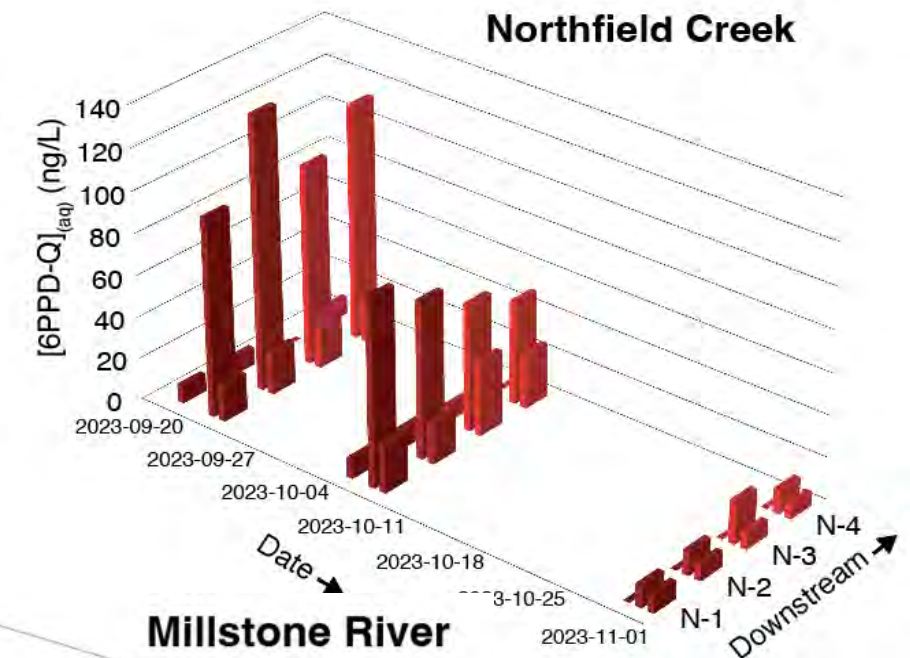
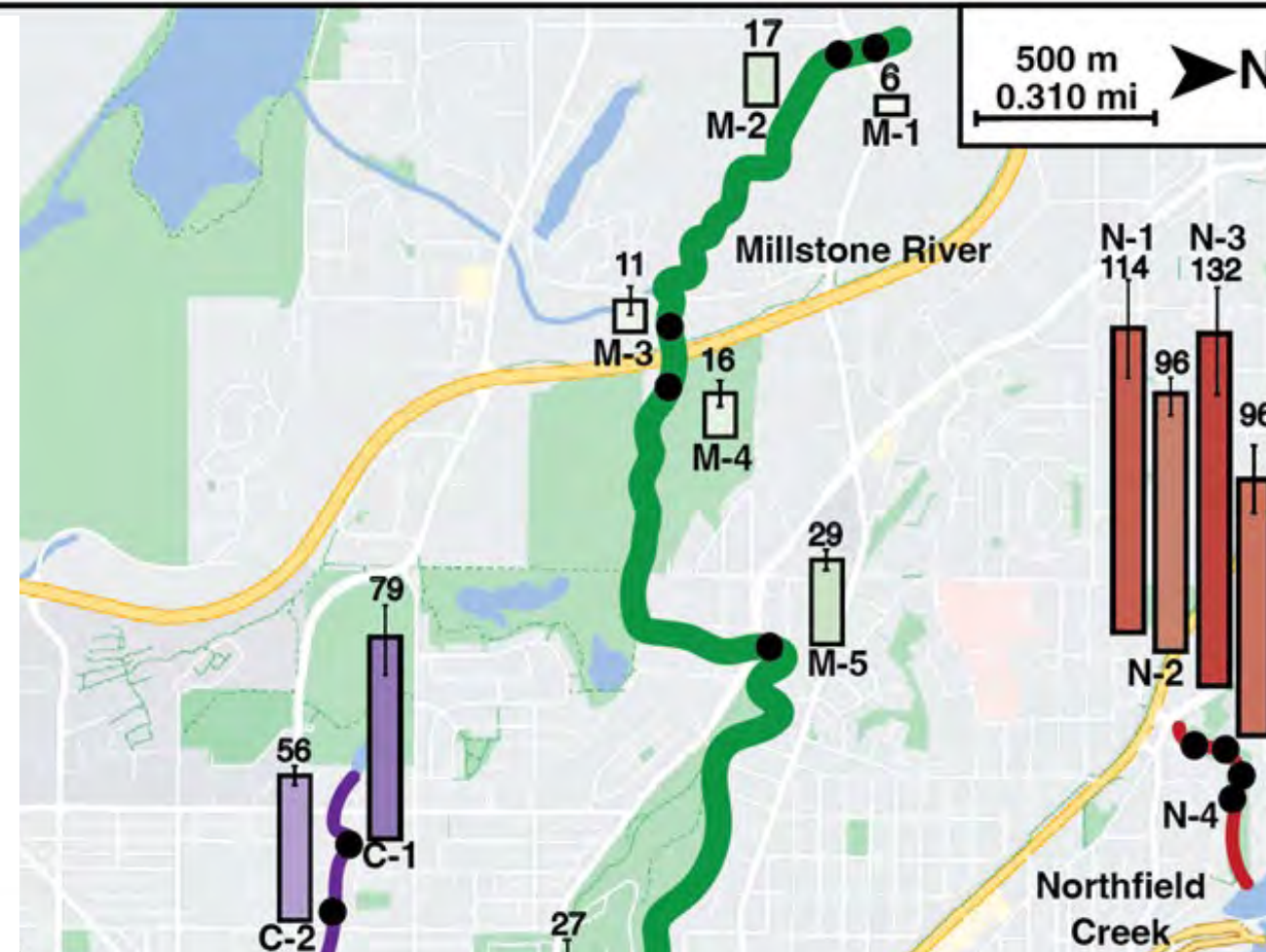
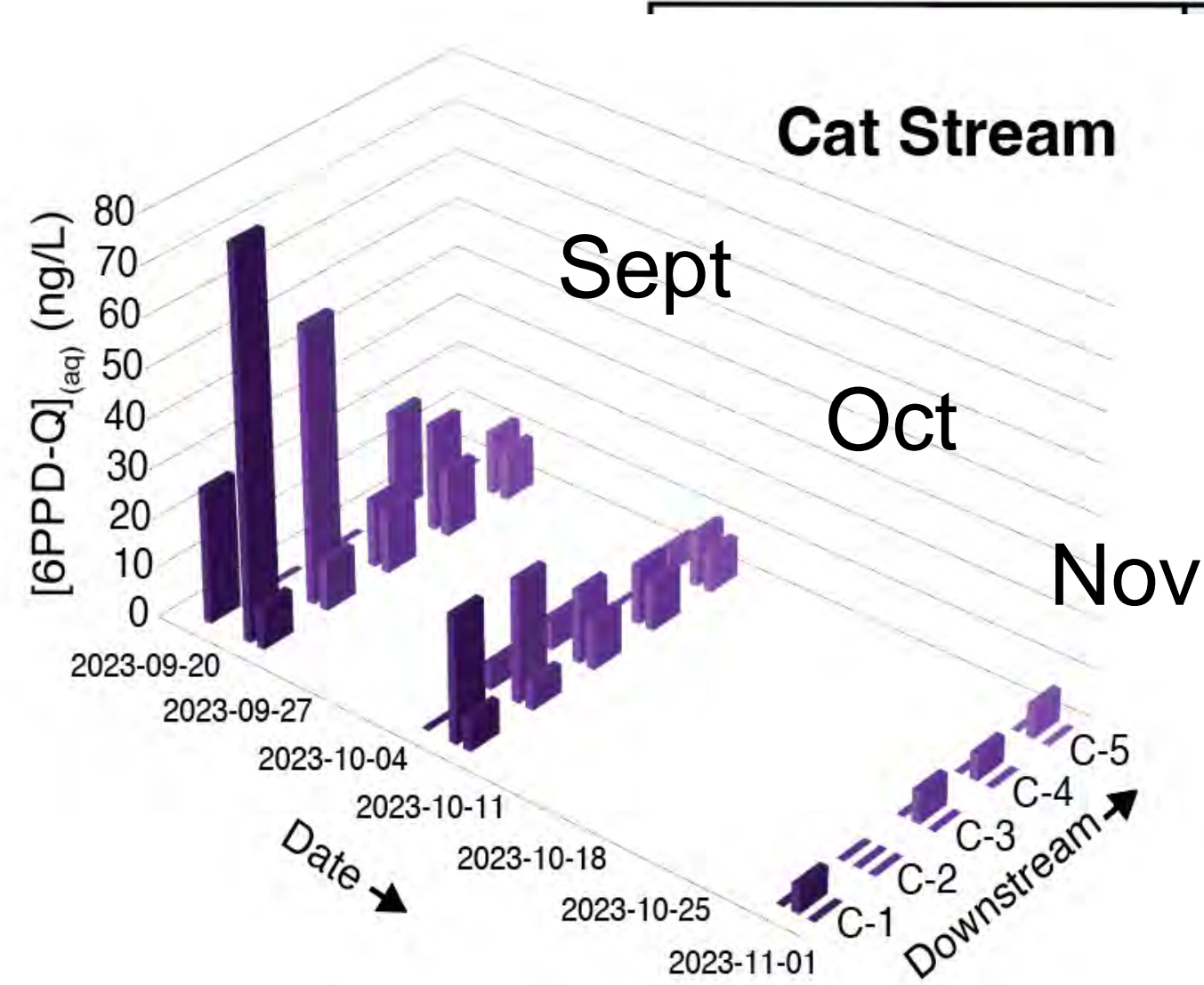
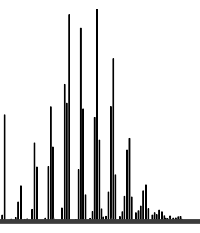
Increased spatial sampling has been occurring on multiple systems.

