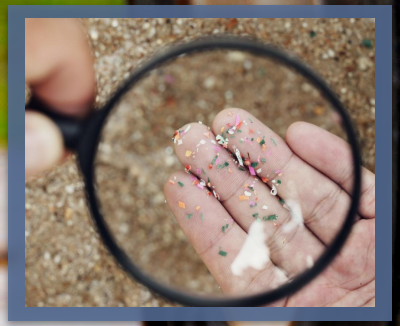


2026 Stormwater Awareness Week
September 24, 2026

Sea Grant
UNIVERSITY OF
SOUTHERN CALIFORNIA

# Clean Streets, Clean Seas: Research, Outreach, and Education on Street Sweeping and Microplastics

**Jill Murray, Ph.D.,** Creeks Supervisor, City of Santa Barbara Sustainability & Resilience Dept.
**Sydney Rilum, M.S.,** Marine Debris Extension Specialist, USC Sea Grant

Award NA23OAR4170171

# Workshop Agenda



MP = microplastic

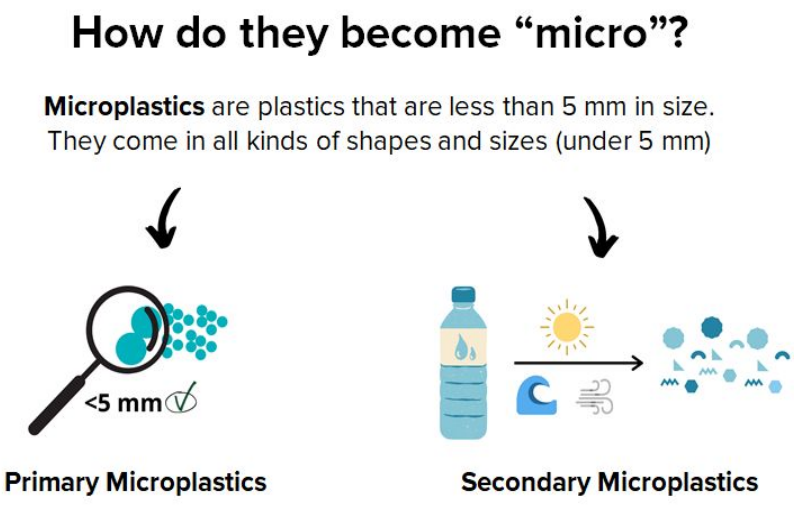
- **Background**
- **Street Sweeping**
  - Quantify reduction of MP in **simulated rainfall** events
  - Optimize **pickup efficiency** of MP
  - Evaluate annual **interception** of MP
- **Trash capture devices**
  - Evaluate generation, capture, and pass through of MP
- **Engagement**
  - **Engage** stormwater managers, Public Works, NGOs, and the public to translate MP research into outreach and curriculum
- **Q&A**

# Clean Streets, Clean Seas Project Team

- **City of Santa Barbara**
  - Jill Murray, Laurie Van De Werfhorst, Caroline Shepherd
- **University of California, Santa Barbara (UCSB)**
  - Patricia Holden, Dong Li, Amanda Strom
- **San Francisco Estuary Institute (SFEI)**
  - Alicia Gilbreath, Jennifer Dougherty, Kayli Paterson, Rebecca Sutton, Tony Hale, Kelly Moran, Diana Lin
- **Moore Institute for Plastic Pollution Research**
  - Win Cowger, Hazel Vaquero, Shelly Moore
- **Southern California Coastal Water Research Project (SCCWRP)**
  - Elizabeth Fassman-Beck, Danhui Xin
- **WSP USA, Inc.**
  - Theodore Von Bitner, Katelynn Webb
- **Cascade Water Resources & WorldSweeper.com**
  - Roger Sutherland and Ranger Kidwell-Ross
- **University of Southern California Sea Grant**
  - Sydney Rilum, Karla Heidelberg, Amalia Almada

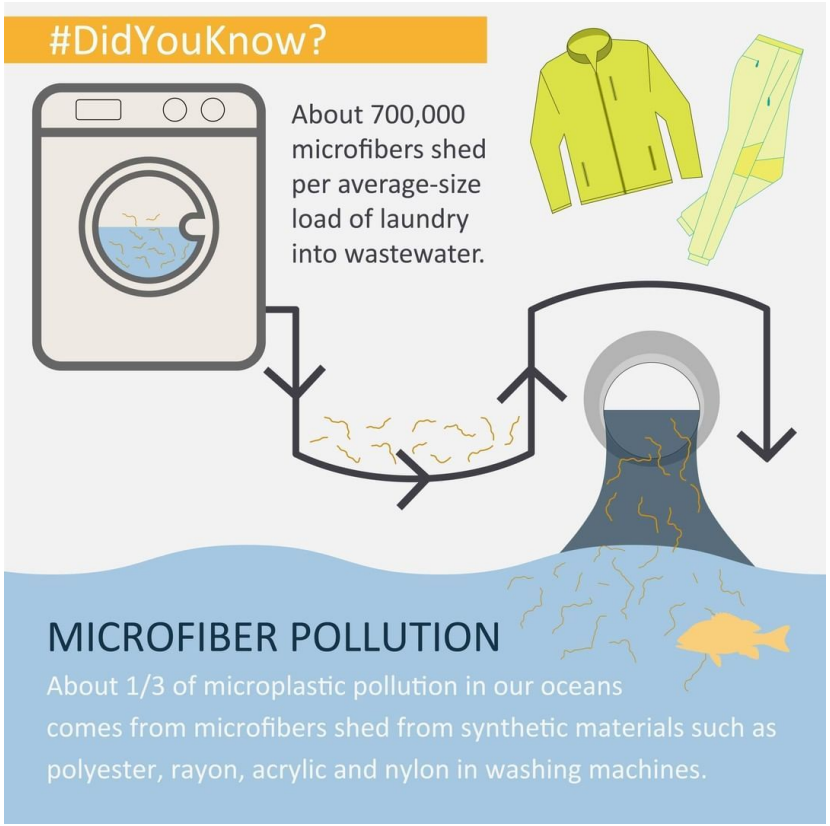
# What are Microplastics?

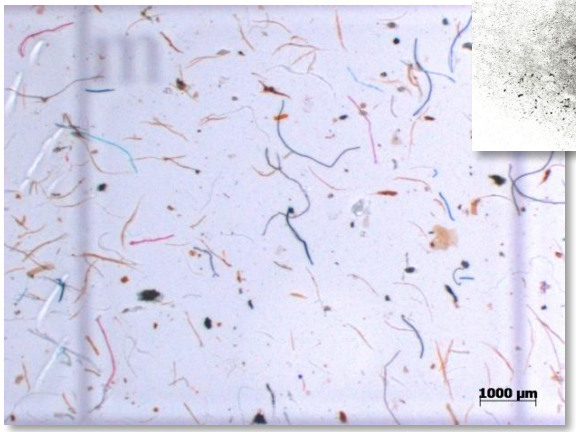


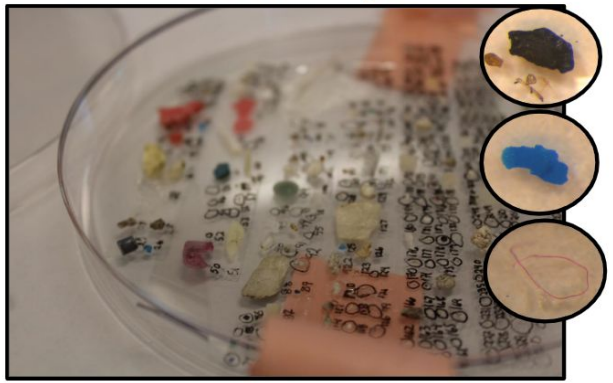

Graphics: Timnet Kefela (U. Arizona)

# What are Microplastics?





# The Microplastic Pollution Problem

Microplastics are *everywhere!*

Microplastics in the Ocean

Won Joon Shim & Richard C. Thompson

Microplastic pollution in deep-sea sediments

Lisbeth Van Cauwenberghe [a], Ann Vanreusel [b], Jan Mees [b, c], Colin R. Janssen [a]

**Microplastics in sea ice and seawater beneath ice floes from the Arctic Ocean**

La Daana K. Kanhai, Katarina Gardfeldt, Thomas Krumpen, Richard C. Thompson & Ian O'Connor

Reaching New Heights in Plastic Pollution—Preliminary Findings of Microplastics on Mount Everest

Imogen E. Napper [1, 2, 9], Bede F.R. Davies [1], Heather Clifford [3, 4], Sandra Elvin [5], Heather J. Koldewey [6, 7], Paul A. Mayewski [3], Kimberley R. Miner [3], Mariusz Potocki [3, 4], Aurora C. Elmore [5], Ananta P. Gajurel [8], Richard C. Thompson [1]

**Microplastic Fallout in Different Indoor Environments**

Qun Zhang, Yaping Zhao, Fangni Du, Huiwen Cai, Gehui Wang, and Huahong Shi*

**Anthropogenic contamination of tap water, beer, and sea salt**

Mary Kosuth, Sherri A. Mason, Elizabeth V. Wattenberg

Occurrence of microplastics in raw and treated drinking water

Martin Pivokonsky [a], Lenka Cermakova [a, b], Katerina Novotna [a, c], Petra Peer [a], Tomas Cajthaml [b], Vaclav Janda [c]

Research Paper

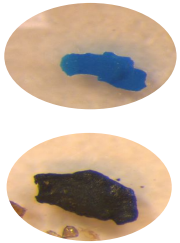
Presence of airborne microplastics in human lung tissue

Luís Fernando Amato-Lourenço [a b], Regiani Carvalho-Oliveira [a], Gabriel Ribeiro Júnior [a], Luciana dos Santos Galvão [c], Rômulo Augusto Ando [d], Thais Mauad [a b]

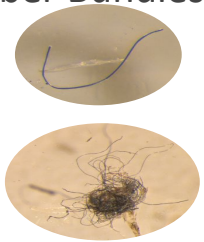
# What do microplastics look like?

**Morphology**

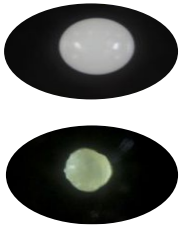
Fragments



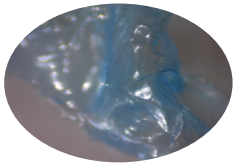
Fibers & Fiber Bundles



Spheres/Pellets



Films



Foams



**Polymer**

Tire wear particles
Paints
Polypropylene
Polyethylene
Polystyrene
Polyvinyl chloride
Polyurethane
Polyethylene terephthalate
etc…

**Additives**

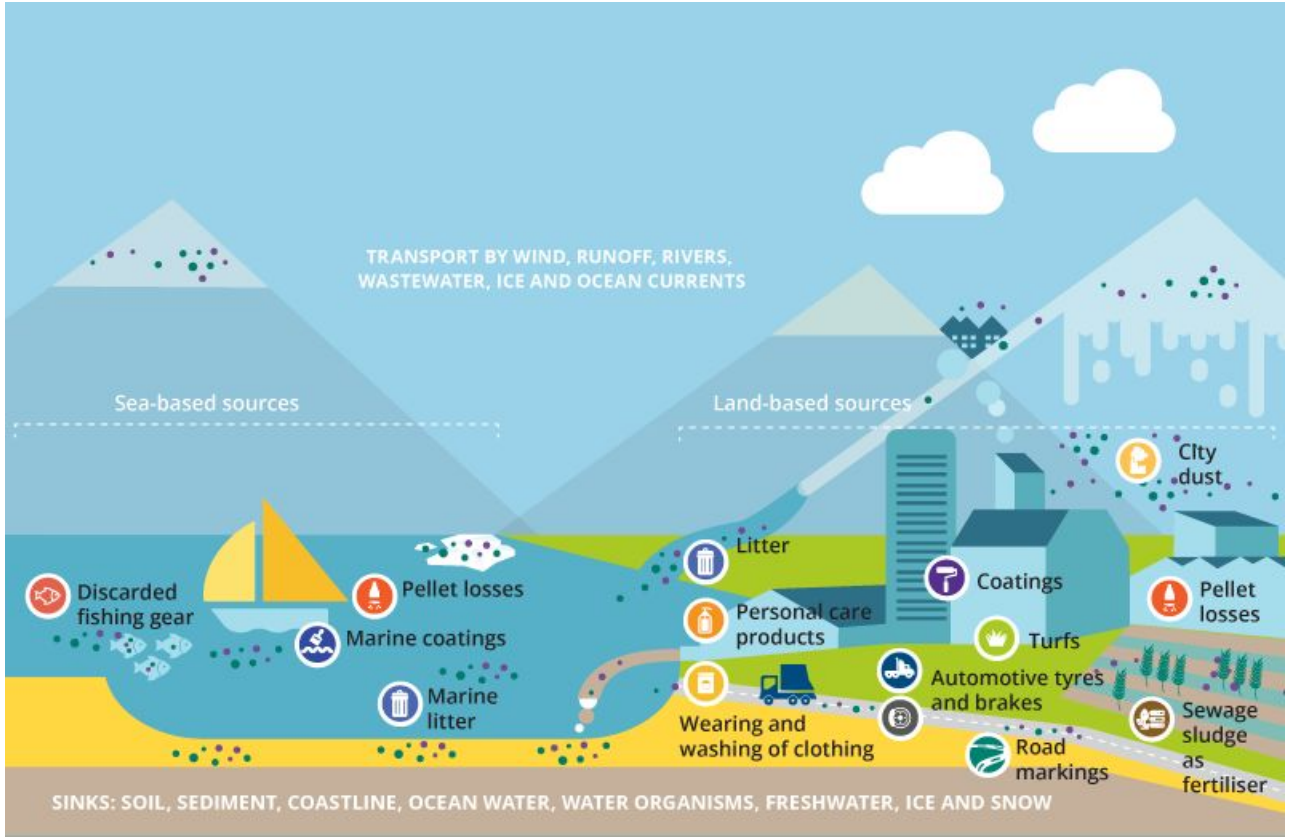
Plasticizers
Flame retardants
Coatings
Colorants
Reinforcements
Stabilizers
etc…

