RESIDENTIAL CAR WASHWATER MONITORING STUDY

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Public Works Department
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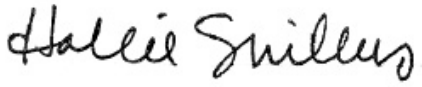

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ABSTRACT

To better understand the nature of urban stormwater discharges to the City of Federal Way Municipal Separate Storm Sewer System (MS4), the Water Quality section of the Surface Water Management (SWM) Division of Public Works embarked on a small study to illustrate the links between car washing, stormwater, local surface waters, and Puget Sound. Findings from the study will be presented to the public as part of our on-going stormwater pollution prevention education campaign targeting residential activities.

The findings presented herein show that most wash water from residential car washing is a source of stormwater pollution. It also demonstrates that any single uncontrolled residential car wash activity might be inconsequential with respect to its contribution to the pollutant load being delivered to the MS4, however, when extrapolated over the entire City of Federal Way for a year, the pollutant loading becomes significant.

The following are several of the crucial pollutants detected and the calculated annual pollutant loading to the City's MS4:

- Petroleum hydrocarbon waste: gasoline, diesel, and motor oil (estimated 190 gallons of annual mass loading).
- Nutrients: phosphorous and nitrogen (estimated 400 pounds of annual mass loading).
- Ammonia (estimated 60 pounds of annual mass loading).
- Surfactants (estimated 2,200 pounds of annual mass loading
- Solids (estimated 3,000 pounds of annual mass loading).

The results of this study support the findings of the Puget Sound Partnership 2008 Action Agenda declaring that pollution-related water quality problems in the freshwaters and marine waters of Puget Sound include excess nutrients and contamination by toxic chemicals draining from urban areas. The Action Agenda also points out that pollution entering Puget Sound's rivers, lakes, and marine waters does so through a variety of pathways, and that surface water runoff appears to be the primary transportation route, with the most concentrated loads coming from developed lands.

1.0 INTRODUCTION

Stormwater generated in Federal Way drains into Puget Sound. Fed by seasonal freshwater from the Olympic and Cascade Mountain watersheds, Puget Sound is a ninety-mile long saltwater estuary in rapidly growing Western Washington. This water body provides recreation for people, and is home to a diverse, but endangered, ecosystem.

In 2007 the Washington State Legislature created the Puget Sound Partnership (PSP), an effort undertaken to implement a strategic and bold plan to restore the health of this regionally important waterbody by 2020. Released at the end of 2008, the PSP issued an Action Agenda that spells out measurable goals for Puget Sound's recovery by demonstrating the complex connections between the land and water. With a good deal of alarm, the PSP emphasizes, in no uncertain terms, that urban stormwater runoff poses a major threat to Puget Sound's ecosystem.

Often society has been slow to recognize the link between individual behaviors and practices, and the detrimental impacts that they may have on our natural aquatic resources. One of these practices, residential car washing, may give rise to surface water quality impacts that can be felt well beyond the front yards and driveways of the communities where it occurs.

In some instances, car washing is carried out on lawns, in sideyards, or on graveled areas, which all allow for the infiltration of the wash water. However, in most cases, it is performed on impervious surfaces – that is, driveways or streets – where the washwater drains directly into the Municipal Separate Storm Sewer System (MS4).

To better understand the nature of urban stormwater discharges to the City of Federal Way Municipal Separate Storm Sewer System (MS4), the Water Quality section of the Surface Water Management (SWM) Division of Public Works embarked on a small study to illustrate the links between car washing, stormwater, local surface waters, and Puget Sound.

1.1 Regulatory Background

In 1999, the Environmental Protection Agency (EPA) issued the National Pollutant Discharge Elimination System (NPDES) stormwater Phase II program regulations (40 CFR Part 122). The ruling was a Federal mandate established to address discharges from small MS4s in an effort to reduce sources of stormwater pollution that impact the water quality of our natural water bodies.

