PACIFIC SALMON FOUNDATION

CONTAMINANTS NEWSLETTER

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Photo: Eiko Jones

Stormwater runoff poses a significant threat to our precious waterways and aquatic ecosystems. As rainwater flows over urban areas, it picks up a range of toxic chemicals, which are then delivered into sensitive environments. Metro Vancouver, a highly urbanized region, sits at the base of one of the world's most important salmon runs. Runoff into the Fraser River catchment has severely impacted salmon habitats through increased water velocity, the addition of harmful silts and toxins, and altered temperatures.

To better understand the impact of stormwater runoff on salmon habitats and to explore opportunities for more effective stormwater management, PSF spoke with municipalities located along the Lower Fraser River. The objective of this effort was to identify key barriers to effective stormwater management and suggest actionable recommendations to mitigate the harmful effects of runoff. Our report compiles insights from interviews with municipal representatives, supported by a literature review, and offers a series of recommendations. It is available to download at the PSF Marine Science Program page. In this newsletter, we summarize the report's highlights, providing readers with a background on stormwater and solutions to improve aquatic habitats in developed areas.

Photo: Mitch Miller

Cover photos by Nicole Christiansen (left and right), Eiko Jones (centre).

FIRST THINGS FIRST – WHAT IS STORMWATER?

When rainwater or snowmelt flows over impervious surfaces like roofs, roads, and commercial and industrial zones, it collects a range of contaminants, including fertilizers, heavy metals, oil, PCBs, pesticides, and road salts. Without natural absorption or filtration, the increased volume of untreated runoff is channelled into sensitive waterways, often at high velocities, leading to flooding, erosion, increased sediment and pollution loads, and elevated water temperatures. Traditional drainage infrastructure, including gutters and pipes exacerbates the issue by concentrating the stormwater into smooth conduits that lead directly into the water bodies (Fig. 1).

IMPACTS OF STORMWATER RUNOFF ON PACIFIC SALMON

Pacific salmon hold significant cultural and economic value in British Columbia; however, the proximity of human development to freshwater, estuarine, and marine habitats can pose a significant threat to a myriad of species, including Pacific salmon (Fig. 2).

The various chemicals and particles that make up stormwater originate from a variety of sources and can affect salmon in different ways. On the next page, Table 1 summarizes where pollutants in stormwater come from and what happens to salmon when they are exposed to those pollutants.

