CITY OF PORTLAND
ENVIRONMENTAL SERVICES

1120 SW Fifth Avenue, Room 1000, Portland, Oregon 97204 ▪ Nick Fish, Commissioner ▪ Michael Jordan, Director

August 30, 2017

Mr. Mark Hynson
Water Quality Specialist
Oregon Department of Environmental Quality
Water Quality Program, NW Region
700 NE Multnomah Street, Suite 600
Portland, Oregon 97232-4100

Subject: **Annual CSO and CMOM Report, FY 2017**
Columbia Boulevard Wastewater Treatment Plant NPDES Permit #101505

Dear Mr. Hynson:

Enclosed, please find two copies of the *Annual CSO and CMOM Report, FY 2017*, submitted as required in the NPDES Permit for the Columbia Boulevard Wastewater Treatment Plant. This annual report provides a comprehensive review of Portland's integrated CSO system and CMOM Program for fiscal year 2017 and addresses the material outlined in section 12.4 of the *Nine Minimum Controls Update Report*, December 2010.

If you have questions regarding this year's report, please do not hesitate to call me at (503) 823-9803.

Sincerely,

Matthew Criblez
Environmental Compliance Manager

Enclosures (Annual CSO and CMOM Report, FY 2017)

CITY OF PORTLAND | BUREAU OF ENVIRONMENTAL SERVICES

Annual CSO and CMOM Report
FY 2017

REQUIRED BY NPDES PERMIT #101505

ENVIRONMENTAL SERVICES
CITY OF PORTLAND
working for clean rivers

Nick Fish, Commissioner

Michael Jordan, Director

Annual CSO and CMOM Report
FY 2017

Required by NPDES Permit #101505
for CBWTP and CSO Systems

September 2017

City of Portland
Bureau of Environmental Services

REGISTERED PROFESSIONAL ENGINEER
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OREGON
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Glossary

BOD. Biochemical Oxygen Demand

CBWTP. Columbia Boulevard Wastewater Treatment Plant

CCTV. Closed-circuit Television

CEPT. Chemically Enhanced Primary Treatment

CIP. Capital Improvement Project (or Program)

CMMS. Computerized Maintenance Management System

CMOM. Capacity, Management, Operation, and Maintenance

COOP. Continuity of Operations Plan

CSCC. Columbia Slough Consolidation Conduit

CSO. Combined Sewer Overflow, especially as it pertains to discharge events. Note that during the CSO Program's implementation, "CSO's" were being captured into the new facilities such as the Willamette CSO Tunnels and the CSCC. Technically, CSOs are no longer being "captured" after the implementation completed—rather, the water that used to produce those events is now controlled within the augmented combined sewer system, and the term *CSO* is limited once again to discharges from the combined system to receiving waters.

CSS. Combined Sewer System

DEQ. Oregon's Department of Environmental Quality

DMR. Discharge Monitoring Report

DO. Dissolved Oxygen

EPA. Environmental Protection Agency

EMC. Event Mean Concentration

EWWPT. Enhanced Wet Weather Primary Treatment

FM. Force Main

FOG. Fats, Oils, and Grease

FY. Fiscal Year (FY 2017 is July 1, 2016, through June 30, 2017)

IPS. Influent Pump Station (pumps water from the Columbia Slough Consolidation Conduit to the CBWTP)

MAO. Mutual Agreement and Order

MGD. Million Gallons per Day

NFAA. No Feasible Alternative Analysis

NMC. Nine Minimum Controls

NPDES. National Pollution Discharge Elimination System

PIO. Public Information Officer

RDII. Rainfall Derived (also, Dependent) Infiltration and Inflow

SICSO. Swan Island CSO; used to refer to the pump station pumping water stored by the Willamette River's West Side and East Side CSO Tunnels.

SPCR. Spill Protection and Citizen Response

SRRP. Sewer Release Response Plan

SSO. Sanitary Sewer Overflow

SWMM. Stormwater Management Manual

TCWTP. Tryon Creek Wastewater Treatment Plant

TSS. Total Suspended Solids

WWTF. Wet Weather Treatment Facility

Section 1 Introduction

The Annual CSO and CMOM Report for fiscal year 2017 (FY 2017: July 1, 2016, through June 30, 2017) provides a comprehensive review of Portland's integrated combined sewer overflow (CSO) system and the Capacity, Management, Operation, and Maintenance (CMOM) Program during FY 2017. This report provides updates to the previous report submitted for FY 2016.