EPA's primary role in the NPDES program was to develop the overall regulatory framework. Under the ruling, authorized states (including Washington) were permitted to tailor their stormwater discharge control programs so that water quality needs and objectives could be addressed through a fine-tuning and adjustment of the regulatory process at a state level. In early 2007, the State of Washington Department of Ecology (DOE) issued the Western Washington Phase II Municipal Stormwater Permit. Over 100 jurisdictions are subjected to this permit, including Federal Way.

The Phase II rule requires that all affected municipalities implement a series of individualized programs designed to control non-stormwater discharges, including both a public education track and procedures to detect and eliminate stormwater pollutants (illicit discharges). With some exceptions, the EPA defines an illicit discharge as "any discharge to an MS4 that is not composed entirely of stormwater".

Phase II jurisdictions are to "effectively prohibit through ordinance, or other regulatory mechanism, illicit discharges into the MS4, and implement appropriate enforcement actions as needed". The Western Washington Phase II Municipal Stormwater permit requires Federal Way to develop a regulatory mechanism that effectively prohibits non-stormwater, illegal discharges, and/or dumping into the MS4 to the maximum extent allowable under State and Federal law. An ordinance accomplishing this will go into effect for the City of Federal Way on August 16, 2009.

By definition, residential car washwater is a non-stormwater discharge, however, the EPA ruling sets it and other types of non-stormwater discharges (including water line flushing, landscape irrigation, de-chlorinated swimming pool discharges, etc.) apart. These discharges would only need to be included in the scope of an illicit discharge detection and elimination (IDDE) program if they were identified as *significant contributors of pollutants* to the MS4. In these cases, specific stormwater controls would need to be implemented. If deemed to be ineffective, an affected municipality would have the authority to prohibit the discharge completely.

1.2 Recent Permit Clarifications

In September of 2008, the Department of Ecology began recommending that permitted municipalities implement a public education approach when attempting to obtain compliance with residential car wash discharges. These recommendations were included in a number of DOE-issued correspondences, including news releases, a fact sheet, and a guidance document to cities and counties clarifying the recommended response actions. DOE recommendations include a learning phase period to allow for behavior change, letting each permitted entity to decide which group of actions would be effective enough to eliminate "significant" prohibited discharges (Howard, 2009).

2.0 STUDY DESIGN

Attempting to sample and quantify stormwater contaminants generated by common residential activities can be difficult. These elusive constituents, many of which are which are invisible to the naked eye, include bacterial loadings produced by poor pet waste management practices, fertilizers, herbicides and or pesticides dissolved in surface runoff from lawns. Depending on the frequency and volume of stormwater flows, concentrations of these pollutants can be highly variable. These type of contaminant loadings are classified as non-point discharges.

Conversely, car washwater streaming into neighborhood stormwater structures presents a more simplified sampling opportunity. It offers a much easier target to examine: the flow stream is often foamy and visible; it can be readily captured as it drops into a catch basin; the concentration of contaminants is relatively consistent; the discharges occur predictably (on nice

days); and the transport of pollutants generated by the activity is not dependant upon fluctuating stormwater runoff. Accordingly, discrete flows of residential car washwater are point source discharges to the MS4.

Sampling multiple individual driveway or street locations around the city in an effort to examine the issue for this study was found to be difficult with respect to timing, coordination, and potentially uneasy interactions with the public. Therefore, washwater grab samples were instead collected at five distinct weekend car wash fund raising events (see Section 4.1), which was considered to be representative of pollutants typically generated by individual car washing activities (See Section 4.2).

3.0 GOALS AND OBJECTIVES

The following were the goals and objectives of the Federal Way Residential Car Washwater Monitoring Study:

- Collect and analyze representative residential car washwater samples in accordance with procedures outlined in Standard Methods for the Examination of Water and Wastewater, 20th Edition.
- Estimate the annual mass loading of select individual pollutants to the MS4.

4.0 VEHICLE WASHWATER TESTING METHODS

4.1 Location of Sampling

The study utilized car washwater from five distinct weekend fund raising functions in the City of Federal Way during the summers of 2007 and 2008. The events were typical, and included groups washing cars and trucks for donations at settings such as commercial business locations and church parking lots. No significant precipitation events occurred before or during any event.