Each system provides variable results – typically seeing greater 6-PPDQ concentrations in increasingly urbanized areas.

Similar trend across all systems is decreasing seasonal 6-PPDQ concentrations, unless long dry period occurred.



Spatiotemporal Distributions



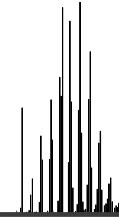
Project Highlights Since September 2023

- 30 groups trained (> 150 volunteers, > 670 hours)
- 56 streams (123 locations total) sampled between Campbell River and Victoria
- 6 rain events were captured (> 2,000 samples analyzed)
- 2 rain events were sampled at high frequency at 3 locations
- 6-PPDQ was detected in ~660 samples (33.2%)
 - ~100 stream samples were above the juvenile (alevin) coho LC50 (41 ng/L)
 - ~50 stream samples were above the juvenile (smolt) coho LC50 (95 ng/L)

Data publicly available with online interactive dashboard.



What We've Learned



- The high sample throughput method that we use allows us to adapt the sampling frequency to ensure that we captured the full in-stream pulse of 6-PPDQ;
- Concentrations observed were very dynamic, emphasizing that the timing of sampling is important;
- We also saw variation in how quickly different waterways reacted to the onset of rain:
 - Northfield Creek showed changes essentially immediately;
 - Cat Stream peaked several hours after the onset of rain.
- A 'first flush' is not a once a year event; dry periods can cause the same effect.





Questions?

Contact Information

Project Website: www.tireweartoxins.com

BCCF ARRC Contact: Haley Tomlin (htomlin@bccf.com)

VIU AERL Contact: Dr. Erik Krogh (erik.krogh@viu.ca)