1.1 Changes from FY 2016 Report

This report has one structural change compared to last year:

- There has been activity regarding updating the Public Notification Program, and a section (Section 7) has been inserted to report on this. This activity was last reported on in the FY 2015 report.

1.2 Programs

CSO Program. The City of Portland (City) completed its CSO long-term control plan implementation in 2011. The City is currently proceeding with implementing its *Post-2011 Combined Sewer Overflow Facilities Plan*, published in 2010. This plan looked at ways to cost-effectively exceed the level of control specified in the 1994 Amended Stipulation and Final Order agreement with Oregon's Environmental Quality Control Commission. This additional work is necessary to handle the pressure on the combined sewer system (CSS) facilities' capabilities to control CSOs due to increased population and development.

CMOM Program. Over several years, the City of Portland has implemented a CMOM program to reduce the likelihood of sewer releases by improving the overall reliability of the sanitary and combined sewer collection systems. The *CMOM Program Report* that was submitted to DEQ on June 28, 2013, explains BES's strategies and activities for the development, reinvestment, operation, and maintenance of the system. The report was developed to comply with Condition 3.b.(1)(B) of Schedule A of the CBWTP NPDES permit #101505, currently administratively extended while the permit renewal application is under review by DEQ.

The CMOM program specifically addresses proper operation and regular maintenance of the collection system (Nine Minimum Controls, or NMC, #1). The City's wastewater collection system includes main lines, trunk lines, interceptors, pump stations, and force mains. The City is generally responsible for service laterals from the sewer main up to the curb line, while the building or private sewer laterals extending behind the curb are the responsibility of the property owner. Portland's sewer collection system consists of a network of 2,597 miles of collection system piping (1,003 miles of sanitary sewer including force mains, 911 miles of combined sewer, and 683 miles of sewer laterals) and 40,789 sewer manholes.

The system also includes two wastewater treatment plants and 98 pump stations. There are 83 City-owned and operated pump stations, 5 pump stations owned by other public agencies that are operated and maintained by the City under satellite or easement agreements, and 10 privately-owned septic tank effluent pumping systems that are maintained by the City under agreements with the property owners. The number of pump stations decreased by two in FY 2017. The Terwilliger Pump Station (also known as Powers Court Pump Station) is no longer receiving flow now that the project to install a new gravity sewer in SW Terwilliger Boulevard is in operation. This pump station has heretofore been managed under the City's service/maintenance agreement with Dunthorpe-Riverdale Service District. Multnomah County onsite sanitation will oversee decommissioning of this pump station. In addition, the City no longer has a contract to maintain the septic tank effluent pumping system located at 10652 NE Holman Street (formerly Portland Motorcycle). The new property owner was notified of this on January 31st, 2017, and their responsibility to properly operate and maintain the system.

This annual update for FY 2017 provides a review of CMOM program actions and key performance indicators, and an evaluation of the effectiveness of BES's risk-based asset management approach to collection system operation and maintenance.

1.3 Summary of CSO and CMOM Performance

1.3.1 CSO Program Achievements

FY 2017 was another extraordinarily wet year, like FY 2016, with an average of about 60.1 inches (varying from 48 to 66 inches depending on location) falling over the combined service area. Normally, only 36-43 inches falls over the City in any given year. Seven CSOs were recorded, and all met or exceeded the permit's minimum requirements for storm return periods.

There were no exceedances in effluent concentrations at the CBWTP effluent outfalls. Maximum 30-day concentrations at the CBWTP effluent outfalls were 18 mg/L for biochemical oxygen demand (BOD) and 26 mg/L for total suspended solids (TSS); 30 mg/L is the permitted effluent limitation. Peak 7-day concentrations at these outfalls were 29 mg/L for BOD and 30 mg/L for TSS; 45 mg/L is the permitted effluent limitation.

The Wet Weather Treatment Facility (WWTF) with Chemically Enhanced Primary Treatment (CEPT) continues to operate well, having achieved 66% biochemical oxygen demand (BOD) removal and 84% total suspended solids (TSS) removal in the wet weather flow stream.