Due to the large number of vehicles washed, and the volume of washwater generated, event organizers were required to install a car wash kit to divert the flow away from the stormwater system. The kit, supplied by the City at no cost, includes power cords, hoses, a small submersible pump, and a plastic insert which fits into catch basin structures that receive the soapy flow.

By means of this set-up (Figure 1), discrete grab samples of the washwater were easily retrieved from the car wash kit discharge hose during the mid-point of each scheduled event. All water flowing across the pavement in the car washing area was collected within the catch basin insert. Collected washwater was delivered as effluent through a hose to either a sanitary clean out, sanitary sewer manhole, or pervious area at the site.

4.2 List of Parameters

It is known that washwater generated from car washing may contain many types of contaminants including high amounts of petroleum hydrocarbons, heavy metals and nutrients. In addition, data provided by the International Carwash Association (ICA) representing wastewater discharged to publicly owned treatment works from various commercial facilities indicates a similar inventory of pollutants generated by car washing activity (ICA, 2002).

Based upon this information, a list of constituents to be analyzed for was developed. The constituents tested are shown in Table 1. The following presents a brief description of the general pollutant categories that were selected to be tested:

- Petroleum hydrocarbons (gasoline, diesel fuel, motor oil, fluids and lubricants) from automobile engines, leaks, and fuel combustion processes.
- Heavy metals resulting from normal wear of auto brake linings (copper), tires, exhaust, and fluid leaks.
- Phosphorous- and nitrogen-containing detergents contained in wash water from cleaning vehicles.
- Surfactants in detergents and cleaning formulations (both synthetic and organic agents) that lower the surface tension of water, allowing dirt or grease to be washed off of cars.

4.3 Sample Collection, Containers, Preservation, and Storage

Laboratory guidance was used to determine the number and type of sample containers used, the correct sample volume, and the proper sample preservative required for each parameter analyzed. Before each sampling event, the following supplies were prepared:

- Sampling bottles, labels, and chain-of-custody forms from the laboratory.
- Powder-free disposable latex gloves.
- Coolers and ice.
- Field notebook to keep records concerning sampling.

The following describes the sampling method:

- Samples of car washwater were collected directly into the sample bottles without transferring into another container to prevent unnecessary contamination.
- Bottles were filled to within two inches of the top to allow for thermal expansion (unless sample analysis requires that no air space be left)

- The samples were placed immediately into a cooler with ice (and then refrigerator) to maintain a 4°C environment until delivery to the laboratory. Samples were delivered within the shortest holding time of the water parameter need to be analyzed.
- No replicates or field blanks were collected.

4.4 Chain of Custody Procedures

The chain-of-custody (COC) refers to the documented account of changes in possession that occur for a particular sample or set of samples. The COC record allows an accurate step-by-step recreation of the sampling path, from origin through analysis. With the COC documentation, there exists confidence that samples have not been tampered with and that they are representative of the car wash water collected from that particular site. Information recorded on the COC includes:

- Name of the persons collecting the sample
- Sample ID number
- Date and time of the sample collection
- Location of the sample collection
- Names and signature of all persons handling the samples in the field and in the laboratory

4.5 Field Records

The following sampling information was submitted on the COC to the laboratory ensuring proper sample handling and analysis by the laboratory:

- A unique identification number assigned to all samples.
- The date and time of sample collection
- The source of the sample.
- The name of sampling personnel.
- Specific analysis required.

5.0 SAMPLE ANALYSIS

5.1 Methods

Analytical methods followed the procedures outlined in Standard Methods for the Examination of Water and Wastewater, 20th Edition. Table 1 describes each parameter analyzed, the analytical method used, and the proper sample preservatives required.

Test America Laboratories prepared written narratives assessing the quality of the data collected for this project. These reviews include a description of analytical methods and assessments of holding times, initial and continuing calibration and degradation checks, method blanks, surrogate recoveries, matrix spike recoveries, laboratory control samples, and laboratory duplicates. No significant problems were encountered in the conventional water quality analyses.

