Analysis of the Quality of Stormwater Runoff Discharged from Representative Connecticut Highways by USGS – Period 1 (07/01/18 – 06/30/19) [Revised Period 1 (07/01/18 – 06/30/20)]

INTERIM REPORT

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Acknowledgments

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Metric Conversion Factor Sheet

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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16. Abstract

The overall objective of this project is to document highway runoff and constituent concentrations discharged from common highway-drainage conveyance structures in Connecticut from nine highway sites during two sequential two-year periods in order to fulfill CTDOT's MS4 Stormwater Permit outfall monitoring requirements. The study will also evaluate the potential transferability of these data to other highway sites by relating constituent concentrations to traffic volumes, impervious area, and selected land-cover characteristics. The event mean concentration data from the highway stations collected as part of this study, will be entered into a new version of the Federal Highway Runoff Database. This new data can be used to support model estimates of loads and concentrations for suspended sediment, major ions, total-recoverable metals, total nutrients, and PAH compounds.

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Introduction and Background Summary

The Department of Energy and Environmental Project (DEEP) issued a permit for the Connecticut Department of Transportation's (the Department) stormwater discharges that are regulated under the Federal Municipal Separate Storm Sewer Systems (MS4) Program. As required by the permit, the Department must screen and/or monitor outfalls that discharge directly to impaired waters. In consideration of the thousands of outfalls connected to the State drainage systems, the Department has worked with the DEEP to incorporate a systematic approach to address the Department's specific sampling requirements. This approach has been successfully utilized by the Massachusetts Department of Transportation (MassDOT) to comply with their MS4 Permit as administered by Environmental Protection Agency Region 1. The Department is working with the United States Geological Survey (USGS) to implement and update an existing drainage model that assesses if, or how, a given segment of highway impacts a receiving water; and what types of stormwater infrastructure and/or best management practices would be most effective at minimizing the impacts.

To utilize the model, the USGS, on behalf of the Department, has been implementing a rigorous monitoring program that will collect water quality data on numerous parameters at select outfalls across the State. This new data will assist in making the model a reliable tool for assessing conditions specific to Connecticut highways.

During Period 1 (July 1, 2018 – June 30, 2019) [Revised Period 1 (07/01/18 – 06/30/20)], USGS continuously monitored a total of five outfalls from local roadways during 18 qualifying wet precipitation (equal to or greater than 0.01 inches) rain events. Each location and event were sampled for over 40 constituents. The sites were selected based upon land use type, impervious area, and the average daily traffic that passes through the drainage area for the outfall. For more information, a copy of the report generated by USGS for the MassDOT runoff study may be accessed here: https://pubs.usgs.gov/sir/2009/5269/.

As required by the Project Proposal (P-18-2, SPR-2312) included in the State Planning and Research (SP&R) Work Program dated July 10, 2018, and revised March 29, 2021, this interim report details the equipment purchased, specific locations/dates for the installation of the monitoring equipment, field data collection and analysis performed in SFY19 and SFY20. It should be noted that SFY20 was added to the schedule due to the impacts of the Federal Government shut down from December 22, 2018, through January 25, 2019, and weather impacts that delayed stations being installed and operational until spring of 2019.

Problem Statement

Stormwater discharges from highways can adversely affect the quality of receiving water and may result in the failure of a water body to meet Connecticut surface-water-quality standards. Many studies have shown that stormwater runoff can be a source of suspended solids, nutrients, metal and polycyclic aromatic hydrocarbons (PAHs). Highway runoff is a complex mix of inorganic and organic constituents from multiple sources including atmospheric deposition, local soils, automobiles, road residuals, winter-maintenance materials, and other sources. Various land covers adjacent to roadways, particularly those with high percentages of impervious area (industrial areas, commercial areas, and medium- and high-density residential areas) may affect concentrations and loads of various water-quality constituents that are discharged to receiving waters. Antecedent conditions, traffic volume, climatic regions, storm characteristics, and other factors also affect the quality of highway runoff. As a result, the quantity and

quality in reported highway runoff studies may vary by orders of magnitude during a storm, and in-between storms.