**Size**

millimeters
micrometers
nanometers

**Sampling and analytical methods still evolving.**

# Sources of microplastics, release routes and sinks

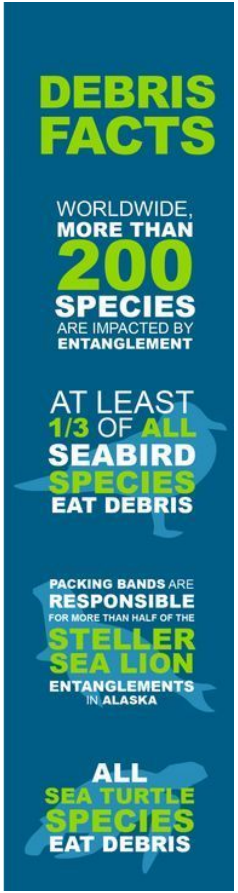



Graphic: Pirjo Tyrväinen, Well with Nature / European Environment Agency

# Environmental Impacts




Graphics: NOAA Marine Debris Program





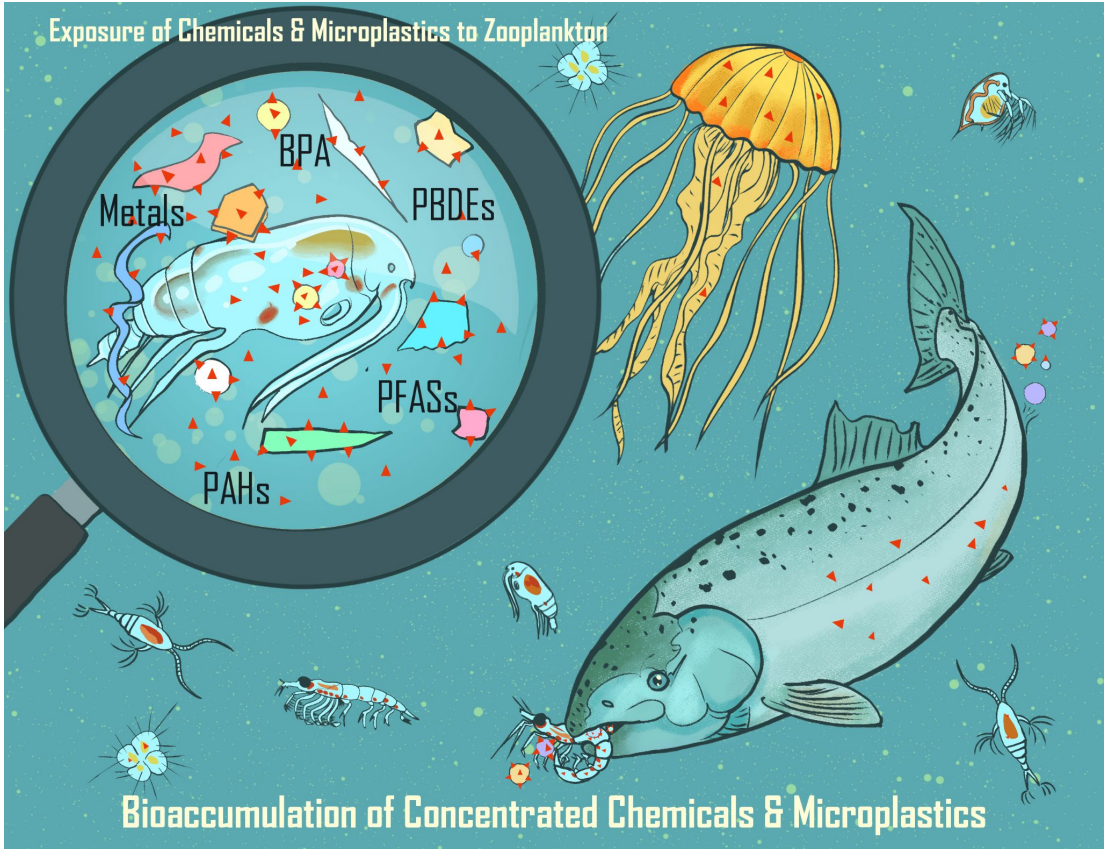







Photos (top to bottom): Kampee Patisena, NOAA Fisheries, Chris Jordan, Korea Inst. of Ocean Science and Technology

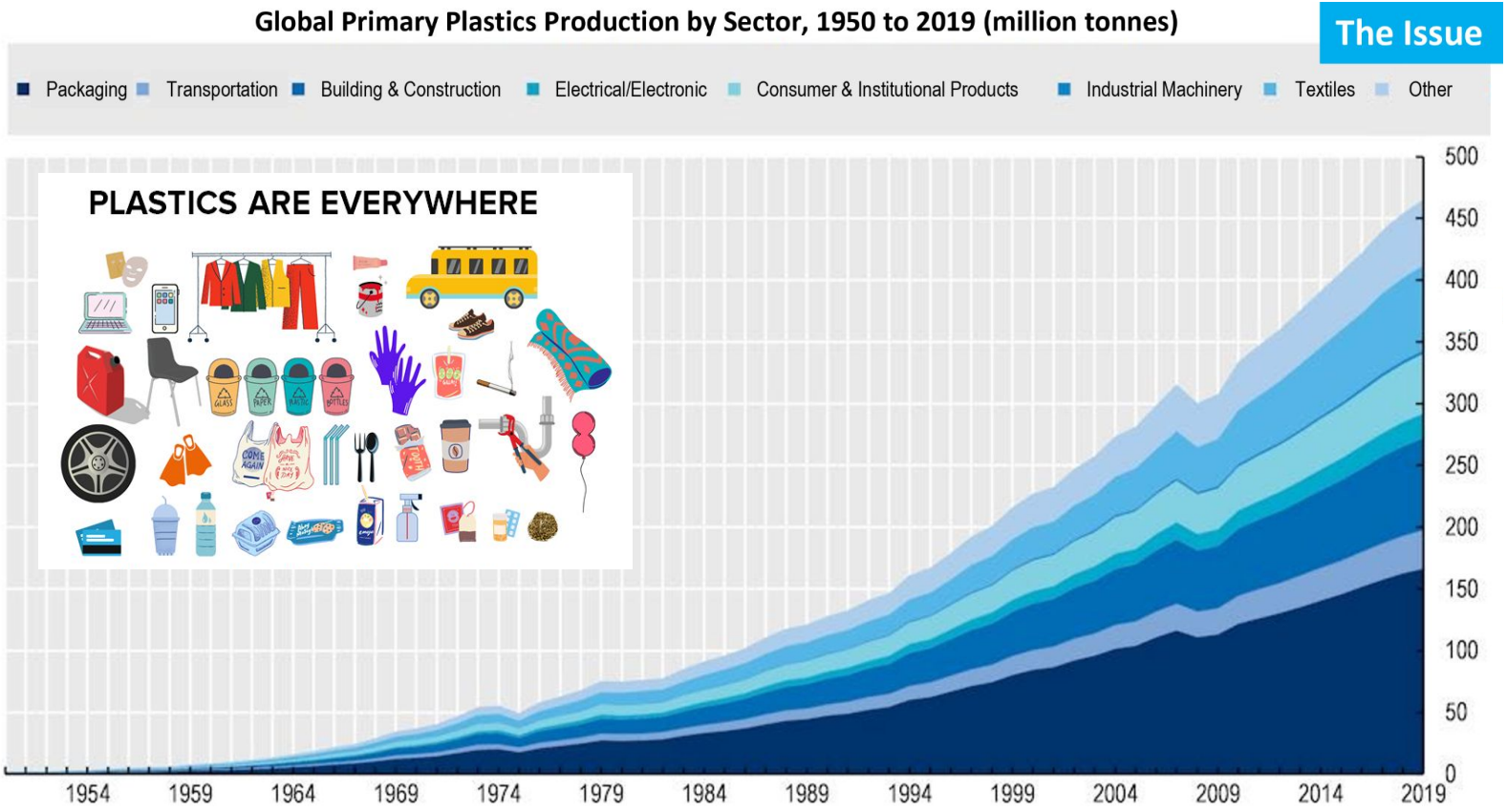
# Environmental Impacts




Graphic: Weis & Alava 2023

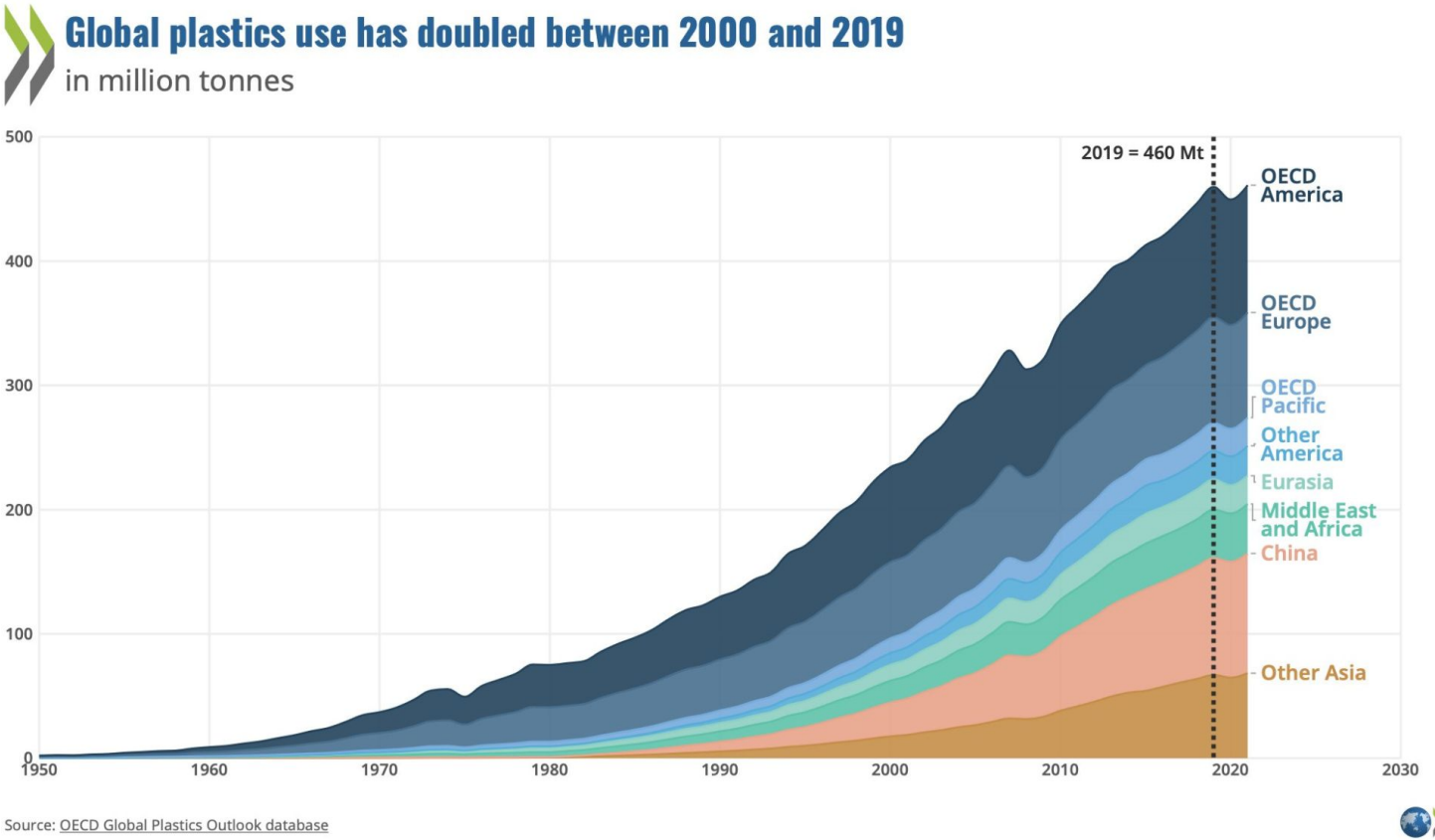
# Global Plastic Production

**The Issue**




Source: OECD (2021), Update by the authors of (Geyer, Jambeck and Law), 2017

# Global Plastic Production

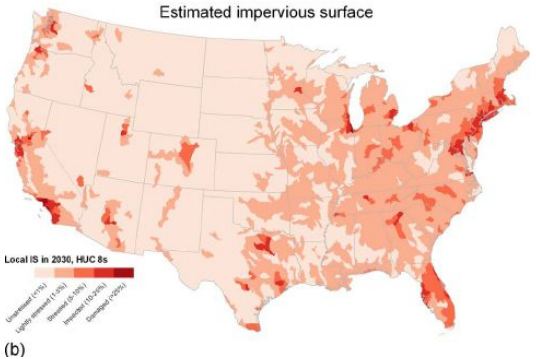



OECD (Organisation for Economic Co-operation and Development)