6.0 PREDICTED CONTAMINANT LOADING

The following series of steps were conducted to estimate annual pollutant loadings to the MS4:

1. An average concentration value was calculated for each parameter tested during the five individual sampling events.

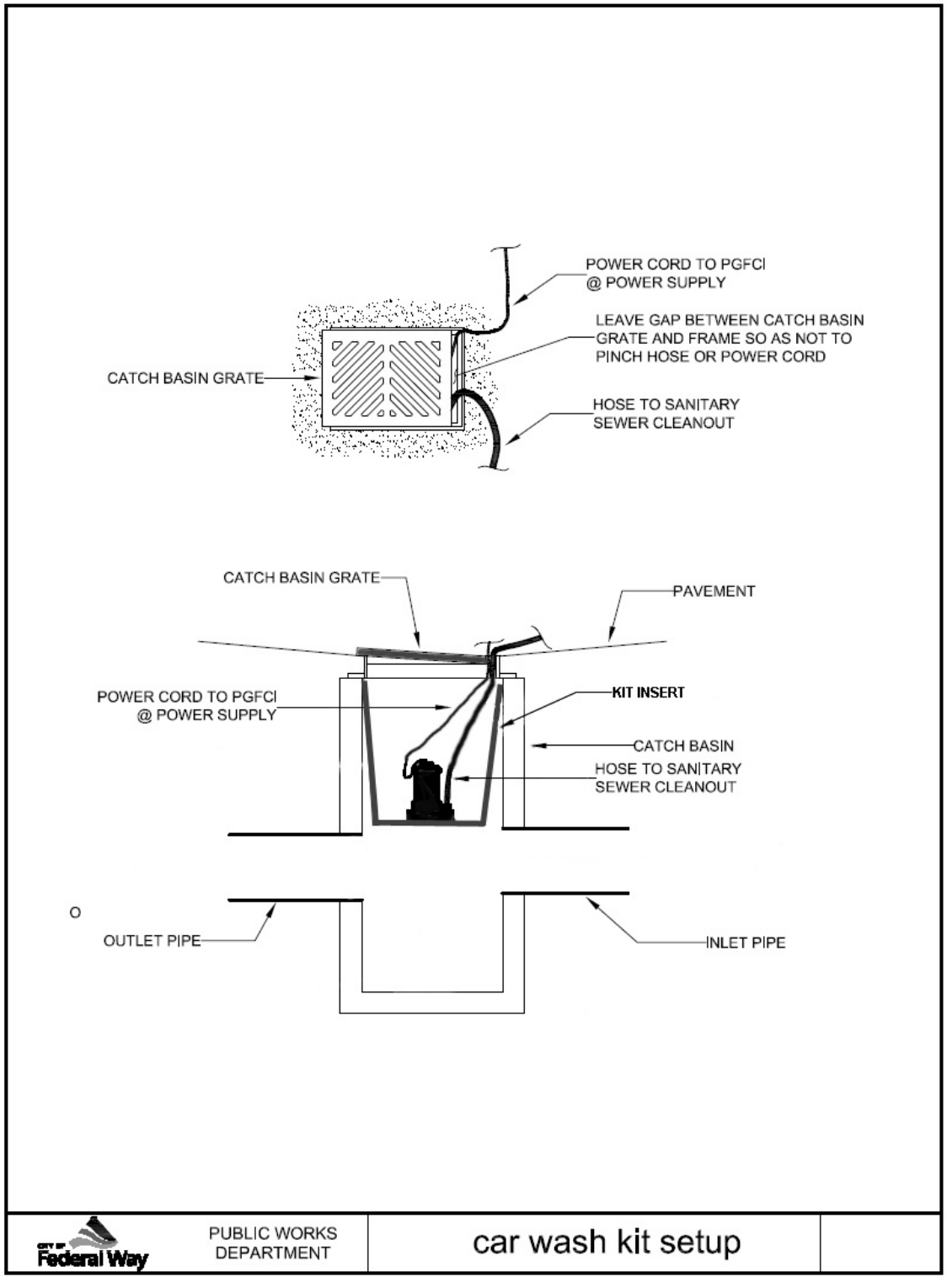
2. The average values were converted into an appropriate volume or mass quantity (either gallons or pounds).