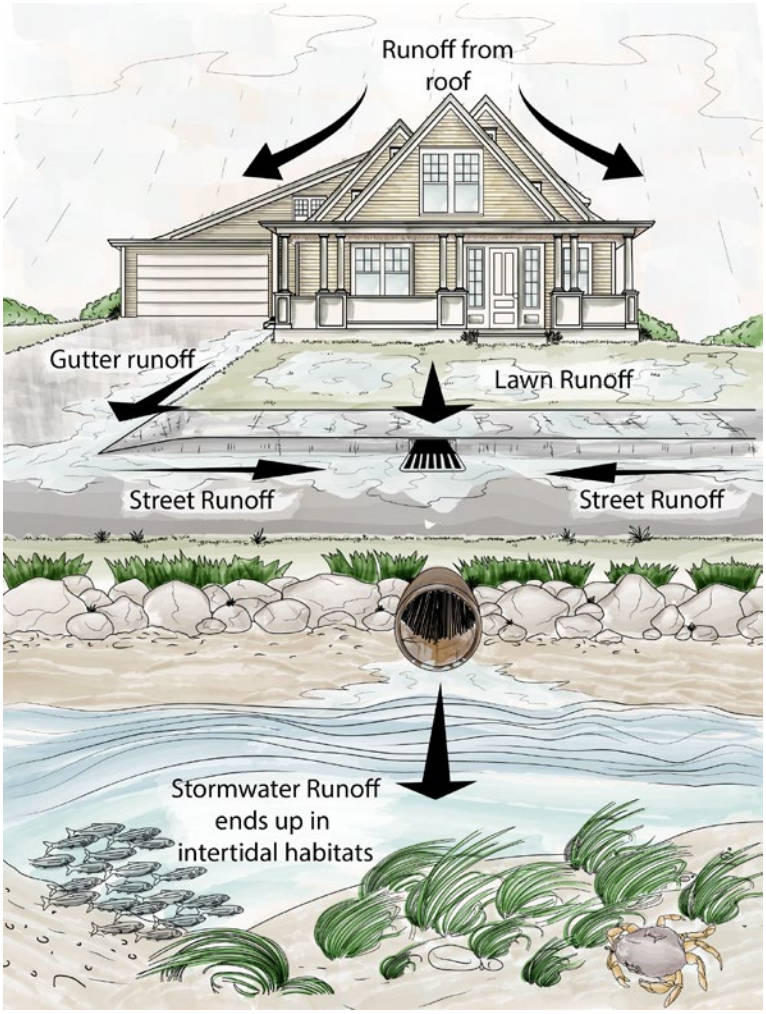

Figure 1. During stormy weather, rainwater runs off impermeable surfaces, such as roofs and roads, into storm drains. Then it typically flows untreated directly into waterways, carrying the sediment and pollutants it picked up along the way.

Illustration: Holly Sullivan and Ravi Maharaj

Figure 2. A yellow salmon emblem is often painted next to storm drains to remind the public that precious wildlife lives downstream.

Photo: Eiko Jones

Table 1. Common pollutants found in urban stormwater, their sources, and their impact on salmon. Refer to the full report for the literature that informs this table.

Constituent	Origin	Impact on Salmon
Copper (Cu)	▸ Break and exhaust emissions from automobiles ▸ Building siding ▸ Industrial discharges ▸ Municipal sewage ▸ Agricultural pesticides and fertilizers	▸ Neurobehavioural toxicant — interferes with the ability of fish to detect and respond to chemical signals in aquatic environments ▸ Toxic to sensory systems of fish — impairs ability to detect odours (olfactory impairment) > Disrupts anti-predator response ▸ Disrupts the downstream migration of juvenile salmonids and reduces survival in seawater ▸ Induces stress and increases susceptibility to secondary stressors through reduced immune response
Nickel (Ni)	▸ Fossil fuel combustion ▸ Mining, smelting, refining ▸ Waste incineration	▸ Respiratory toxicity — alters gill morphology ▸ Impairs swim performance and oxygen consumption patterns
Zinc (Zn)	▸ Brick walls ▸ Tire wear ▸ Metal roofs	▸ May induce avoidance of rearing habitat ▸ Induces physiological stress and reduces immune response
Cadmium (Cd)	▸ Wet deposition ▸ Building walls ▸ Dry deposition ▸ Smelter fumes and dust ▸ Fertilizers ▸ Municipal wastewater and sludge discharges	▸ Disruption of the olfactory system ▸ Reduces growth
Petroleum-Derived Compounds (oils, grease, vehicle exhaust, soaps and detergents)	▸ Industrial and domestic ▸ Soaps ▸ Car washing ▸ Lawns ▸ Roadways ▸ Parking lots	▸ Suppresses the immune system ▸ Renders the organism more vulnerable to pathogens ▸ Depresses the growth rate of juvenile salmon ▸ Impacts the cardiovascular system causing heart failure or permanent heart defects
6PPD-quinone	▸ Tire wear particles	▸ Lethal acute toxicity where the onset of symptoms includes: > Disrupts vascular permeability > Gasping at water's surface > Fin splaying > Loss of equilibrium ▸ Blood-brain barrier compromised
Pesticides (insecticides, herbicides, fungicides)	▸ Agricultural practices ▸ Landscape maintenance	▸ Suppresses the immune system ▸ Renders the organism more vulnerable to pathogens ▸ Toxic to the salmon nervous system – disrupting feeding and predator avoidance ▸ Disrupts the food web by depleting aquatic and terrestrial species salmon rely on for food
Nutrient Rich Material	▸ Agricultural runoff ▸ Landscape maintenance ▸ Municipal wastewater ▸ Pets and wildlife	▸ Causes plant and algal blooms, which has cascading impacts to salmon habitats, including depletion of oxygen levels below what can support salmon
Sediment	▸ Soil Erosion	▸ Smothers stream habitat, alters stream flow ▸ Increases nutrients to harmful levels ▸ Suffocates spawning gravel where eggs could be laid ▸ Impacts proper water flow, therefore reducing oxygen exchange to eggs ▸ Reduces the amount of light penetration into the water column and increases turbidity
Thermal Pollution	▸ Dark impervious surfaces such as streets and rooftops ▸ Loss of streamside trees due to erosion of banks	▸ Energy loss and increase of non-aerobic fuelling resulting in oxygen debt and reduced capacity to recover ▸ Energetic trade-offs impact migration ▸ Production of less viable gametes