# Why Microplastics Interception in Stormwater is Urgent

- Runoff from impervious surfaces dominates transport of MP to ocean (Sutton, 2019; Moran, 2021)
- Marine ecosystems will be harmed (Isobe et al. 2019)
- Tire wear particles harm salmon fisheries
- Impervious surfaces increasing (Theobald et al. 2009)
- Long term solutions: product bans, producer responsibility, and infiltration (CA Ocean Protection Council and NOAA, 2021)
- California's Trash Amendment targets trash > 5 mm

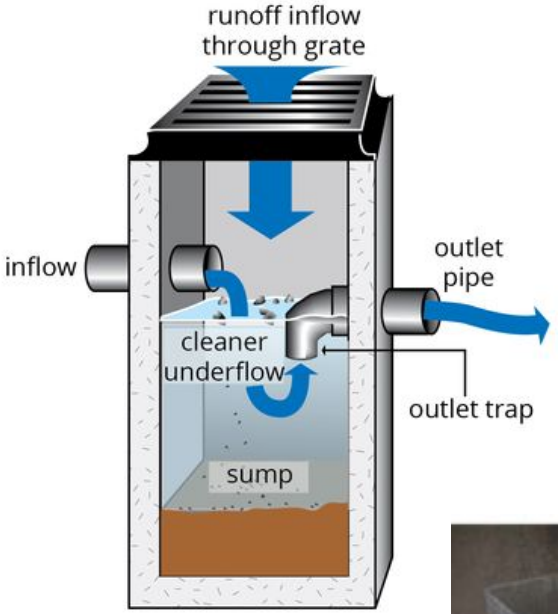




# California Trash Amendments

- GOAL: 100% trash-free stormwater by 2030
- Requires 100% interception of trash > 5 mm
- Track 1: Full Capture Devices installed in storm drains
- Track 2: Treatment controls, institutional controls, and/or multi-benefit projects

**Does NOT address microplastics!**

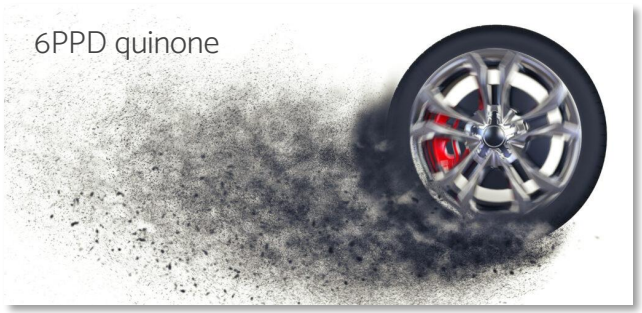



Catch Basin



# How are microplastics transported in stormwater runoff?







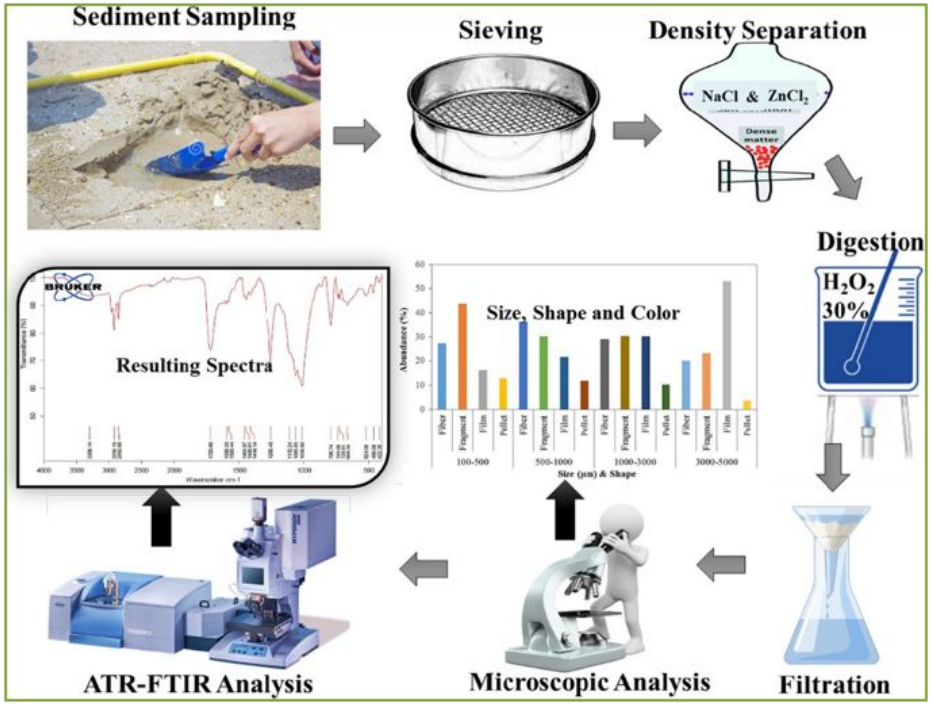





# How are microplastics quantified?



20-200 L sample, sieved on site




It's not easy! Sampling and analytical methods are laborious and expensive

# Street Sweeping Study #1 - Approach

Objective: **Quantify street sweeper reduction of microplastic** concentrations in simulated rainfall events

## Pilot Project

- Develop a reliable method to measure a difference in runoff water quality between swept and unswept pavements
- What is the pollutant concentration reduction in runoff due to street sweeping?



Rainfall Generator & Runoff Collection System



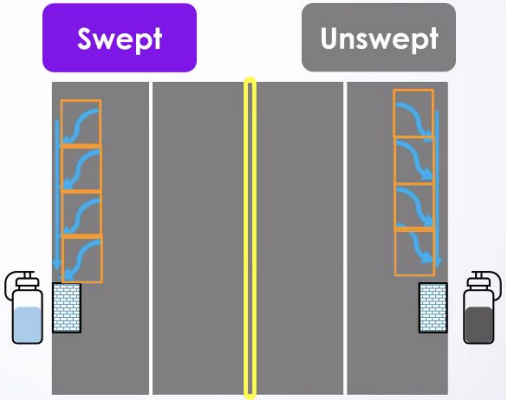


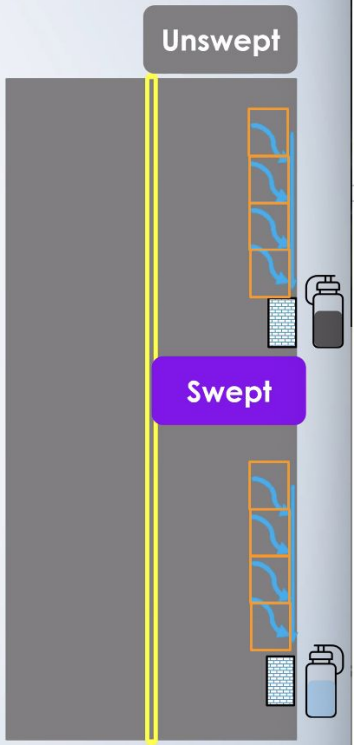

# Street Sweeping Study #1 - Methods

## Testing Method



1 composite sample
per 280 ft² pavement area
per pavement condition



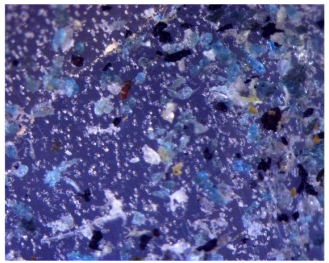



# Street Sweeping Study #1 - Results

**% Difference of microplastics concentrations between swept and unswept samples in <355 µm size fractions.**

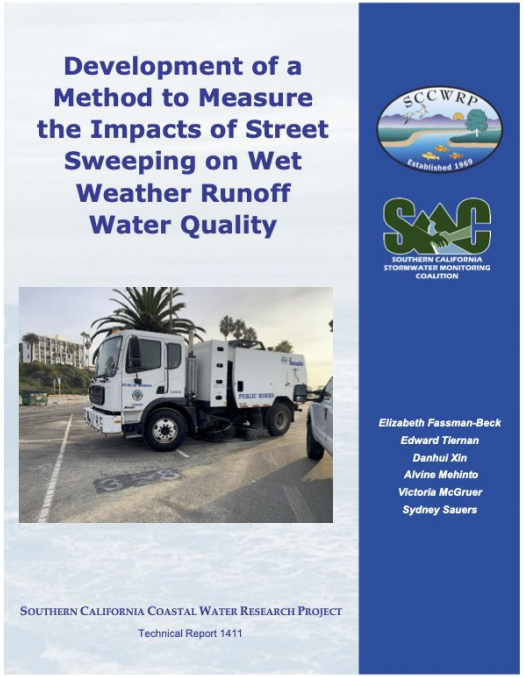
| Size Fraction | Unswept Concentration (mg/L) | Swept Concentration* (mg/L) | % Difference |
|---|---|---|---|
| 125 µm | 0.224 | 0.064 | 71 |
| 63 µm | 0.041 | 0.059 | -44 |
| 20 µm | 0.068 | 0.027 | 60 |
| All | 0.33 | 0.150 | 55 |

* Average of sample duplicates



Microscopy of the 63 µm fraction

- Reliable method
- Microplastics reduced in runoff after sweeping
- Limited number of samples in pilot study
- Two controlled field studies underway:
  - SoCal Stormwater Monitoring Coalition: 10 sites tested 2025-2026, MP results pending
  - Los Angeles Safe, Clean Water Program: 10 sites to be tested 2026-2027




Tiernan et al. (2025) Design of a Mobile, Field-Scale Rainfall Generator for Urban Runoff Water Quality Studies. *Journal of Irrigation and Drainage Engineering*. 151(4). https://doi.org/10.1061/JIDEDH.IRENG-10507

# Street Sweeping Study #2 - Approach

Objective: **Optimize street sweeper pickup efficiency** for interception of microplastic

- Street sweeper industry provided 6 sweepers (5 operators)
- 3 mechanisms
- 2 speeds (5, 10 mph)
- 5 microplastic types, street dirt recipe



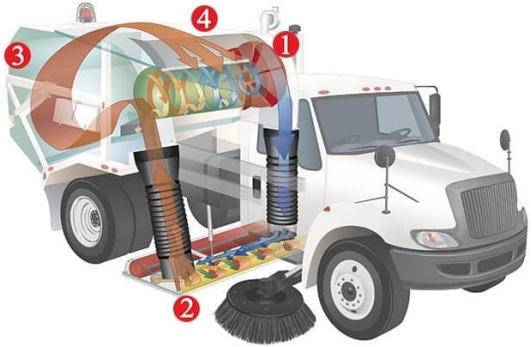
*Pickup Efficiency (%) = 100* Simulant removed /Simulant applied*

*Simulant removed by street sweeper = Simulant applied – Simulant remaining (vacuumed)*