3. Total annual MS4 pollutant loadings were calculated based upon the amount of residential car washing estimated to be carried out in Federal Way.

6.1 Laboratory Results

Table 2 provides a summary of laboratory results for each of the five separate sampling events and the calculated average concentration for each parameter.

Figure 1. Car wash kit set up diagram



6.2 Conversion Factors

The final study figures hinged upon the following key referenced statistics and conversion factors:

- There are an estimated 62,000 passenger cars and trucks registered in Federal Way (WDOL, 2009).
- Thirty-eight percent (38%) of car owners wash their cars in the driveway (ICA, 2005).
- The average frequency of residential car washing in the Puget Sound region is once every two weeks (Hardwick, 1997).
- Twenty (20) gallons is the average amount of water used to wash a vehicle (based upon field observations and simulations using a low-flow nozzle).
- Assumed that 80% of driveway car washing effluent drains to MS4.
- The average weight of used motor oil is 7.0 lbs/gal, (USEPA, 1993).
- The average weight of gasoline is 6.1 lbs/gal, (USDOE, 2009).
- The average weight of #2 diesel fuel is 7.0 lbs/gal, (USDOE, 2009).
- The weight of ammonia is 5.15 lbs/gal at 60°F, (USDOL, 2009).

Table 1. Analytical methodology and preservation methods, residential car washing in Federal Way, WA, 2007-2008

Parameter	Analytical Methodology	Container/Preservative
Gasoline	NWTPH-Gx, SW846 5030B	40 ml VOA vials (3), HCl
Motor Oil	NWTPH-Dx, SW846 3510C	1 liter amber glass, HCl
#2 Diesel	NWTPH-Dx, SW846 3510C	1 liter amber glass, HCl
Surfactants (MBAS)	SM5540 C	250 ml poly, unpreserved
Total recoverable metals	6010B ICP (3005A)	250 ml poly, HNO3
Dissolved metals	6010B ICP	250 ml poly, HNO3
Total dissolved solids	EPA 160.1	1 liter poly, unpreserved
Total suspended solids	EPA 160.2	1 liter poly, unpreserved
Oil and grease (HEM)	EPA 1664A	1 liter amber glass, H2SO4
Ammonia	EPA 350.1	250 ml poly, H2SO4
Nitrate + Nitrite	EPA 300.0	250 ml poly, H2SO4
Total Phosphorous	EPA 365.1	250 ml poly, H2SO4

6.3 Final Results

By converting sample concentration to mass or volume, hypothetical annual pollutant loading estimates to the MS4 could be calculated. Significant findings are summarized in Table 3 that lists select contaminants tested and their average annual estimated mass loading to the City of Federal Way MS4 from residential car washing.

7.0 DISCUSSION OF STUDY RESULTS

The following is a brief discussion concerning several of the crucial pollutants detected, the calculated annual pollutant loading, impacts to the City's MS4, potential effects on downstream water quality:

Petroleum hydrocarbon waste: gasoline, diesel, and motor oil (estimated 190 gallons of annual mass loading). Compounds in petroleum hydrocarbons are highly toxic, and in the surface water environment, they can cause harm to wildlife through direct physical contact, contamination by ingestion, and the destruction of food sources and habitats.

Bottom-dwelling or bottom-feeding aquatic organisms may ingest petroleum contaminants and transmit them up through the food chain until they accumulate in dangerous concentrations in fish. Hydrocarbons also harm fish directly, and damaged fish eggs may not develop properly (EPA, 2003). Additionally, oil can be particularly problematic because a single spilled cup can contaminate the surface area of a waterbody the size of a football field (EPA, 2003).

Dissolved copper (estimated 14 pounds of annual mass loading). Exposure to dissolved copper may be sufficient to impair the sensory biology (olfactory system) of coho salmon (*Oncorhynchus kisutch*), listed as an ESA Species of Concern. Coho and other salmonids rely on their sense of smell for critical behaviors such as homing, foraging, and predator avoidance. Sub-lethal impacts on olfactory function may reduce the chances of survival or reproduction of individual salmon and, therefore, are a concern for the survival of salmon populations within the Pacific Northwest (Baldwin, et al, 2003). Dissolved copper is also toxic to phytoplankton, the base of the aquatic food chain (National Research Council, 2008).