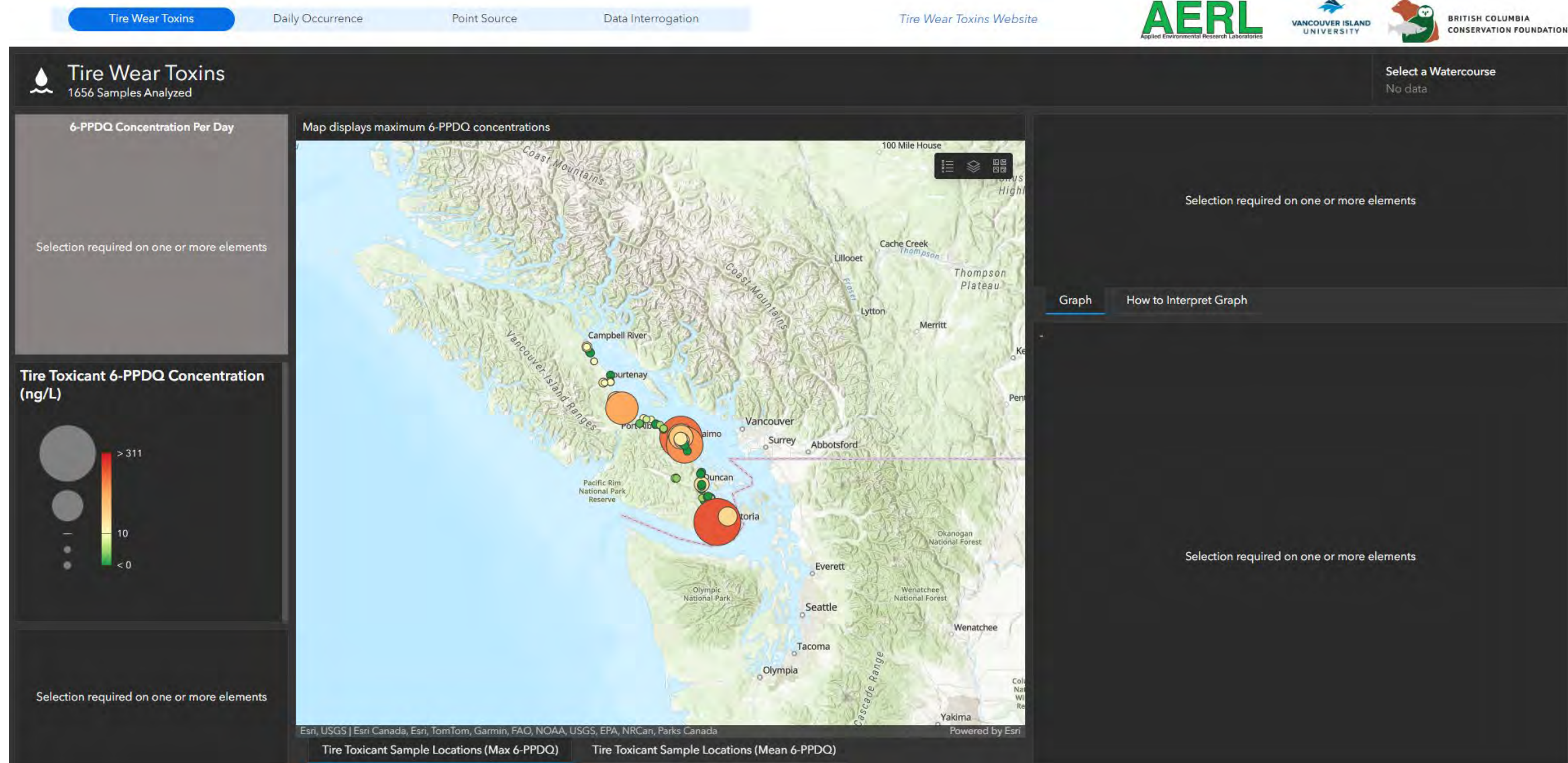
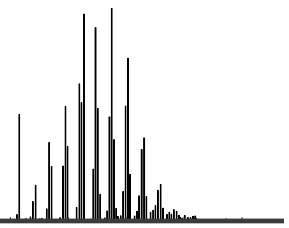


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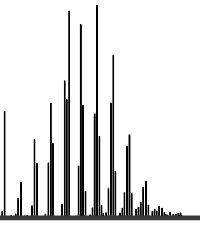
Interactive Data Dashboard



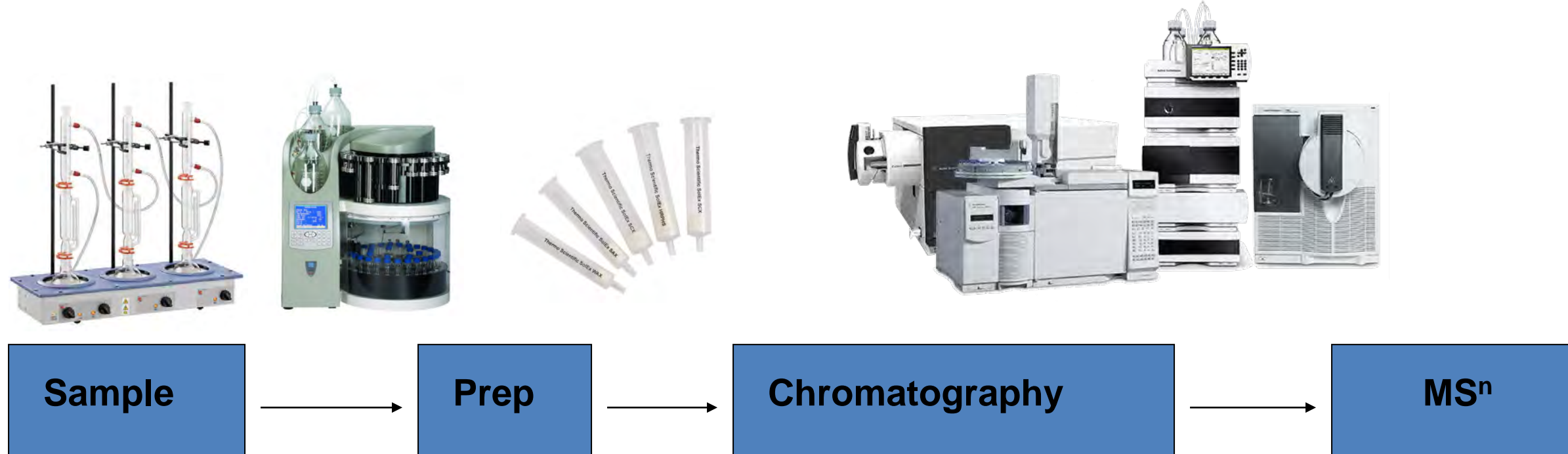
Can be found on the project website: www.tireweartoxins.com