# Street Sweeper Types




Mechanical Broom




Regenerative Air

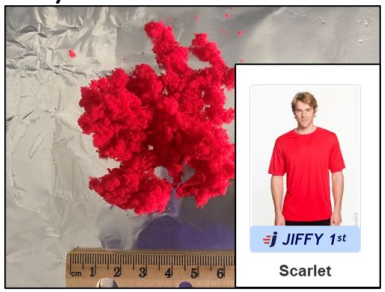


Pure Vacuum

WORLD SWEEPER .COM

# Street Sweeping Study #2 - Methods

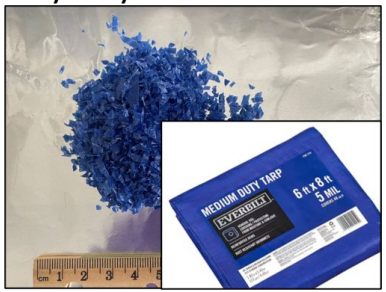
Polyester



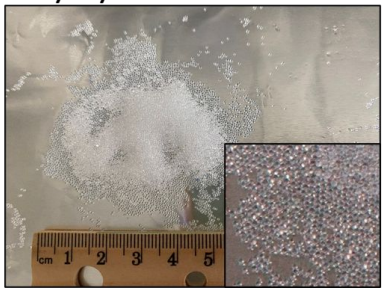

Polyamide




Polyethylene




Polystyrene



Tire wear particles



Simulant in Mason Jar





Method Article

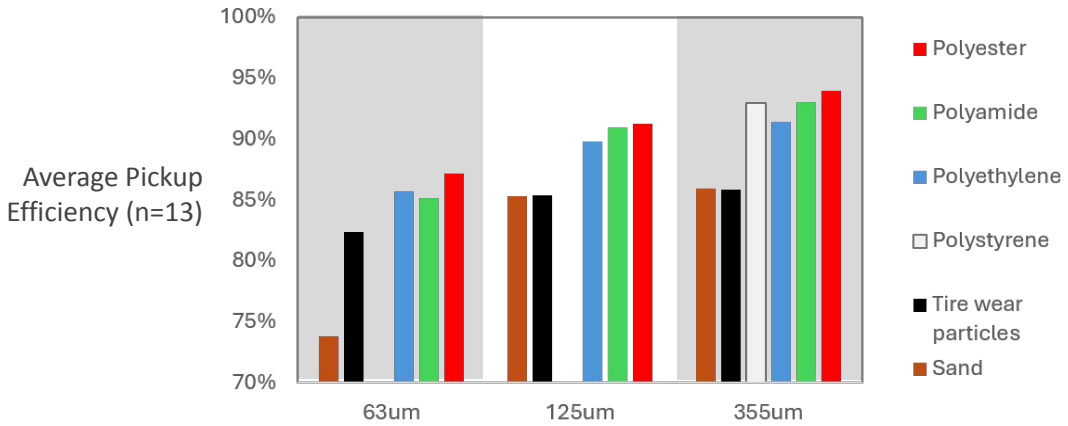
Think positive: Proposal of a simple method to create reference materials in the frame of microplastics research

Alexandre Dehaut*, Charlotte Himber, Mathilde Colin, Guillaume Duflos

*ANSES – Laboratoire de Sécurité des Aliments, 6 Boulevard du Bassin Napoléon, 62200 Boulogne-sur-Mer, France*

Sample size: ~200 g of simulant
Sieve sizes: 20, 63, 125,  µm, 125 µm
Particle and Polymer Identification: stereo microscopy, OPTIR in progress

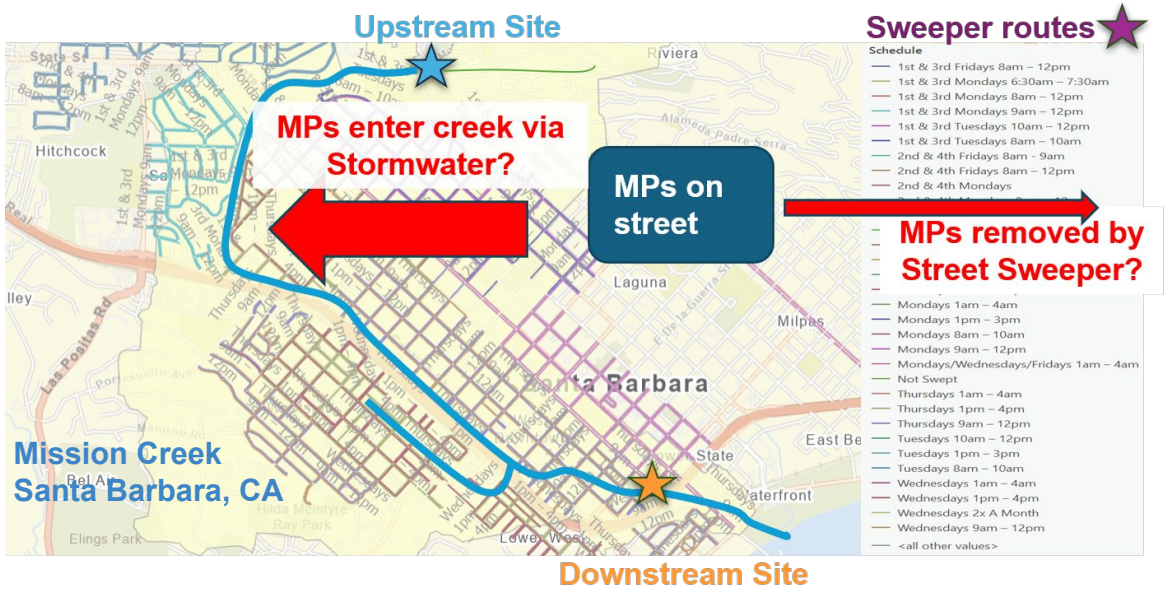
# Street Sweeping Study #2 - Results




- Street sweeping removed microplastics (85-95%)
- Significantly higher for most MP than dirt ($p<0.05$)
- Significantly higher for 63-um TWP than dirt ($p<0.05$)
- Slower speed increased pickup by ~10% for broom and regenerative air
- Vacuum >> regenerative air >> mechanical broom

# Street Sweeping Study #3 - Approach

Objective: Determine the ability of **street sweeping** to intercept microplastic and **reduce stormwater loads of microplastic on an annual basis**



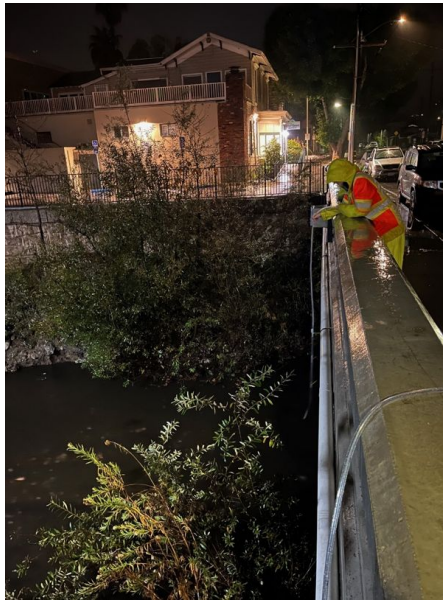
# Street Sweeping Study #3 - Methods

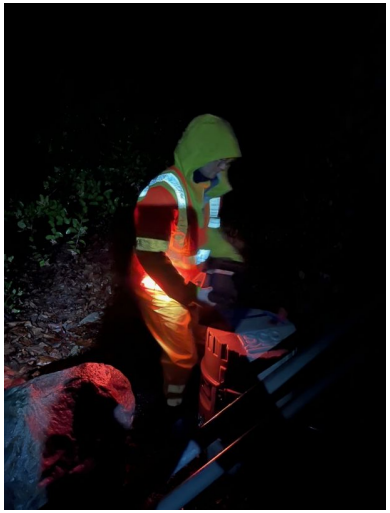


**Creek Water**

- Targeted 3 dry dates and 3 storms
- Upstream, downstream sites
- Composite over rising and falling limbs of hydrograph
- Sample size 100L water (moved intake throughout water column and near streambed, not bedload)
- Sieve sizes: 63, 125, 355 um
- Laboratory digestion: Fentin
- Microscopy: Stereomicroscopy for count, size, color, shape
- Polymer Identification: OPTIR (in progress)
- Tire Wear Particle: by color and texture

# Street Sweeping Study #3 - Methods



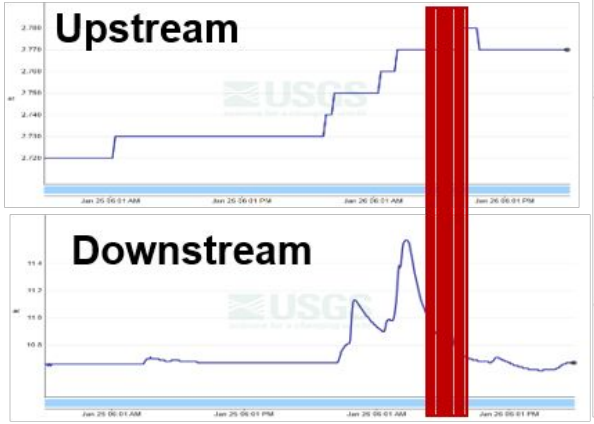




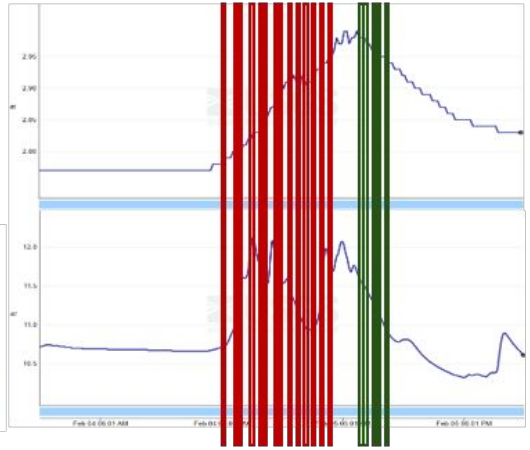



# Street Sweeping Study #3 - Methods

## Small storm Jan 26, 2025




## Medium storm Feb 3-4



Rising Limb

Falling Limb

## Large storm February 13-14



Rising Limb

Falling Limb

And 3 dry dates

# Street Sweeping Study #3 - Methods





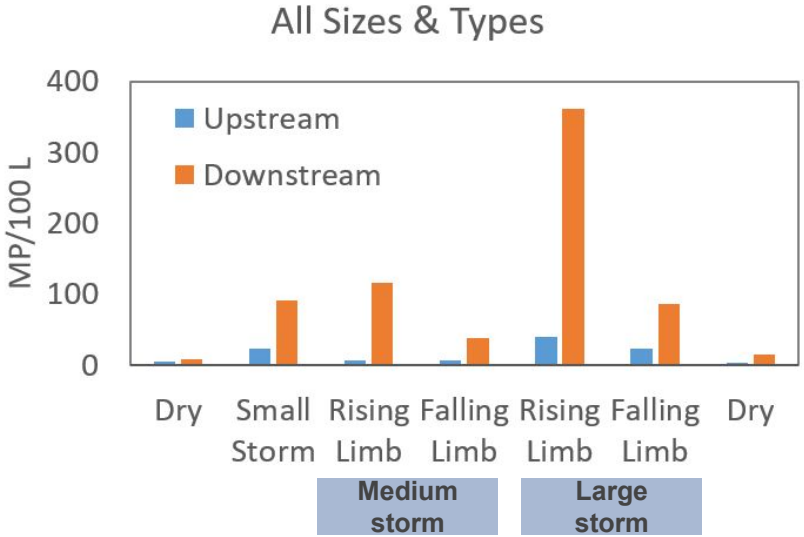

## Street Sweeper Debris

- Street sweeper- 14 L sample, composite of debris from each day
- Sieve sizes: 63, 125, 355 um
- 12 dates
- Laboratory digestion: Fentin
- Microscopy: Stereomicroscopy for count, size, color, shape
- Polymer Identification: OPTIR (in progress)
- Tire Wear Particle: by color and texture

# Street Sweeping Study #3 - Results

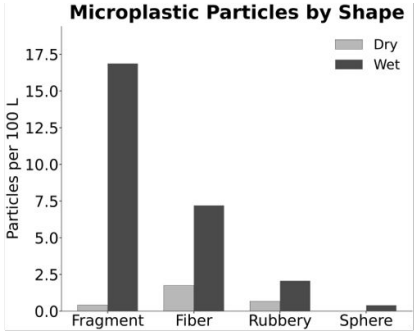
MPs in Mission Creek

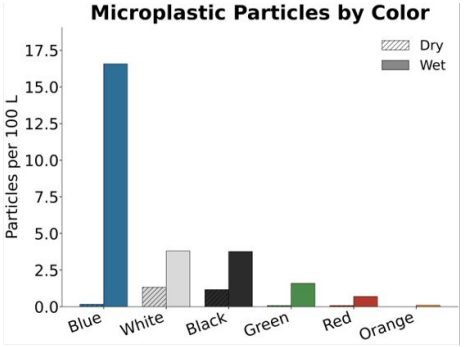
- Low in dry weather, higher in storms
- Downstream site higher
- Rising limb of storm higher
- 10% are Tire Wear Particles
- Caveat - TWP in bedload