Nutrients: phosphorous and nitrogen (estimated 400 pounds of annual mass loading). An increase in nutrient loading to a surface water body leads to excessive plant growth and decay. This creates low dissolved oxygen levels, changes in animal populations, and an overall degradation of water quality and aquatic habitat. This process is known as eutrophication. In the 2008 Water Quality Assessment, DOE found numerous locations in South Puget Sound impaired due to a lack of dissolved oxygen caused by excess sources of nitrogen from human-related pollution.

Table 2. Analytical summary and concentration averages for select contaminants from residential car washing in Federal Way, WA, 2007-2008

Parameter	Date	Date	Date	Date	Date	Average Concentration
	6/23/2007	*5/17/2008*	*6/28/2008*	*7/12/2008*	*7/26/2008*	
Gasoline (mg/L)	0.12	0.071	0.12	0.062	0.084	0.091
Motor Oil (mg/L)	8.2	2.8	12	9.4	10	8.5
#2 Diesel (mg/L)	5.8	3.2	13	3.9	3.7	5.9
Total Metals (mg/L)						
Arsenic	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect
Cadmium	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect
Chromium	Non Detect	Non Detect	0.025	0.030	Non Detect	0.028
Copper	0.83	0.15	0.71	0.59	0.38	0.532
Lead	0.054		0.034	0.061	0.056	0.051
Nickel	0.021		0.056	0.19	ND	0.089
Zinc	0.74	0.14	0.62	0.57	0.44	0.502
Dissolved Metals (mg/L)						
Arsenic	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect
Cadmium	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect
Chromium	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect
Copper	0.21	0.11	0.23	0.16	0.13	0.168
Lead	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect	Non Detect
Nickel	Non Detect	Non Detect	0.027	0.023	Non Detect	0.025
Zinc	0.32	0.092	0.22	0.24	0.16	0.206
Nitrate + Nitrite (mg/L)	Non Detect	0.96	0.77	0.73		0.82
pH (Ph)	6.09	7.01	6.5	7.16	6.99	6.75
Hardness (mg/L)	45	95	75	75	35	65
Total Dissolved Solids (mg/L)	210	300	180	230	150	214
Total Suspended Solids (mg/L)	82	Non Detect	280	230	200	198
Oil & Grease (mg/L)	21		45	11	8.8	21.5
Turbidity (NTU)	180	27	270	220	100	159
Total Phosphorus (mg/L)	0.75	0.73	5.8	6.1	6.3	3.94
Surfactants MBAS (mg/L)	30	12	35	40	19	27
Ammonia (mg/L)		0.61	0.65	0.97	0.73	0.74

Table 3. Select contaminant annual pollutant concentrations and estimated annual pollutant loading from residential car washing in Federal Way, WA, 2007-2008

Parameter	Analytical Methodology	Estimated annual mass pollutant discharge
Fuel (Gasoline, #2 Diesel)	NWTPH-Gx, SW846 5030B, NWTPH-Dx, SW846 3510C	492 lbs (70 gals)
Motor Oil	NWTPH-Dx, SW846 3510C	695 lbs (120 gals)
Surfactants (MBAS)	SM5540 C	2,200 lbs
Chromium, total recoverable	6010B ICP (3005A)	2 lbs
Copper, total recoverable	6010B ICP (3005A)	44 lbs
Lead, total recoverable	6010B ICP (3005A)	4 lbs
Nickel, total recoverable	6010B ICP (3005A)	7 lbs
Zinc, total recoverable	6010B ICP (3005A)	41 lbs
Copper, dissolved	6010B ICP	14 lbs
Total dissolved solids	EPA 160.1	17,500 lbs
Total suspended solids	EPA 160.2	16,200 lbs
Oil and grease (HEM)	EPA 1664A	1,400 lbs
Ammonia	EPA 350.1	60 lbs
Nitrate-Nitrite	EPA 300.0	67 lbs
Phosphorous	EPA 365.1	320 lbs

Nutrient availability also impacts the formation of hazardous algal blooms (HABs) which can produce high concentrations of nerve or liver toxins in the water column at levels that pose human health concerns (WDOE, 2009). HABs in Washington ponds, lakes, and reservoirs (including Federal Way) have been documented at an increasing rate over the past 25 years (WDOH, 2008).