Combined removal for all plant flows during wet weather events was 84% for BOD and 90% for TSS. Combined removal for all plant flows at all times was 92% for both BOD and TSS.

The CBWTP received the highest volume to date of flow captured by the Willamette and Columbia Slough storage facilities (termed in previous reports as "Captured CSO") at 11.2 billion gallons. Operators enabled the integrated collection system to treat 57% of this volume through the secondary system, with 43% treated through the WWTF. There were 41 events in which flows were sent through the WWTF. The average WWTF event lasted 32 hours and discharged 117 million gallons from the WWTF. During the events, the average flow rate treated by the dry weather/secondary system was 119 million gallons per day (MGD), exceeding the 110 MGD minimum required in the NPDES permit.

1.3.2 CMOM Program Achievements

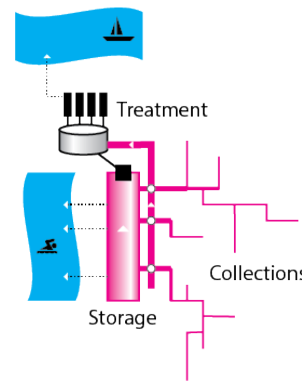
Portland's CMOM program was designed to ensure that components of the collection system are cleaned and inspected at the right frequency and that preventive maintenance and repairs are performed to cost-effectively reduce the number of sewer releases, extend the useful life of the City's sewer infrastructure, and properly manage collection system operations. CMOM program accomplishments in FY 2017 include:

- Inspection of 0.68 million feet (129 miles) of sewer pipe, or about 7% of the mainline sewer system
- Cleaning of 1.14 million feet (216 miles) of sewer pipe, or about 11% of the mainline sewer system
- Completion of mainline sewer maintenance repairs on 10,100 feet of pipe; 62% of the repairs were in response to collection system problems
- Repair of 588 service laterals totaling about 7,930 feet of pipe; 65%of those repairs were in response to discovered problems
- Treatment of 298,000 feet (56 miles) of sewer pipe for roots using chemical root foaming
- Completion of 500 inspections of manholes considered to be at greatest risk of failure (Tier 2—see Section 3.1.5).
- Completion of ten Capital Improvement Program projects repairing and rehabilitating portions of the sanitary and combined collection system during the 2016 calendar year, resulting in an estimated risk reduction of $11.4 million. Maintenance activity on mainlines and service laterals also resulted in an estimated risk reduction of $12.5 million.

The number of sewer releases from the City-maintained sanitary and combined sewers increased in FY 2017, in part due to weather-related releases during severe winter storms. The number of sewer releases per 100 miles of sewer was 6.9 in FY 2017, which fell short of BES's target of 5.0.

Sewer emergency response crews arrived on site within the City's 2-hour response time target during all months except October, when response time was affected by the large number of calls associated with severe storms.

Section 2 Integrated CSO System Performance for FY 2017



The integrated CSO system consists of the combined sewer collection system; the CSO collection, storage, and pumping system; and the CBWTP treatment system. This section reports on the performance of the overall integrated CSO system during FY 2017.

2.1 Rainfall Patterns for the Past Fiscal Year

FY 2017 was a high rainfall year for the City of Portland. The area weighted average rainfall measured 60.1 inches over the year, compared with an annual average rainfall of 36-43 inches for Portland. This is about 50% greater than the yearly average rainfall for the city.

During this period, five winter storms generated CSO discharges after exceeding the 4-per-winter design storms. Two summer storms generated CSO discharges after exceeding the 3-year summer design storm.

- October 13-17, 2016 – Summer CSO event
- November 22-25, 2016 – Winter CSO event
- January 17-18, 2017 – Winter CSO event
- February 3-6, 2017 – Winter CSO event
- February 7-10, 2017 – Winter CSO event
- February 15-16, 2017 – Winter CSO event
- May 12-14, 2017 – Summer CSO event

Seven other winter storms were large enough to have caused a permitted CSO had they occurred. CSOs were avoided for the following events:

- November 5, 2016 – Winter storm event
- November 13-15, 2016 – Winter storm event

- December 9-11, 2016 – Winter storm event
- December 19-20, 2016 – Winter storm event
- January 8-10, 2017 – Winter storm event
- February 18-21, 2017 – Winter storm event
- March 13-15, 2017 – Winter storm event

The winter storm CSO event of January 17-18, 2017, was affected by snowmelt from a record snowstorm six days prior. The snowfall between January 10-11, 2017, resulted in approximately 8-12 inches of accumulation throughout the city. Unusually persistent cold temperatures preserved the snow until it melted during the storm of January 17-18 when temperatures rose above freezing. The rainfall that fell during the event was sufficient to cause the CSO, but the snowmelt contributed to the size of the CSO.