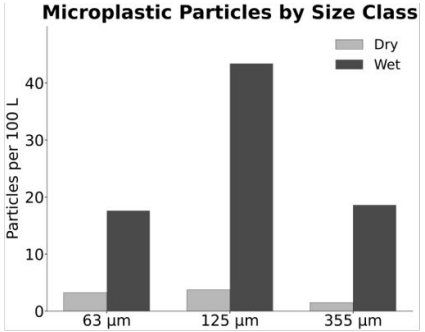



Creek Water Samples

# Street Sweeping Study #3 - Results

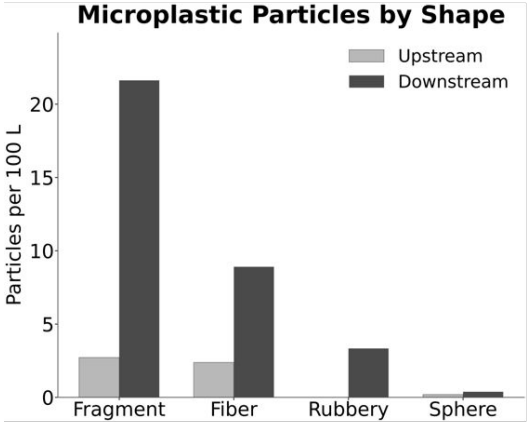


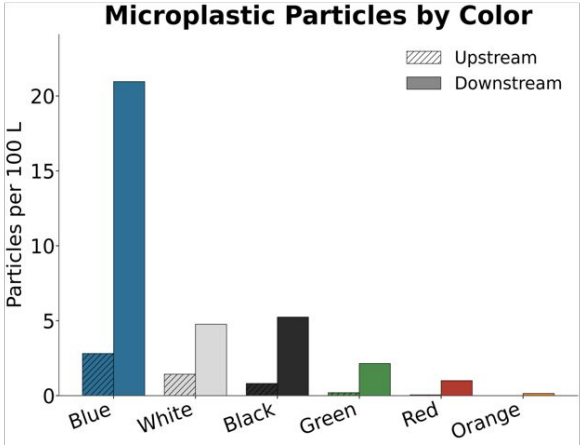



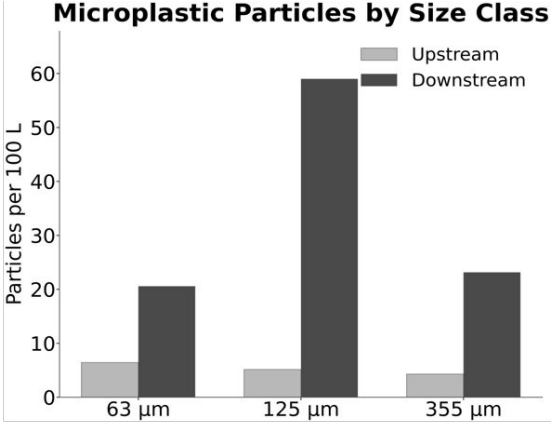




- All shapes,  colors, and sizes increase in wet weather

# Street Sweeping Study #3 - Results




- All shapes, colors, and size increase going downstream

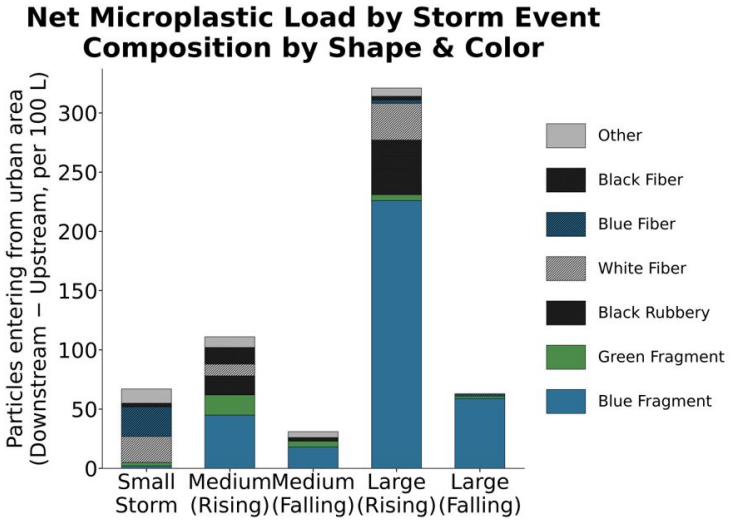
# Street Sweeping Study #3 - Results

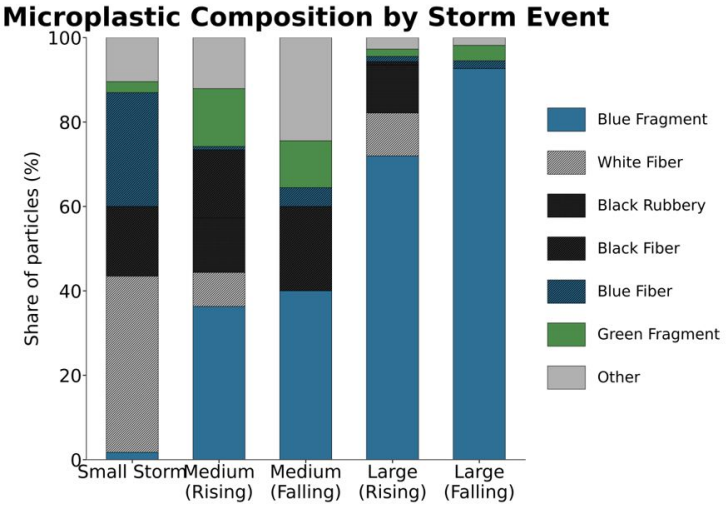
## Most Common Microplastics in Creek Water Samples

| MP Type | % of all MPs |
|---|---|
| Blue Fragments | 55% |
| White Fibers | 14% |
| Black Rubbery (TWP) | 8% |
| Black Fibers | 7% |
| Blue Fibers | 5% |
| Green Fragments | 4% |

- 6 categories account for 94% of all MPs
- 125-um blue fragments = 35%
- Source? OPTIR results coming

# Street Sweeping Study #3 - Results



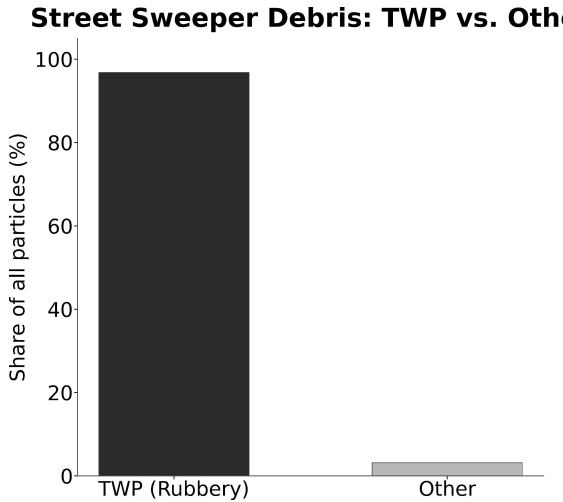

- Blue fragments highest by input numbers and proportion, except first small storm
- Blue fragments keep coming, other particles drop out

# Street Sweeping Study #3 - Results

MPs in Street Sweeper Debris

- Highest before wet season
- 97% are Tire Wear Particles
- All size classes similar

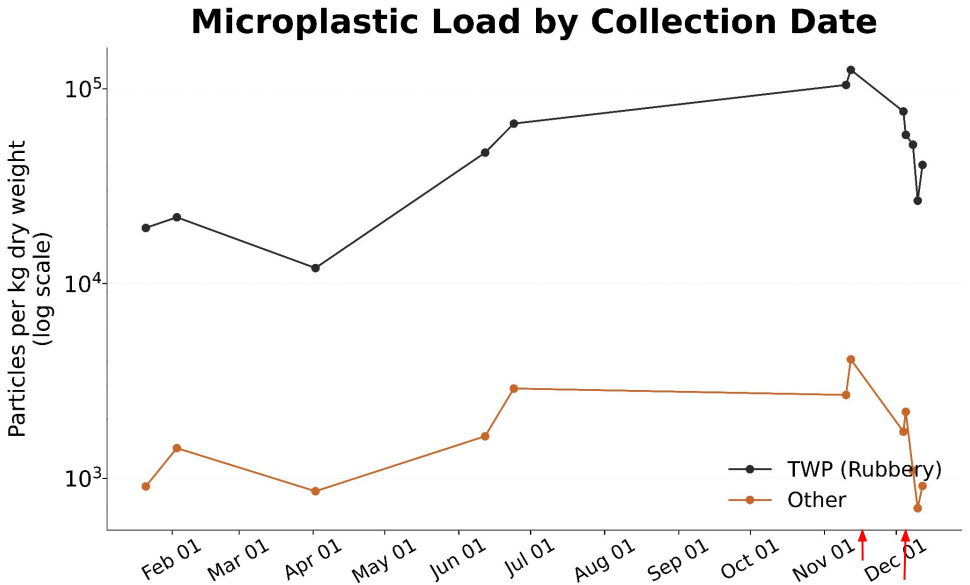


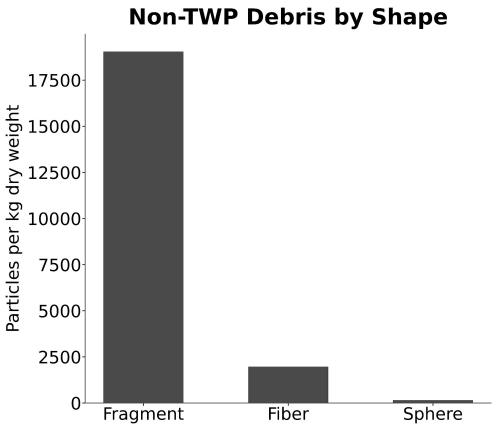
# Street Sweeping Study #3 - Results

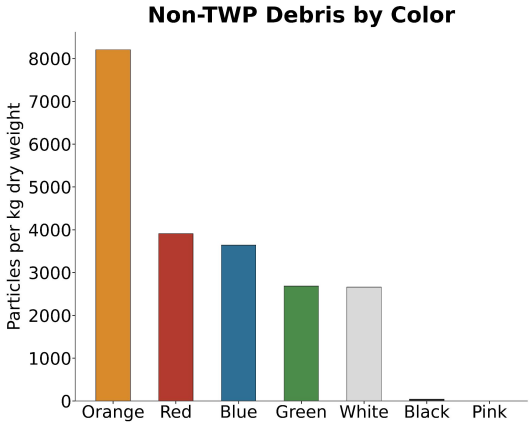
MPs in Street Sweeper Debris

- Highest before wet season
- 97% are Tire Wear Particles
- All size classes similar



# Street Sweeping Study #3 - Results

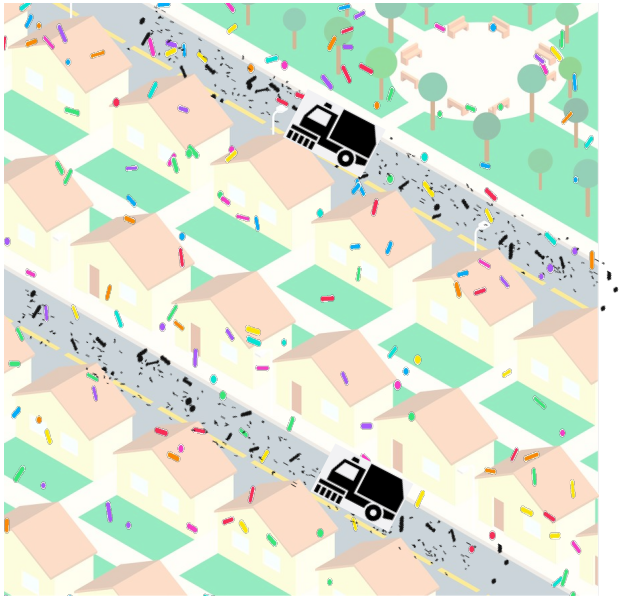



| Combo | % of "Other" |
|---|---|
| Orange Fragments | 39% |
| Red Fragments | 18% |
| Blue Fragments | 17% |
| Green Fragments | 12% |
| White Fibers | 8% |

# Street Sweeping Study #3 - Results



First estimate of annual street sweeping on impact on MP removal

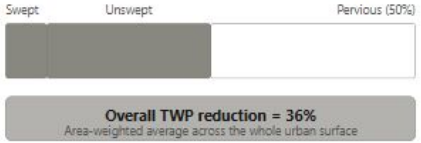
- Approx. equal number of TWPs removed by street sweeping and discharged to creek
- Approx. 1% as many colored MPs removed compared to discharged
- Likely due to concentration of TWP in street
- Caveat - did not measure transport

# Street Sweeping Study #3 - Results

## Street Sweeping and Tire Wear Particles (TWP) (Chocolate Sprinkles)

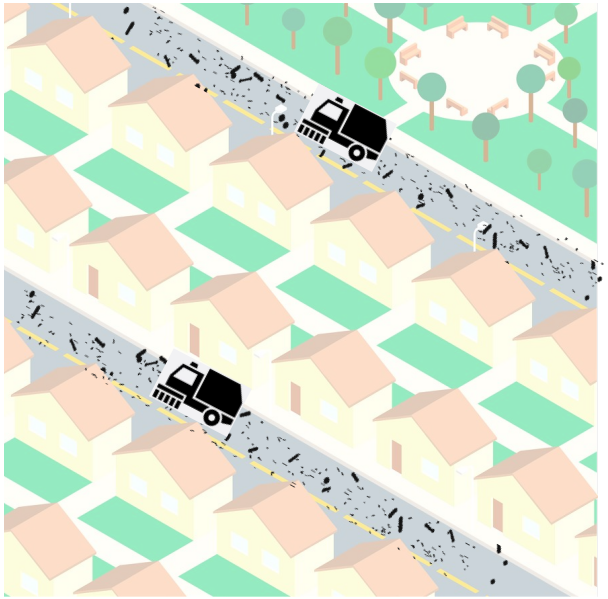
This tool shows how street sweeping may reduce tire wear particles (TWP) in the environment, based on several relevant factors. Sweeping only affects the swept portion of impervious area; runoff from unswept surfaces dilutes the overall benefit, while the higher TWP concentration typically found in swept curb areas before sweeping improves it.

| | |
|---|---|
| Fraction of total area that is impervious | 50% |
| Fraction of impervious area that is swept | 20% |
| **Relative concentration of TWP in swept areas (before sweeping), relative to unswept**<br>(curb areas collect more TWP than other impervious surfaces) | 1000% |
| **Sweeping effectiveness in swept area**<br>(annual average fraction of TWP mass removed; actual results vary by particle size class and are more environmentally significant for some sizes than others) | 50% |
| **Runoff from permeable (pervious) areas, relative to impervious surfaces**<br>(low for small storms or dry soil, high for large storms or saturated soil) | 0% |
| **TWP concentration in permeable areas, relative to impervious surfaces** | 100% |




**Overall TWP reduction = 36%**
Area-weighted average across the whole urban surface

Simple linear area-weighted mixing model. Post-sweep concentration in the swept area = pre-sweep relative concentration × (1 − sweeping effectiveness). Pervious contribution = runoff fraction × relative concentration. Actual TWP generation, transport, and sweeping removal vary substantially by particle size class, storm characteristics, soil condition, and sweeping technology — fine TWP fragments are typically harder to remove by sweeping and may pose greater environmental concern than coarse fragments.