Objectives

The overall objective of this project is to document highway runoff and constituent concentrations discharged from common highway-drainage conveyance structures in Connecticut from nine highway sites during four sequential two-year periods. The initial phase under this proposal consists of the first two-year period monitoring five locations. The study will also evaluate the potential transferability of these data to other highway sites by relating constituent concentrations to traffic volumes, impervious area, and selected land-cover characteristics. The event mean concentration data from the highway stations collected as part of this study, will be entered into a new version of the Federal Highway Runoff Database (Granato and Cazenas, 2009). This new data can be used to support model estimates of loads and concentrations for suspended sediment, major ions, total-recoverable metals, total nutrients, and PAH compounds.

The project is divided into four periods on a State Fiscal Year (SFY) basis:

Period 1: SFY19 and SFY20 (July 1, 2018 – June 30, 2019) [Revised Period 1 (07/01/18 – 06/30/20)]

- o Purchase and install stormwater monitoring equipment at five outfall locations in Hartford, Glastonbury (2 locations), Vernon, and Torrington.
- o Monitor stormwater parameters at the five outfall locations.
- o Sample as many qualifying rain storms as possible of the 15-18 rain storms required during Period 1 at the five outfall locations.

Period 2: SFY21 (07/01/20 – 06/30/21)

- o Finish monitoring stormwater parameters at the five outfall locations identified in Period 1.
- o Finish sampling 15-18 rain storms at the five outfall locations.

Period 3: SFY22 (07/01/21 – 06/30/22)

- o Uninstall the stormwater monitoring equipment from the five locations identified in Period 1 and reinstall the equipment at four other outfall locations (different from the locations identified in Period 1).
- o Begin to monitor stormwater parameters at the four outfall locations identified in Period 3.
- o Begin to sample 15-18 rainstorms during Period 3 and 4 at the four outfall locations.

Period 4: SFY23 and SFY24 (07/01/22 – 06/30/23) (07/01/22 – 06/30/24)

- o Complete Period 4 stormwater sampling and monitoring.
- o Data analysis for all monitored sites.
- o Prepare of Draft Report.
- o Peer Review Draft Report (USGS, CTDOT, FHWA).
- o Revise Draft Report/Finalize Report and distribute.

Period 1 of the project will be funded by SPR-Part II Research Funds.

Period 2 through Period 4 of the project will be funded from another funding source (not SPR-Part II Research Funds).

Work Summary

<u>Equipment Purchased</u>

All monitoring equipment needed to sample the locations selected for Period 1 was procured by December 2018. This included but was not limited to monitoring shelters, flumes, auto sampling equipment, roadway cameras and instrumentation to monitor water levels and collect background flow data (See Photo 1).

Photo 1: USGS Monitoring Equipment

Locations and Dates for Installation of the Equipment

Outfall locations for Period 1 are summarized in Table 1 below.

Table 1: Period 1. Composite Sampling Locations

Town	Highway / State Route
Glastonbury, CT.	Route 2
Glastonbury, CT.	Route 3
Torrington, CT.	Route 8
Vernon, CT.	Route 74
Hartford, CT.	Interstate 91

Site preparations for the Route 3 Glastonbury location were largely completed by early December of 2018. However, frozen ground prohibited the installation of the other stations until spring of 2019.

Field Data Collection

Significant progress was made collecting field data by the end of the SPR funding on June 30, 2020, despite multiple challenges that included poor forecast accuracy, the Federal Government shut down in 2019, a moratorium on field sampling due to mandatory telework for USGS staff in April of 2020 (COVID) and a truck crashing into the Glastonbury Route 2 monitoring station on June 8, 2020. The number of composite samples collected at each location as of June 30, 2020, is summarized in Table 2 below.