<https://experience.arcgis.com/experience/597c33d27da84f1789bc41a36e37253d/page/Tire-Wear-Toxins/>

Sample Analysis Workflows

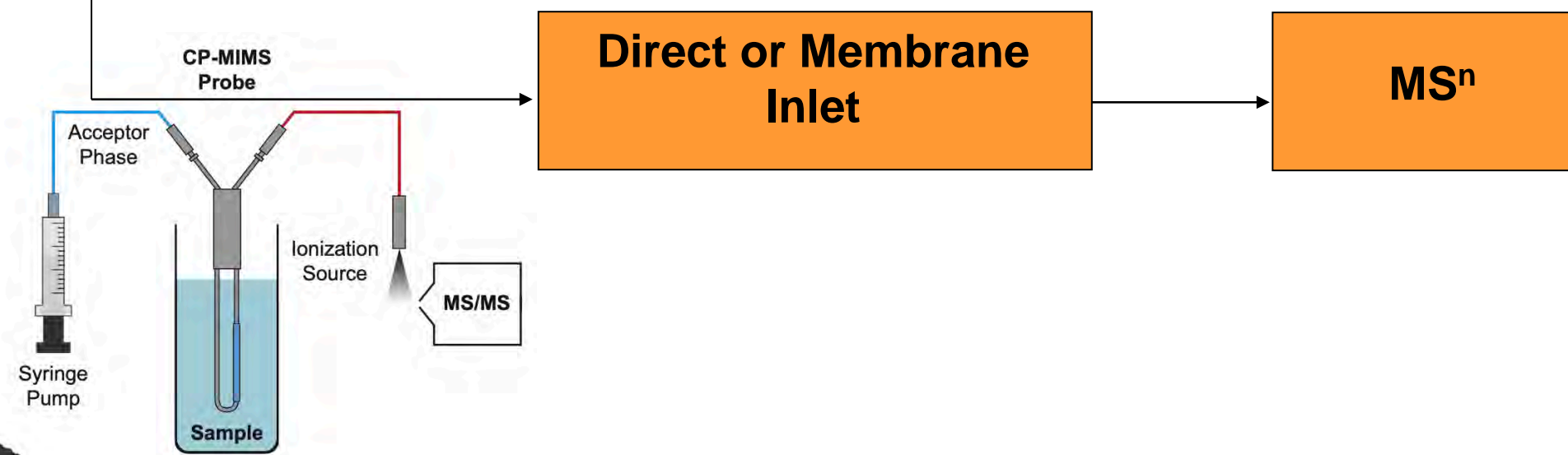


Conventional – LC-MS



- ✓ **Sensitive**
- ✓ **Selective**
- ✓ **Exhaustive**
- ✓ **\$\$\$**

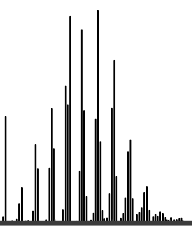
Direct – CP-MIMS



- ✓ **Easy**
- ✓ **Fast**
- ✓ **Real-time & Portable**
- ✓ **Cost effective**



Method Validation with LC-MS



UHPLC - TSQ Fortis
LLE w/ Heptane
5 min isocratic separation
~1 ng/L LoD in water

**Agreement with
conventional
method (LC-MS)!**