The National Weather Service reported 10.36 inches of rain at the Portland airport in February 2017, making it the rainiest February since recordkeeping began in 1940. Other gages across the Willamette CSO area recorded even more rainfall, with 11.94 inches on average for the month. The high rainfall volume is reflected in the three CSO events that occurred during that month, and by the intrusion of debris into certain parts of the collection system as described in Section 2.2.

2.1.1 Winter Storm Review

The five winter storms that caused CSO discharges and exceeded the 4-per-winter NPDES Permit thresholds are shown graphically in Figure 1 below. This graph is a "Depth-Duration" chart that displays the maximum depth of rainfall that occurred for the range of storm duration, from 1-hour to 48- hours. The five events that caused CSO to occur are shown with solid colored lines. The five CSO events are compared to the two NPDES Winter Design Storms (4-per-winter and 5-year winter) shown with blue-tinted dashed lines. The seven storms that exceeded the 4-per-winter design storm but did not result in CSOs are shown in gray.

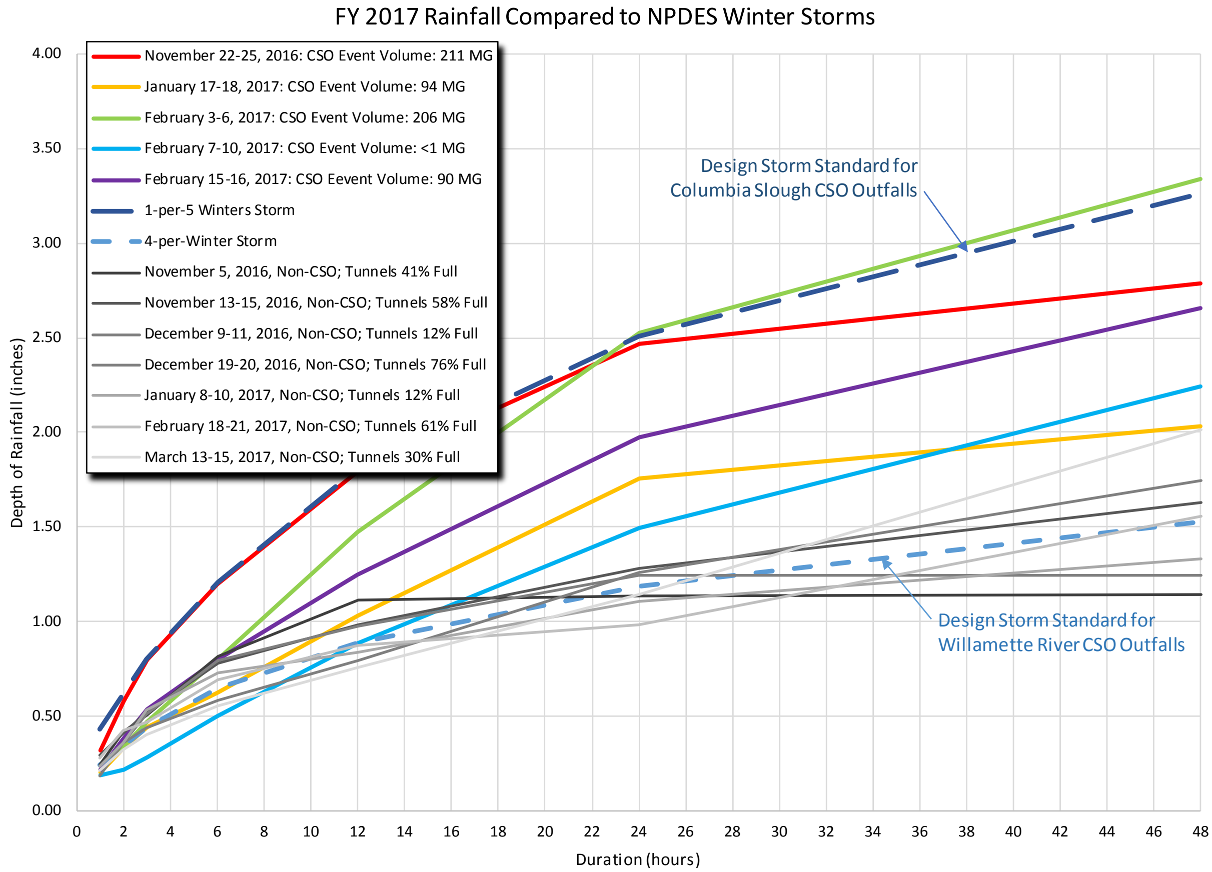


Figure 1 FY 2017 CSO Winter Storms Compared to NPDES Winter Storms

Details for the rainfall for the winter overflow events are provided in Table 1 below.

Table 1 FY 2017 Winter Storm Comparisons