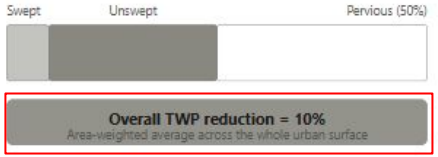
https://claude.ai/public/artifacts/ccbf8d69-67d3-44b6-9872-7d9c1fee63fa

# Street Sweeping Study #3 - Results

**Street Sweeping and** Rainbow Sprinkles

This tool shows how street sweeping may reduce tire wear particles (TWP) in the environment, based on several relevant factors. Sweeping only affects the swept portion of impervious area; runoff from unswept surfaces dilutes the overall benefit, while the higher TWP concentration typically found in swept curb areas before sweeping improves it.

| | |
|---|---|
| **Fraction of total area that is impervious** | **50%** |
| **Fraction of impervious area that is swept** | **20%** |
| **Relative concentration of TWP in swept areas (before sweeping), relative to unswept**<br>(curb areas collect more TWP than other impervious surfaces) | **100%** |
| **Sweeping effectiveness in swept area**<br>(annual average fraction of TWP mass removed; actual results vary by particle size class and are more environmentally significant for some sizes than others) | **50%** |
| **Runoff from permeable (pervious) areas, relative to impervious surfaces**<br>(low for small storms or dry soil, high for large storms or saturated soil) | **0%** |
| **TWP concentration in permeable areas, relative to impervious surfaces** | **100%** |




Simple linear area-weighted mixing model. Post-sweep concentration in the swept area = pre-sweep relative concentration × (1 − sweeping effectiveness). Pervious contribution = runoff fraction × relative concentration. Actual TWP generation, transport, and sweeping removal vary substantially by particle size class, storm characteristics, soil condition, and sweeping technology — fine TWP fragments are typically harder to remove by sweeping and may pose greater environmental concern than coarse fragments.

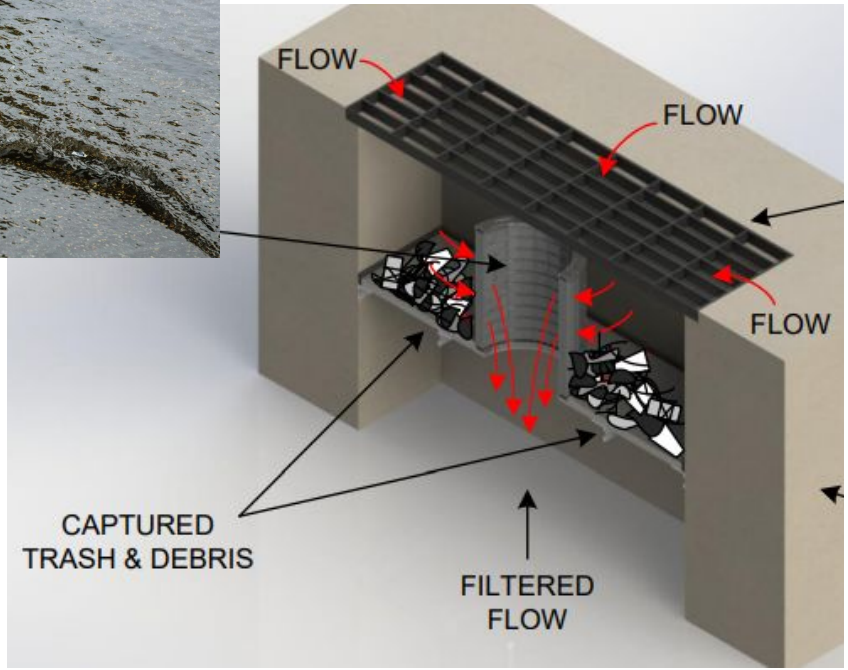


https://claude.ai/public/artifacts/ccbf8d69-67d3-44b6-9872-7d9c1fee63fa

# Trash Capture Devices



Objective: Evaluate whether trash capture devices generate, capture, or pass along MP



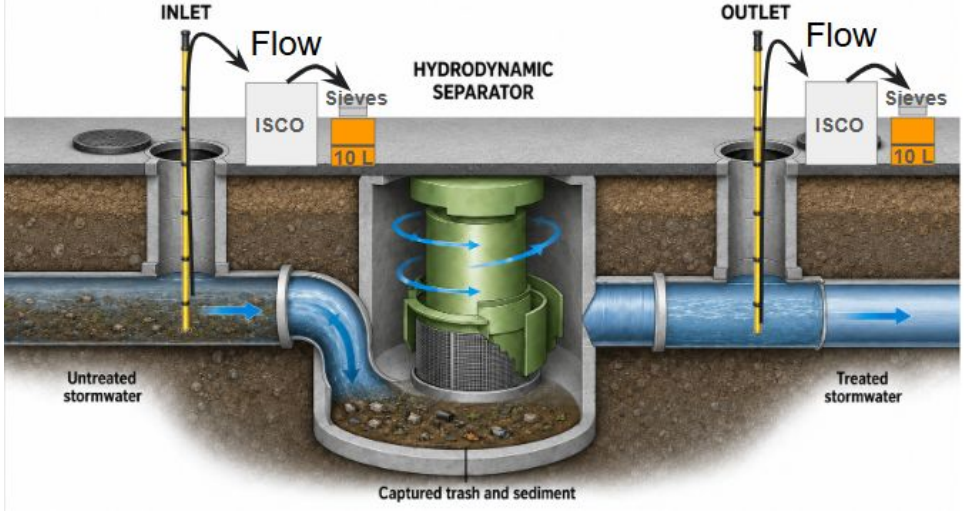



Is microplastic generated by tumbling litter?

# Trash Capture Device Study

Stormwater Sampling at Inlet and Outlet





# Trash Capture Device Study

Different types of devices sampled



Connector Pipe Screen (CPS) (right)



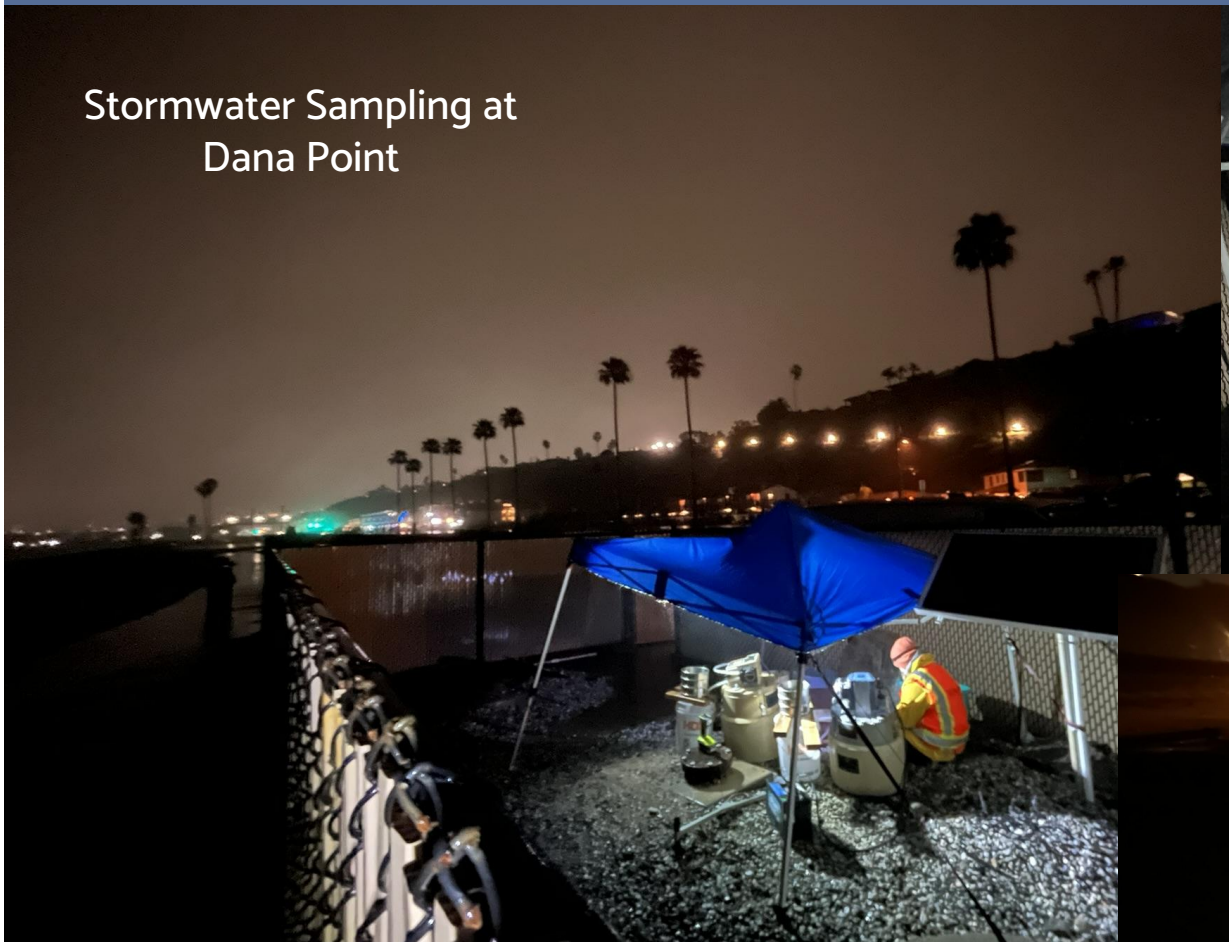

Drop Inlet (above)



Continuous Deflector System (CDS) Hydrodynamic Separator (left)

# Trash Capture Device Study

Stormwater Sampling at
Dana Point







# Trash Capture Device Study

Stormwater runoff samples collected with sieves











Sample volume: 20 - 40 L stormwater runoff
Sieve sizes: 50 µm, 125 µm
Particle and Polymer Identification: FTIR (in progress)

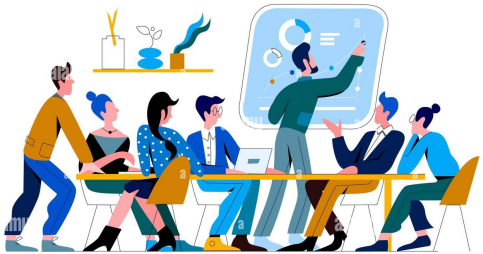
# Engagement & Education

Objective: Engage stormwater managers, Public Works groups, non-governmental organizations, and public audiences to maximize impact and innovation of research approach and findings

Sea Grant
UNIVERSITY OF SOUTHERN CALIFORNIA

## Technical Advisory Committee

Guides research and technical application



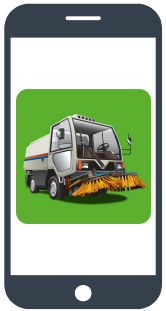
## Education & Engagement Working Group

Connects research with educators and students



## Street Sweeping Notifications & Alerts

Helps residents comply with street-streeping schedules



# Technical Advisory Committee (TAC)

The TAC is made up of representatives from:

- **California State Agencies**
  - CalTrans District 4 *(Daisy Laurino)*
  - Los Angeles Regional Water Quality Control Board *(Ivar Ridgeway)*
  - Ocean Protection Council *(Kyla Kelly)*
- **California County & City Public Works**
  - Orange County Public Works *(James Fortuna)*
  - City of Los Angeles, Watershed Protection Division *(Jon Ball)*
  - City of San Diego, Stormwater Division *(Kellyn Baker)*
- **Consulting Firms & Specialists**
  - Geosyntec Consultants *(Brandon Steets)*
  - Herrera Environmental Consultants *(Dylan Ahearn)*
  - Inland Engineer Consultants *(Yaneth (Janet) Rodriguez Livesey)*
  - University of Nevada, Reno, Hydrology/Microplastics PhD student *(Rachel Kozloski)*