Table 2: Collection of composite samples of highway runoff as of June 30, 2020

Highway and location	Proposed number of composite samples	Current number of composite samples collected to date
State Route 2, Glastonbury, CT.	15-18	10
State Route 3, Glastonbury, CT.		12
State Route 8, Torrington, CT.		11
State Route 74, Vernon, CT.		10
Interstate 91, Hartford, CT.		11

To obtain the full 18 composite samples wanted at each of the five locations, composite sampling continued through the spring of 2021 and was paid for with other funding sources.

The monitoring measured flow, water temperature, specific conductance, precipitation and snow depth. The sampling system also collected composite runoff samples for a variety of water-quality constituents (See Table 3) for 15 to 18 rainstorms. A comprehensive description about the sampling and analysis is included in the MassDOT runoff study performed by USGS (Smith and Granato, 2010).

Table 3: List of Constituents or Parameters (and Reporting Levels) Measured in Composite Samples of Highway Runoff

Analyte	Reporting level	Unit	Analyte	Reporting level	Unit
Alkalinity	4.6	mg/L	specific conductance	5	uS/cm
Aluminum (whole water)	3.8	ug/L	Sulfate (dissolved)	0.02	mg/L
Arsenic (whole water)	0.2	ug/L	Zinc (whole water)	2	ug/L
Barium (whole water)	0.3	ug/L	Suspended sediment	1	mg/L
Cadmium (whole water)	0.03	ug/L	Total suspended solids	15	mg/L
Calcium (dissolved)	0.022	mg/L	Acenaphthylene	0.3	ug/L
Dissolved organic carbon	0.23	mg/L	Acenaphthene	0.28	ug/L
Chloride (dissolved)	0.02	mg/L	Anthracene	0.38	ug/L
Potassium (dissolved)	0.03	mg/L	Benzo[b]fluoranthene	0.3	ug/L
Sodium (dissolved)	0.06	mg/L	Benzo[k]fluoranthene	0.3	ug/L
Chromium (whole water)	0.4	ug/L	Benzo[a]pyrene	0.32	ug/L
Copper (whole water)	0.8	ug/L	Chrysene	0.32	ug/L
Iron (whole water)	4.6	ug/L	Fluoranthene	0.3	ug/L
Lead (whole water)	0.04	ug/L	Fluorene	0.34	ug/L
Magnesium (dissolved)	0.011	mg/L	Indeno[1,2,3-cd]pyrene	0.38	ug/L
Manganese (whole water)	0.4	ug/L	Nitrobenzene	0.26	ug/L
Nickel (whole water)	0.2	ug/L	Phenanthrene	0.32	ug/L
Dissolved total nitrogen	0.05	mg/L	Pyrene	0.36	ug/L
Particulate nitrogen	0.03	mg/L	Benzo[ghi]perylene	0.38	ug/L
Mercury (whole water)	0.005	ug/L	Benzo[a]anthracene	0.26	ug/L
Phosphorus (whole water)	0.004	mg/L	Dibenz[a,h]anthracene	0.42	ug/L
pH	0.1	pH	Naphthalene	0.22	ug/L

Discussion and Recommendations

The SPR funding was vital in getting the outfall monitoring project started due to the significant upfront equipment and mobilization costs associated with auto-sampling five locations for more than 40 constituents. Additionally, the SPR funding paid for more than half of the composite samples ultimately obtained at each location which will make the SELDM model a better tool for assessing impacts from CT highways to local waterbodies. The SELDM model has been used by various DOT's nationwide to improve their assessments for evaluating locations where roadway drainage is potentially impacting a receiving waterbody. The analysis will allow the Department to be in compliance with the MS4 permit by highlighting potential locations for stormwater retrofits that aid in the improvement of stormwater quality.

The results of the composite samples collected will not be fully analyzed until samples from the remaining locations are collected over a period of the next two years. A preliminary analysis of the data

collected to date indicates that the constituent concentrations for all five locations are generally consistent with roadway runoff from comparable interstates or state routes from other areas of the country.

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