Storm	Duration (hours)						Notes
	1	3	6	12	24	48	
Willamette River Winter Design Storms (inches)							
4-per-Winter Design Storm	0.24	0.44	0.65	0.89	1.19	1.53	
5 Year Winter Design Storm	0.43	0.80	1.21	1.81	2.51	3.26	
FY 2017 Winter Storms - Average Rainfall over Willamette CSO Basin (inches)							
November 22-25, 2016	0.32	0.80	1.19	1.80	2.47	2.79	Exceeds 4-per-winter design storm 1-48 hours.
January 17-18, 2017	0.20	0.44	0.62	1.03	1.76	2.03	Exceeds 4-per-winter design storm 3 hours and 12-48 hours.
February 3-6, 2017	0.22	0.47	0.80	1.48	2.52	3.34	Exceeds 4-per-winter design storm 3-48 hours, and 5-year winter design storm 24-48 hours.
February 7-10, 2017	0.19	0.28	0.50	0.88	1.49	2.24	Exceeds 4-per-winter design storm 24-48 hours.
February 15-16, 2017	0.21	0.54	0.80	1.25	1.98	2.66	Exceeds 4-per-winter design storm 3-48 hours.

2.1.2 Summer Storms Review

Two summer storms exceeded the NPDES Permit 3-year Summer Storm. The October 13-17, 2016, storm is shown graphically in the Depth-Duration chart in Figure 2 below. The event is shown with a red line. The two comparison Summer Design Storms (3-year summer and 10-year summer) are shown with blue-tinted lines. Table 2 provides rainfall details for this event. This storm was a classic atmospheric river winter storm that happened to start at the end of the summer season.