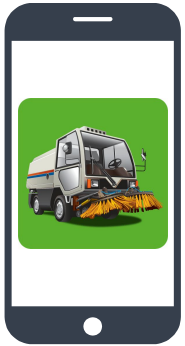
# Street Sweeping Notifications

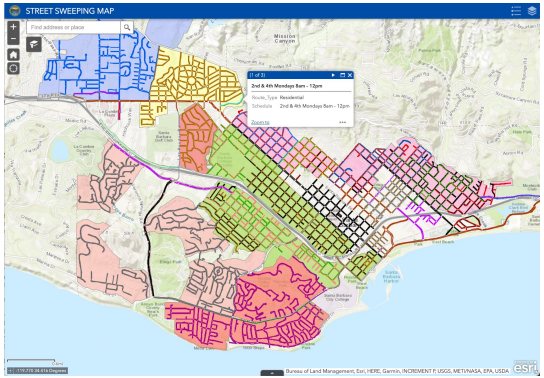
Text alert system to help Santa Barbara residents comply with street sweeping schedules

- Reminds residents when to move parked vehicles on selected streets
- Alerts users of street sweeping schedule changes
- Goal: Reduce parking violations and improve street sweeping effectiveness







# Education & Engagement Working Group (EEWG)

**San Francisco / Bay Area:**

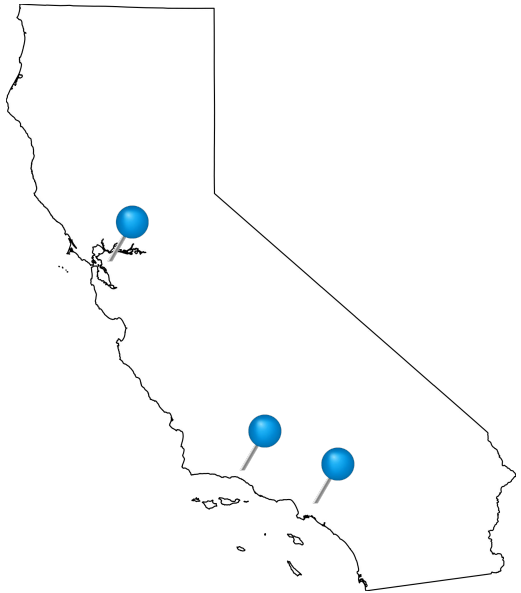
- Ecole Bilingue de Berkeley (French-American Bilingual School) - **George Speckman**
- San Francisco Marine Science Institute - **Kyrie Vesley**
- San Francisco State University - **Stephanie Sisk-Hilton**

**Santa Barbara / Ventura:**

- Explore Ecology - **Veronica Lee**
- Santa Barbara ChannelKeeper - **Penny Owens**
- MERITO Foundation - **Rocío Lozano Knowlton**

**Los Angeles:**

- Marine Biologist and Environmental Steward - **Jennifer Kolbauer**
- Pasadena City College - **Jillian Blatti**
- Generation Earth (TreePeople) - **Maria Adame**



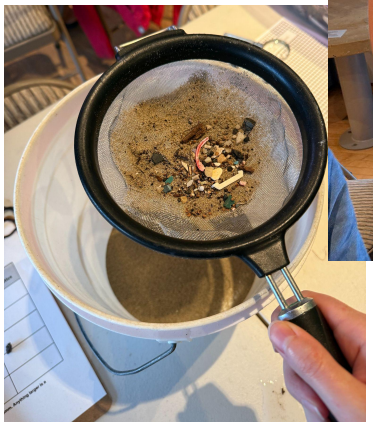
# City of Santa Barbara Creek Week

Hosted a Microplastics Talk & Watershed Activity during City of Santa Barbara's annual Creek Week in 2025!







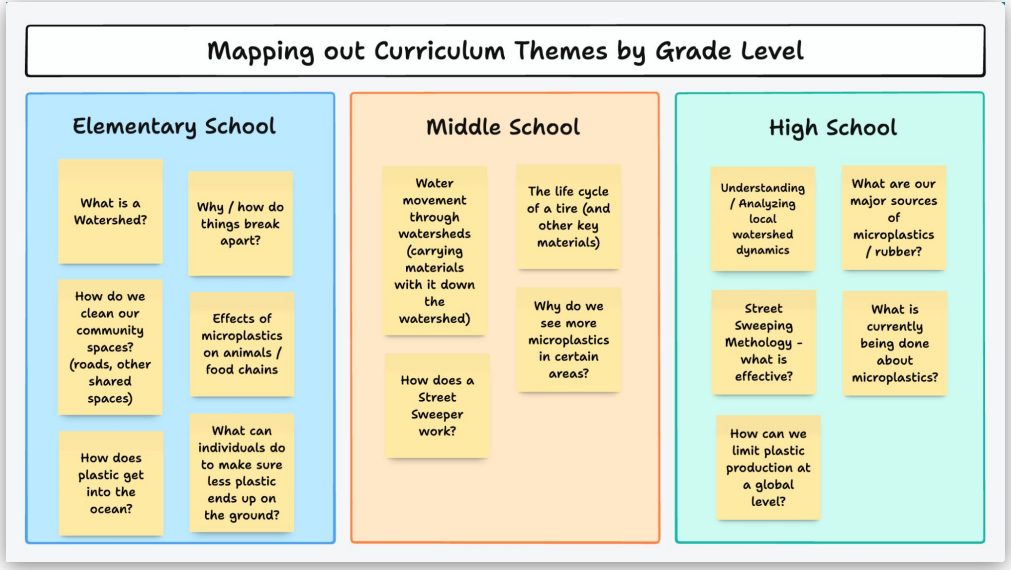




# Curriculum Series Development

Elementary, Middle, & High School level curricula in-progress:

- **4th-5th grade:** Adapted watershed lesson to include microplastic pollution and street sweeping
- **6th-8th grade:** Adapting "Watersheds to Whales" lesson from NOAA Marine Sanctuaries
- **AP Environmental Science:** Developing a tire-wear particle & coho salmon case study with integration across APES unit curriculum

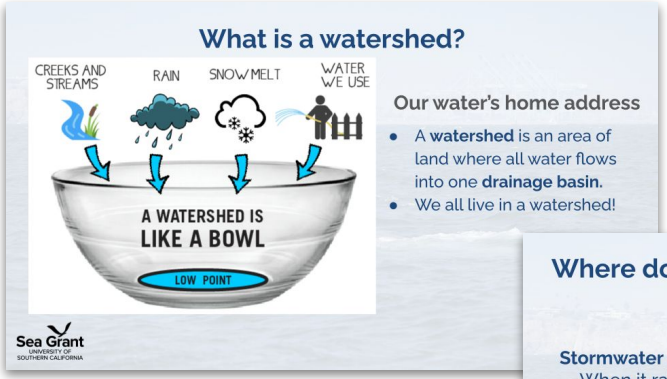



Curriculum series and other reports/resources will be publicly accessible on our project page by spring/summer 2027!
https://dornsife.usc.edu/uscseagrant/clean-streets-clean-seas/

# Curriculum Series - Elementary Watershed Lesson

## 4th & 5th grade watershed lesson:

- Adapted watershed lesson to include microplastic pollution and street sweeping concepts







**EnviroScape® Watershed Model Clean Streets, Clean Seas Lesson**

**Subject: Impact of microplastics on waterways and marine environments, and street sweeping as a solution**

**Grades: 4-5**
**Time: 1 hour**

**Materials:**

- Enviroscape watershed model
- Google slides presentation
- Individual pieces to the watershed model (houses, animals, etc.).
- Large posterboard size paper
- 100 "clean" droplets
- 60 "microplastic" droplets
- Water
- Watering can
- Cocoa powder (microplastics produced by cars)
- Sugar-free drink mix (microplastics produced by trash)
- Sponges (bioswales)
- Plastic cup/bottle (for beginning plastic pollution demonstration)

**NGSS Essential Standards and Clarifying Objectives**

- NGSS PE: 5-ESS3-1 – Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment.
- DCI: ESS3.C – Human activities in agriculture, industry, and everyday life affect land, vegetation, streams, oceans, and air, but people also take actions to protect these systems.

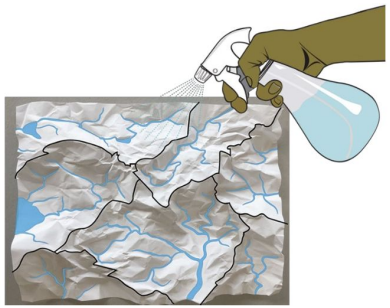
**Lesson objective(s):**

- Describe what a watershed is and show how water flows from high to low ground using the EnviroScape watershed model.
- Understand what microplastics are and describe two examples of where microplastics come from.
- Explain at least two ways that humans create microplastics.
- Explain how microplastics enter our waterways through stormwater runoff.
- Explain the negative impacts of microplastics on the environment, and the negative impacts on animals and people.
- Describe how communities play a role in keeping watersheds healthy.
- Explain how public works can contribute to keeping watersheds clean.

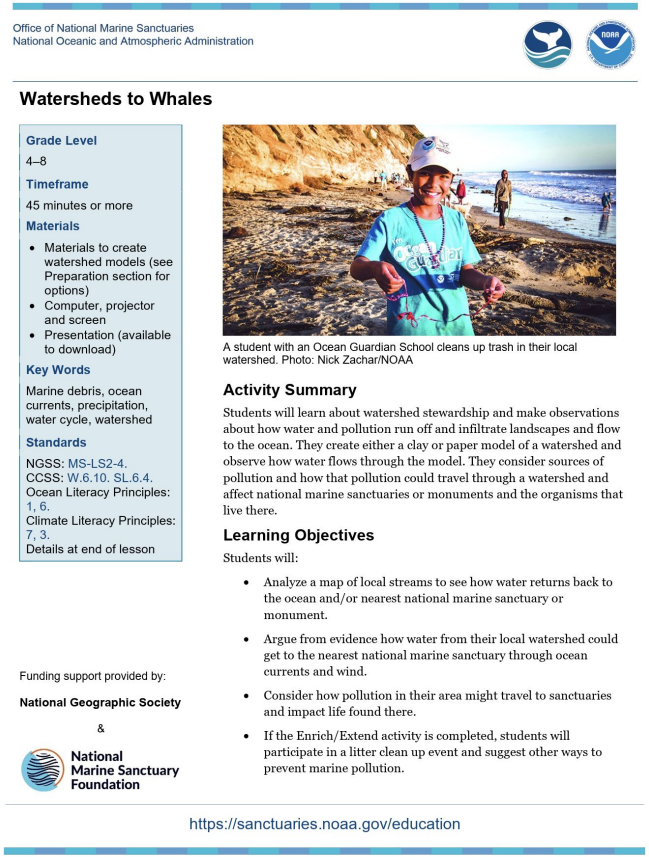
# Curriculum Series - Middle School Watershed Lesson

## 6th - 8th grade watershed lesson:

- Adapted from NOAA's Office of National Marine Sanctuaries' "Watersheds to Whales" lesson
- Includes topics: watersheds, runoff, pollution transport
- Students build 3D models/maps of a watershed and observe flow of water
- Replace oil/food coloring with simulated tire wear particles and microplastics
- Additional thought questions (e.g., "where would a street sweeper interrupt this pathway?)



A crumpled paper watershed model
Graphic: Adapted from SERP (CC BY-NC-SA)



Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration

### Watersheds to Whales

**Grade Level**
4–8

**Timeframe**
45 minutes or more

**Materials**
- Materials to create watershed models (see Preparation section for options)
- Computer, projector and screen
- Presentation (available to download)

**Key Words**
Marine debris, ocean currents, precipitation, water cycle, watershed

**Standards**
NGSS: MS-LS2-4.
CCSS: W.6.10. SL.6.4.
Ocean Literacy Principles: 1, 6.
Climate Literacy Principles: 7, 3.
Details at end of lesson

Funding support provided by:
**National Geographic Society**
&
**National Marine Sanctuary Foundation**

A student with an Ocean Guardian School cleans up trash in their local watershed. Photo: Nick Zachar/NOAA

**Activity Summary**

Students will learn about watershed stewardship and make observations about how water and pollution run off and infiltrate landscapes and flow to the ocean. They create either a clay or paper model of a watershed and observe how water flows through the model. They consider sources of pollution and how that pollution could travel through a watershed and affect national marine sanctuaries or monuments and the organisms that live there.