SPOTLIGHT ON 6PPD-Q

For the past two decades, researchers in the Pacific Northwest have been studying the phenomenon of urban runoff mortality syndrome in coho salmon, where exposure to road runoff was causing mortality of 40-90% of returning coho salmon prior to spawning. It is now understood that these storm-water-driven die-offs are caused by a compound derived from a preservative in tires called 6PPD (Fig. 3). When this compound reacts with ozone in the air, it transforms into a highly toxic form called 6PPD-quinone (6PPD-Q) (N-(1,3-dimethylbutyl)-N′-phenyl-p-phenylenediamine-quinone); both compounds surpass the threshold for very high acute aquatic toxicity in the Globally Harmonized System of Classification and Labelling of Chemicals.

Evolving research indicates that environmentally relevant concentrations of 6PPD-Q do not affect all closely related salmonid species equally. Studies have shown that coho and Chinook salmon, cutthroat, steelhead and rainbow trout, and white-spotted char are the salmonids most sensitive to 6PPD-Q. The onset of acute symptoms mimics respiratory distress, including gasping at the water's surface, fin splaying, and loss of equilibrium. The progression from asymptomatic to death can occur within a span of a few hours.

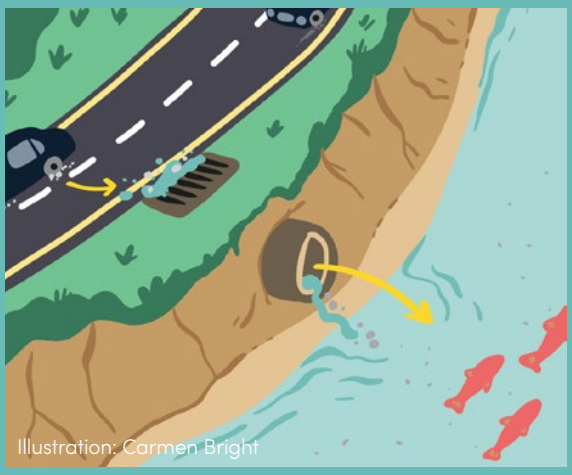

Figure 3. Particles from tires are shed into the environment as vehicles drive around. When it rains, the problematic particles and chemicals wash into streams. It is thought that the highest concentrations of 6PPD-Q occur with the first rain after a period of dry weather. This matches the behaviour of Pacific salmon species that wait for the rain in the fall to make their migrations after the dry summer.

As we are learning about the devastating impacts of 6PPD-Q researchers are also discovering how to mitigate the impacts with green infrastructure, as well as monitoring where and when harmful spikes of 6PPD-Q occur to prioritize intervention. For example, it has been found that stormwater bioretention systems, or rain gardens, designed with a bioretention soil mixture that includes biochar can effectively mitigate more than 90% of 6PPD-Q loadings to water bodies under typical storm conditions.

To learn more, visit this link, which includes talks given by the leading experts researching 6PPD-Q at a Tire Toxin Workshop held by the BC Conservation Foundation (BCCF) Aquatic Research & Restoration and Vancouver Island University's (VIU) Centre for Health & Environmental Mass Spectrometry (CHEMS) and co-sponsored by PSF. You can also view the results from BCCF's and VIU's ongoing monitoring effort on the east coast of Vancouver Island (Fig. 4) in an interactive Tire Wear Toxin Load Map.

Figure 4. Researchers and volunteers sample stormwater on Vancouver Island during rain events to understand the dynamics of 6PPD-Q contamination in fish habitats.

Figure 5. A rain garden integrated into a parking lot ensures pollutants deposited on the pavement won't make it to the nearby waterbody. At the same time, the feature enhances the setting with attractive vegetation and pollinator habitat.