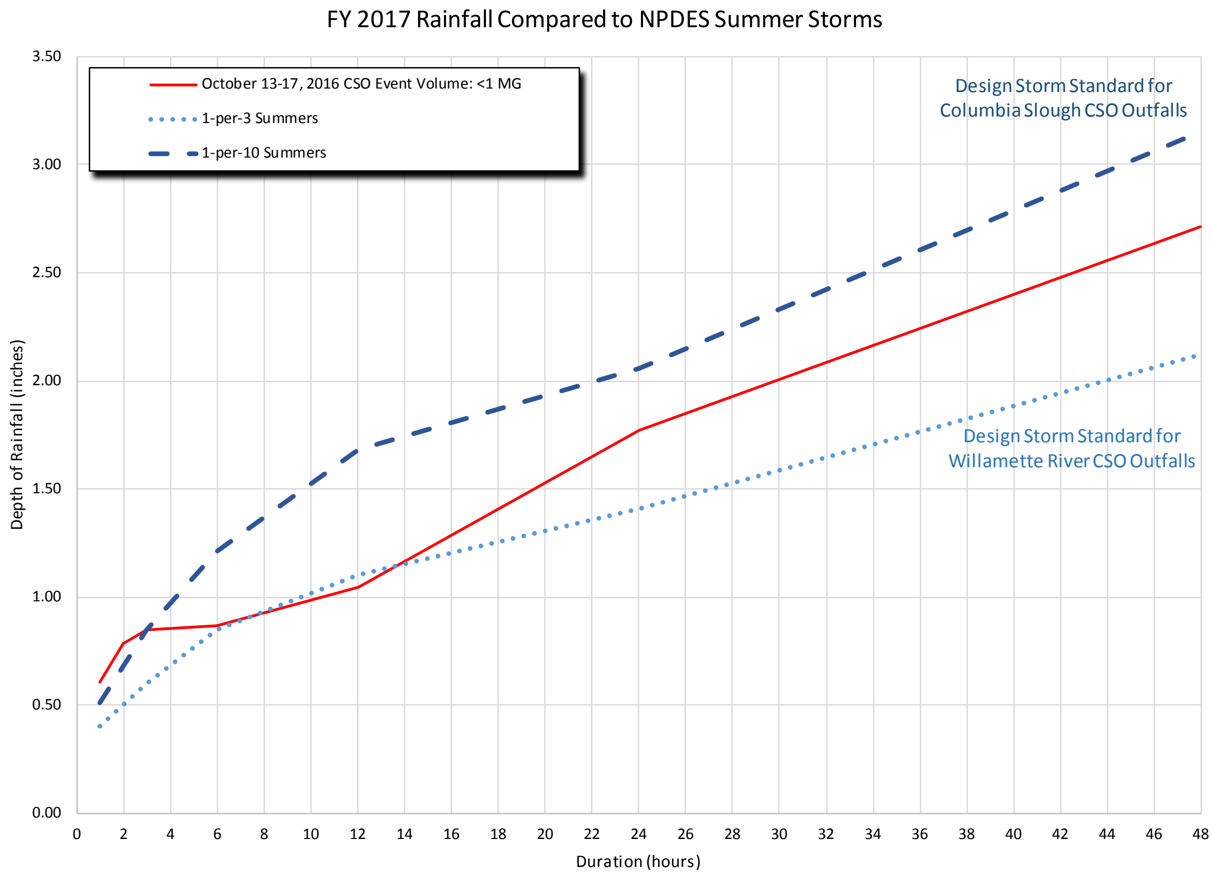


Figure 2 FY 2017 Rainfall Compared to NPDES Summer Storms

Table 2 FY 2017 Summer Storm Comparisons

Storm	Duration (hours)						Notes
	1	3	6	12	24	48	
Willamette River Summer Design Storms (inches)							
3-Year Summer Design Storm	0.40	0.60	0.85	1.10	1.41	2.12	
10-Year Summer Design Storm	0.51	0.85	1.21	1.68	2.06	3.15	
FY 2017 Summer Storms - Average Rainfall over Willamette CSO Basin (inches)							
October 13-17, 2016	0.61	0.85	0.87	1.05	1.77	2.71	Exceeds 10-year summer design storm for 1 hour, 3-year summer design storm for 3-6 hour and 24-48 hour.

The May 12-14, 2017, storm involved highly cellular, intense thunderstorms that traveled through the southwestern part of the city. The short duration intensities associated with the storm required us to examine it using a shorter time scale than shown in Figure 1 and Figure 2.

The May 12-14, 2017, storm is shown graphically in Figure 3 below. This graph displays the maximum depth of rainfall that occurred for the range of storm duration, from 15 minutes to 6 hours. The event is shown with a red line. The two comparison Summer Design Storms (3-year summer and 10-year summer) are shown with blue-tinted lines. Table 3 provides rainfall details for this event.