**Learning Objectives**

Students will:

- Analyze a map of local streams to see how water returns back to the ocean and/or nearest national marine sanctuary or monument.
- Argue from evidence how water from their local watershed could get to the nearest national marine sanctuary through ocean currents and wind.
- Consider how pollution in their area might travel to sanctuaries and impact life found there.
- If the Enrich/Extend activity is completed, students will participate in a litter clean up event and suggest other ways to prevent marine pollution.

https://sanctuaries.noaa.gov/education

# Curriculum Series - AP Environmental Science (APES)

## ROADS TO RIVERS

### Tire Wear Particles, 6PPD-Quinone, & Coho Salmon

*An AP Environmental Science (APES) Case Study and Associated Curriculum*

| **Materials Provided** | **Duration** | **Primary Unit** | **Cross-Units** |
|---|---|---|---|
| Overview, Lesson Plans, Worksheets, Slides | 8 class periods throughout the course | Unit 8 | Units 1–5, 7, 9 |



For over twenty years, residents, students, and scientists watched coho salmon return to their streams and die before spawning, but no one knew why.



The answer lies in one of the great interdisciplinary detective stories in environmental science: a tire-rubber chemical, turned deadly by ozone in ordinary road dust.

# Curriculum Series - APES Case Study

**Units**

- **Unit 1:** The Living World: Ecosystems
- **Unit 2:** The Living World: Biodiversity
- **Unit 3:** Populations
- **Unit 4:** Earth Systems and Resources
- **Unit 5:** Land and Water Use
- **Unit 6:** Energy Resources and Consumption
- **Unit 7:** Atmospheric Pollution
- **Unit 8:** Aquatic and Terrestrial Pollution
- **Unit 9:** Global Change

## 5.13 Methods to Reduce Urban Runoff

Verified for the 2027 exam · Updated September 2026 · Fiveable Content Team

listen · add to ChatGPT · print · cite

### How do you reduce urban runoff in AP Environmental Science?

Urban runoff is rainwater and snowmelt that flows off hard city surfaces instead of soaking into the ground. You reduce it by increasing water infiltration: swapping regular pavement for permeable pavement, planting trees, using more public transportation, and building up instead of out. These methods cut down flooding, pollution, and groundwater depletion in cities.

Unit 5 resources | MCQs | FRQs | Practice test | Cheatsheets

### Why This Matters for the AP Environmental Science Exam

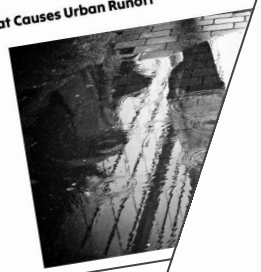
This topic is your go-to for proposing solutions to a human-caused environmental problem, which is exactly the kind of thinking AP Environmental Science rewards. When you understand why impervious surfaces create runoff, you can connect this topic back to urbanization (Topic 5.10) and forward to water pollution ideas in later units.

On the exam, you may be asked to describe methods that reduce urban runoff and explain how each method works. Being able to name a specific method and then explain the mechanism (more infiltration, less surface flow) is what separates a full-credit answer from a vague one.

### Key Takeaways

- Urban runoff happens when precipitation hits impervious surfaces like roads, sidewalks, parking lots and cannot soak into the soil.
- The main goal of runoff mitigation is to increase water infiltration so water reaches the ground instead of rushing off.
- Permeable pavement lets water pass through into the soil below, reducing surface
- Planting trees helps because roots and soil absorb water, and tree canopy slows
- Increasing public transportation use reduces the need for wide roads and lar which means fewer impervious surfaces.
- Building up instead of out keeps development compact, leaving more op absorb water.

### What Causes Urban Runoff



continue practicing 5.13
- Multiple choice
- Free response
- Unit 5 practice test

report an error

| Fremont Water Data |
|---|
| The shopping center's parking lot is 200 meters long and 100 meters wide. |
| Fremont has an area of 10 $km^2$. |
| Impervious surfaces cover 20 percent of Fremont's area. |
| The FWTP typically treats 5,000 $m^3$ of domestic sewage per day. |
| The FWTP has the capacity to treat 10,000 $m^3$ of combined sewage and storm water per day. |

**(a) Identify TWO specific pollutants in storm-water runoff that degrade the quality of surface water.**

You can earn two points—one for each specific pollutant. Some correct answers to this part include nitrogen, phosphates, pesticides, herbicides, trash, and detergents.

- 4.6 Watersheds
- 4.7 Solar Radiation and Earth's Seasons
- 4.8 Earth's Geography and Climate
- 4.9 El Niño and La Niña

continue practicing 4.6
- Multiple choice
- Free response
- Unit 4 practice test

report an error

### What a Watershed Is



Image Courtesy of Pixabay

A watershed, also called a drainage basin or catchment, is all the land area that collects and channels runoff toward one main discharge point. That point is usually a large body of water like a lake or ocean, and it sits at the lowest elevation in the watershed.

**Headwaters** are the beginning of a watershed, often at higher elevations downhill, forming streams and rivers that move toward the outlet.

Watersheds are separated from each other by form the boundary between one wa flows toward one outlet.

# Curriculum Series - APES Case Study




YouTube Link

# Curriculum Series - APES Case Study




| Lesson | Title | Unit(s) |
|---|---|---|
| 1 | The Mystery (+ optional Particle Math add-on) | Introduction |
| 2 | Ecosystem Stakes | Units 1 & 2 |
| 3 | Population Collapse | Unit 3 |
| 4 | The Pathway | Units 4 & 5 |
| 5 | The Chemistry | Units 7 & 8 |
| 6 | The Dose | Units 8 & 5 |
| 7 | The Response | Units 9 & 5 |
| 8 | Capstone | Units 9 & 8 |

Benefits:

- Touches on eight APES units
- Addresses five APES Science Practices
- Is interdisciplinary in nature – ecology, biology, environmental chemistry, watersheds, hydrology, stormwater BMPs, and policy
- Involves an impact all of us contribute to and is engaging to teens – driving
- Focuses on salmon but can be adapted to impacts on other species
- Shows the scientific process up close, describing how researchers learned which chemical is doing the environmental damage
- Includes many opportunities for quantitative practice
- Is contemporary and relevant
- Environmental scientists are working on solutions right now - you can follow this story and add more content

# Curriculum Series - APES Case Study

**Lesson Jobs — Purpose & Learning Outcomes**

### Lesson 1: The Mystery
*Introduction (course opener, ~day 2)* • *Anchor: Longfellow Creek, West Seattle*

**Purpose:** Hook students with a genuine scientific whodunit and model how environmental science actually works.
**Students walk away able to:** Describe the URMS mystery, generate testable hypotheses, and explain why the problem took 20 years and multiple disciplines to solve.
*Optional add-on — Particle Math: introduces dimensional analysis (SP6) using tire wear (mass → particles, g → mg → µg → ng, surface-area/size scaling). Deployable here early, or portable into The Pathway or The Dose.*

### Lesson 2: Ecosystem Stakes
*Units 1 & 2* • *Anchor: Longfellow Creek / Puget Sound*
**Purpose:** Show why coho matter — build the food web and reveal coho as both keystone and indicator species.
**Students walk away able to:** Construct a Pacific coastal stream food web, trace a trophic cascade from coho loss, and explain the marine-derived nutrient subsidy.

### Lesson 3: Population Collapse
*Unit 3* • *Anchor: Longfellow Creek*
**Purpose:** Quantify how fast a population crashes under pre-spawn mortality, grounded in real Longfellow Creek survey data (49–90% PSM since 2015).
**Students walk away able to:** Model population decline over generations, solve for the stability-threshold mortality rate, and connect the math to real recovery timelines.

### Lesson 4: The Pathway
*Units 4 & 5* • *Anchor: Longfellow Creek*
**Purpose:** Trace the particle from road to creek and show how urbanization transforms water and pollutant movement.
**Students walk away able to:** Compare natural vs. urban hydrology, map the stormwater pathway, and calculate first-flush pollutant loads.

### Lesson 5: The Chemistry
*Units 7 & 8* • *Anchor: Puget Sound region*
**Purpose:** Explain how an antiozonant becomes a toxin — the ozone photochemistry that creates 6PPD-Q.
**Students walk away able to:** Write the NOx + VOC → ozone → 6PPD-Q reaction chain and connect regional ozone conditions to aquatic toxicity.

### Lesson 6: The Dose
*Units 8 & 5* • *Anchor: Longfellow Creek*
**Purpose:** Deliver the scientific resolution to the mystery — dose-response and species sensitivity.
**Students walk away able to:** Interpret a dose-response curve, calculate LC50 exceedances, and (if Particle Math is included) explain why particle size drives chemical release.

### Lesson 7: The Response
*Units 9 & 5* • *Anchor: Longfellow Creek / Duwamish*
**Purpose:** Confront the management reality — the three tracks, their trade-offs, and policy/equity — with the non-structural track built around authentic street-sweeping research.
**Students walk away able to:** Compare source control, non-structural, and structural management; analyze why no single track suffices; and critique a real study design.
*Non-structural track is the centerpiece — see Signature Research Feature below.*

### Lesson 8: Capstone
*Units 9 & 8* • *Anchor: Mission Creek (worked example) → student's own watershed*
**Purpose:** Synthesize everything into a defensible watershed protection plan — first modeled on Mission Creek, then applied to the student's own local watershed.
**Students walk away able to:** Design an integrated, evidence-based watershed plan AND design how they would measure whether it works (transferring experimental-design thinking from The Response).

- **Rigorously checked and re-worked generative AI.**

## For each unit

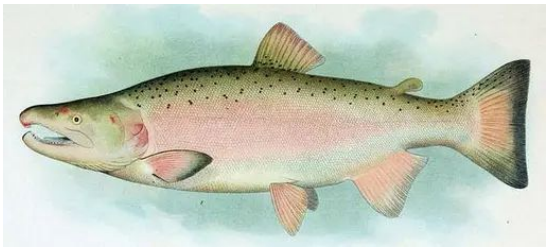
- Teacher guide
- Student worksheet
- Teacher slides

# Summary & Next Steps

- Multiple lines of evidence support street sweeping for microplastic interception
  - Leverages BMP already used by Public Works departments nationwide
  - Suggests greatest benefit from regenerative air sweepers driven at slow speed with vacuum
  - Addresses particles < 5 mm not captured by California Trash Amendment requirements
  - Reduces transport of microplastics from streets to aquatic ecosystems
  - Targets capture of tire-wear particles, helping protect fisheries

- Next Steps
  - Complete sample processing & catch basin sample collection
  - Synthesize results & expand outreach (Master's Group Project, disseminate curricula, public presentations)

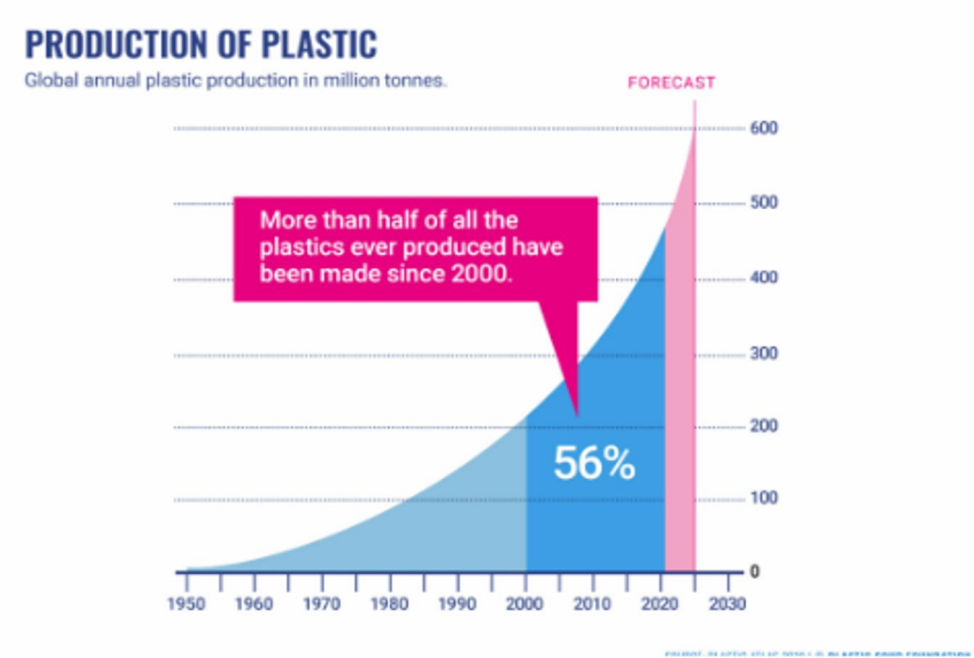






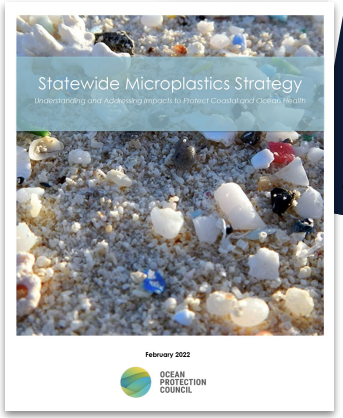


# Plastics will continue to increase




Source: Plastic Atlas 2019 Plastic Soup Foundation






# Thanks for listening!



*Questions?*


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