GREEN INFRASTRUCTURE TO MANAGE STORMWATER

Green infrastructure refers to low-impact, nature-based solutions that have the capacity to retain and/or treat rainfall where it lands. Examples include *natural* green infrastructure: forests, grasslands, wetlands; and *engineered* green infrastructure: human-designed devices that mimic natural watershed infiltration, such as bioswales, pervious pavement, and rain gardens (Fig. 5). Constructing green infrastructure and preserving natural buffers are complementary strategies that can re-establish the natural water cycle that existed prior to urbanization. There are a number of benefits of green infrastructure, many of which extend beyond stormwater management, including:

- **Water Management:** Green infrastructure retains and filters rainwater at its source and increases evapotranspiration and infiltration, decreasing the risk of flooding and combined sewer overflows whilst protecting and improving water quality.
- **Temperature Moderation:** Urban green spaces help moderate temperature and reduce heat-related deaths during extreme heat waves for humans and animals alike.
- **Erosion Control:** Green infrastructure systems can capture sediment that would otherwise be carried away; and reduce the volume and rate of runoff flow into nearby bodies of water.
- **Ecosystem Services:** Green infrastructure can serve multiple functions, including filtration for improved air and water quality, enhanced water security, pollination opportunities, enhanced food security, health and wellness improvements, enhanced livability, and urban biodiversity.
- **Climate Change Resilience and Adaptation:** Green infrastructure enables and supports community resiliency and promotes global water security by providing physical adaptation and mediating the extremes of climate change, such as drought and flooding events.

Green infrastructure elements can be woven into a community at multiple scales, from individual rain barrels against a house to a constructed wetland near residential housing. Given the many benefits of green infrastructure incorporating them into communities is truly a 'win-win'.

BARRIERS AND SOLUTIONS

From discussions with Metro Vancouver and its municipalities, it was clear there is a strong commitment to protecting the ecological integrity of aquatic and riparian habitats. Balancing stormwater management with the demands of urban growth and densification proves to be challenging. Despite the municipalities' best intentions, funding and capacity are perennial barriers, among others, to achieving an optimal stormwater management approach (Table 2). Nonetheless, municipalities have focused on making continuous improvements in stormwater management during development to protect and improve riparian and instream habitat. Efforts include new technology, in-stream real-time monitoring units, and expanding water quality programs.

Table 2. Summary of barriers discussed when interviewing municipal representatives.

Type of Barrier	Identified Barrier
Funding	▸ Lack of funding for infrastructure implementation, operation, and maintenance. ▸ Oversubscribed grants, there is a lot of need but not enough to go around.
Political and Policy	▸ Competing priorities between housing demand and stormwater management. ▸ Need for more support and regulatory drivers from senior levels of government to manage issues such as water quality. ▸ Need for stronger policies and enforcement of documents such as Integrated Stormwater Management Plans. ▸ Lack of resources/funding/leadership/enforcement to implement source controls on private property.
Organization and Capacity	▸ Limited by local government staff and resource capacity. ▸ Lack of collaboration across disciplines and standardization of practices.
Knowledge and Education	▸ Limited/lack of community engagement (opportunities). ▸ Climate change uncertainty.

Effective management requires a collaborative effort among all levels of government, industry, the private sector, the community, and across municipalities. Existing policies, including calls for housing densification, are sometimes in contradiction with practices that would benefit the management of rainwater. However, there are ways to coordinate strategies that can safeguard sensitive habitats (Table 3).

Table 3. Summary of key recommendations.

Key Recommendation	Summarized/Actionable Areas of Impact
Shift stormwater management from being the sole responsibility of the individual municipality to a collaborative watershed approach.	▸ Establish regional-specific stormwater water quality guidelines for receiving water bodies. ▸ Create an end-of-pipe monitoring program.
Consider a stormwater utility charge on property owners in the municipality.	▸ Create long-term funding opportunities for municipalities to finance and support: > Maintenance and infrastructure upgrades > Water quality monitoring and testing > Comprehensive green infrastructure programs > Source control programs, including public education, stricter regulations on industry, retrofitting urban areas with pollution control devices
Standardize common practices including Green Stormwater Infrastructure.	▸ Creation of common green infrastructure guidelines to decrease the cost of contractors. ▸ Decrease the burden on private and public sectors to design, review, and approve green infrastructure systems. ▸ Build in budgets for maintaining green infrastructure.
Increase public engagement and outreach by collaborating with stewardship and community groups, developers, homeowners, and educational institutions.	▸ Engage citizens in maintenance and monitoring programs. ▸ Increase education and awareness of stormwater impacts with younger generations and homeowners. ▸ Increase data collection and sharing.
Reform policies and legislation of all governments in the region to ensure implementation of GI across the landscape, as well as ongoing maintenance.	▸ Establish guidelines and performance requirements that increase low-impact development. ▸ Use performance and demonstration sites to enhance public engagement and support for green infrastructure.
Educate and collaborate with other departments of the city.	▸ Partnerships with parks, community development, and transportation to increase space and the implementation of green infrastructure. ▸ Parks and operation teams can aid in green infrastructure maintenance.
Ensure source controls on private property.	▸ Zoning can impose stormwater requirements on private properties and developments (See Burnaby SSMUH zoning district).
Increase low-hanging fruit practices such as street sweeping.	▸ Upscaling street sweeping and ensuring correct disposal can reduce the pollutant loads entering stormwater drains.