Ammonia (estimated 60 pounds of annual mass loading). Forms of nitrogen (ammonium), in combination with pH and temperature variations, can be toxic to fish. When this toxic combination occurs, large amounts of oxygen in the water is consumed, subsequently stressing or killing fish and other aquatic organisms (King County, 2009).

Surfactants (estimated 2,200 pounds of annual mass loading. In surface water environments, surfactants are acutely toxic to aquatic life, stripping fish gills of natural oils, thereby interrupting the normal transfer of oxygen.

Solids (estimated 3,000 pounds of annual mass loading). Sediment, the most common pollutant in stormwater runoff by volume and weight, makes streams and lakes less suitable for recreation, fish life, and plant growth. Sediment is of particular concern in fish-bearing streams where it can smother trout and salmon eggs, destroy habitat for insects (a food source for fish), and cover prime spawning areas. Uncontrolled sediment can also clog storm drains, leading to increased private and public maintenance costs and flooding problems (King County, 2009).

8.0 CONCLUSION

The purpose of this study was to quantify the pollutant loading to the MS4 from residential car washing activities in areas upstream of in-flow treatment structures such as catch basin sumps, oil/water separators, ditches and retention/detention ponds.

While many of the known contaminants in car wash water were tested for, there are many other chemicals that were not. Some of these compounds include degreasers, metal brighteners, waxes and other potentially toxic components, and are more extensively addressed by recent studies investigating the overall aquatic toxicity of car wash effluent and synthetic detergents (Abel, 2006) (Brasino, et al, 2007).

Given both the nature and concentration of the pollutants found in the car washwater tested, it is apparent that significant quantities of stormwater contaminants are generated annually from residential car washing activity in Federal Way. Stormwater carries these pollutants – soapy water and all – to storm drains in urban areas, which then flow to surface waters with little or no water quality treatment (WDOE, 2009). This study demonstrates that while any single residential car wash might be considered inconsequential with respect to its contribution to the pollutant load being delivered to the MS4, however, when extrapolated over the entire City of Federal Way for a year, the pollutant loadings becomes more significant.

The City of Federal Way recognizes the challenges faced by the average homeowner as they struggle to implement car wash stormwater pollution prevention best management practices in their own driveway or neighborhood street. Solving these challenges becomes more urgent when considering the population growth trends developed for Washington's ten central Puget Sound counties. Currently, there are approximately 4.2 million people residing here, but the figure is expected to swell 1.3 million more by 2020 (WSOFM, 2009). These census predictions show us how powerful and effective incremental behavioral changes by people can be, and how small changes – when they benefit the environment – can translate into larger and more geographically significant water quality improvements.

Even though professional car washing facilities employ water treatment systems, and in many cases recycle the wastewater, surveys conducted by the International Carwash Industry from 1999 to 2008 indicate that the majority of home washers consistently feel that residential car washing is better for the environment than commercial car washes (ICA, 2008). From this information, it appears that more effective public education efforts will be needed to affect

sufficient behavior changes to reduce prohibited discharges caused by residential car washing activity.

Other survey data indicates that people will act more environmentally responsible as more accurate information is attained (NEETF, 2005). The City of Federal Way's public education program continues to embrace this concept, and will follow the DOE lead in utilizing the results of this study to craft more meaningful, effective, and accurate educational tools that describe the overall magnitude of stormwater pollution created by all home-based activities, including residential car washing.

For the average resident, we hope that this study will bring to view the amount of car washing contamination produced in their own community, causing them to be concerned by the prospects of pollutant loadings to our local salmon streams and Puget Sound when the sum of discharges from the entire Western Washington region are considered.

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