WHAT YOU CAN DO TO MINIMIZE STORMWATER FROM YOUR PROPERTY

While communities are working towards implementing best stormwater practices on a municipal and/or regional scale, there are steps you can take on your own property that can help reduce flows and erosion as well as pollutant loads in sensitive habitats.

- ✓ **Increase permeable surfaces by installing permeable pavers, gravel, or grass that allow water to be absorbed on-site rather than concrete paving.**
- ✓ **Install a rain barrel to capture rainwater coming off your roof** (Fig. 6)**.**
- ✓ **Install a rain garden or bioswale to retain, absorb and treat water runoff.**

Additional information can be found on the Resilient Coasts for Salmon Tool Kit page. And check out Water Balance Express, an interactive tool designed for homeowners to calculate how much runoff is generated on their property and what solutions can be implemented to restore the natural water balance!

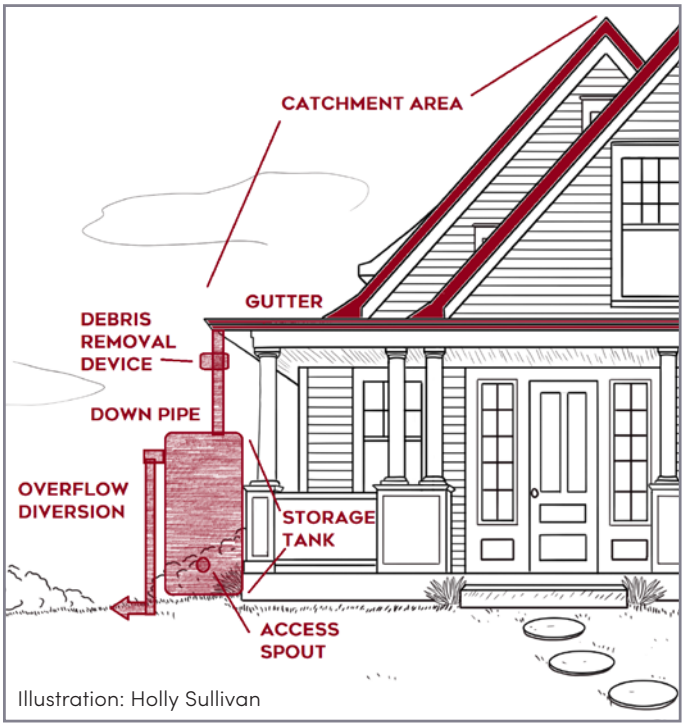

Figure 6. A rainwater tank installed next to your house can be a great way to reduce runoff from your property and conserve water in dry seasons. Learn more in this Tool Kit article.

WHAT PSF IS DOING

Particularly with the extreme threat the 6PPD-Q poses to coho and other salmonid species, stormwater is a focus for the Pacific Salmon Foundation. Here are a few of the actions we have taken to minimize stormwater impact on Pacific salmon.

- ✓ PSF's Community Salmon Program supports stormwater management in communities throughout B.C. with community grants to fund the installation of rain gardens.
- ✓ PSF researched and reported on stormwater management in Metro Vancouver and its municipalities.
- ✓ Within PSF's Marine Data Centre, a Contaminants Atlas is being built to collate studies and data on pollution in the waters of B.C.
- ✓ From 2022 to 2024, PSF supported monitoring and research of 6PPD-Q by funding BC Conservation Foundation (BCCF) and Vancouver Island University (VIU) to coordinate a community monitoring network on eastern Vancouver Island.
- ✓ PSF convened experts for knowledge sharing as a co-host of workshops on 6PPD-Q and salmon with BCCF and VIU.
- ✓ PSF submitted a formal request to Environment and Climate Change to prioritize 6PPD-Q, which led to 6PPD-Q being placed on the priority list for assessment as of October 2024.

If your community or streamkeeper group is interested in implementing green infrastructure, consider applying for a Community Salmon Grant.

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