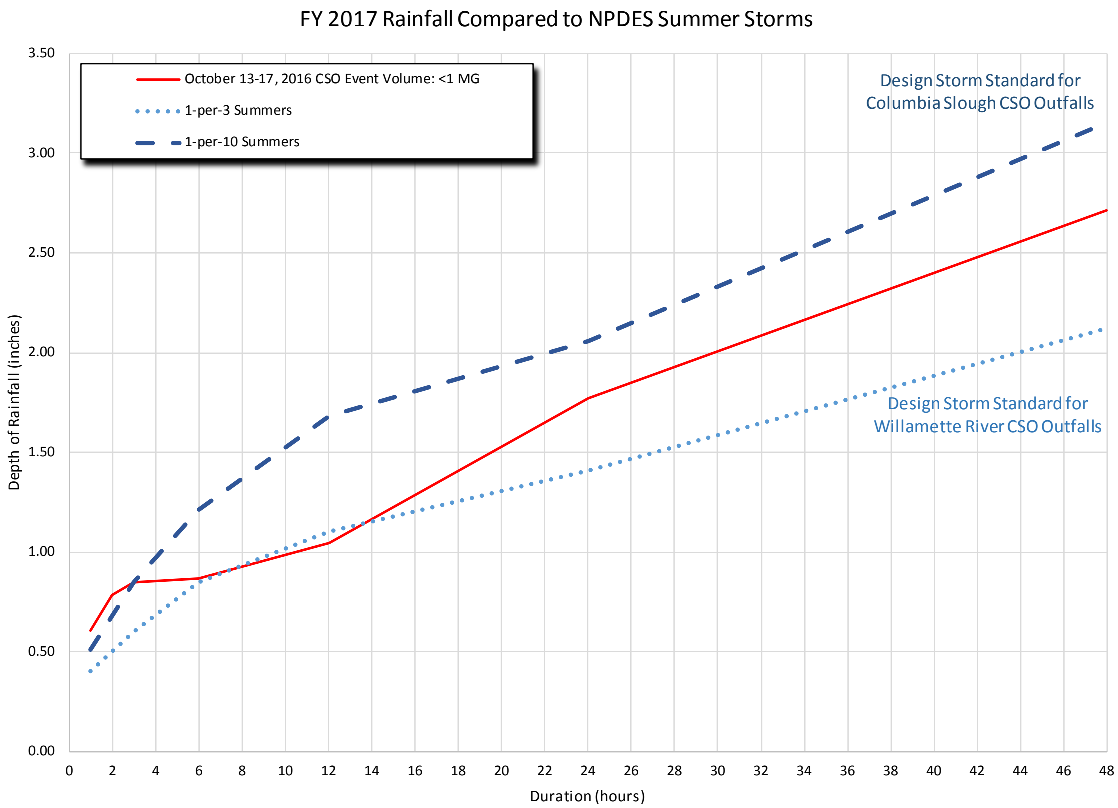


Figure 3 FY 2017 Rainfall for Short Events, Compared to NPDES Summer Storms

Table 3 FY 2017 Summer Storm Comparison, Short Duration Event

Storm	Duration (minutes)				Notes
	15	30	60	120	
Willamette River Summer Design Storms (inches)					
3-Year Summer Design Storm	0.15	0.26	0.40	0.52	
10-Year Summer Design Storm	0.17	0.3	0.51	0.71	
FY 2017 Summer Storms - Average Rainfall over Willamette CSO Basin (inches)					
May 12-14, 2017	0.24	0.28	0.28	0.43	Exceeds 10-year summer design storm for 15 minutes, 3-year summer design storm for 30 minutes

2.2 CSO Discharges into the Willamette River and Columbia Slough

2.2.1 Discharge Events

In FY 2017, there were seven separate CSO discharge events, with all seven contributing discharges to the Willamette River. Please consult the compliance letters submitted to DEQ for details on the circumstances and for validation of the events as permitted by the current NPDES permit for CBWTP #101505.

- **October 13-17, 2016:** 0.92 MG discharged over 38 minutes from the East and West Side Willamette River CSO Tunnels. This highly localized storm featured a very intense line of showers that followed a very moist front that crossed the city on October 13, 2016. This line of showers brought high rainfall intensities to the southern parts of the city. Two rain gauges in south Portland experienced 1-2 hour intensities at 100-year recurrence intervals.

- **November 22-25, 2016:** 211 MG discharged over 17 hours from East and West Side Willamette River CSO Tunnels. Rainfall that led to the CSO discharges was generated by a front that stalled over the Portland area and was amplified by several waves of additional moderately heavy rainfall. The heaviest rainfall totals were recorded close in to the Willamette River, with more intense amounts in the northern part of the city. Rainfall intensities exceeded 1-per-5 winters recurrence intervals.

- **January 17-18, 2017:** 93.5 MG discharged over 8.9 hours from the East and West Side Willamette River CSO Tunnels. This storm was characterized by steady, consistent rainfall combined with snowmelt from a record snowstorm 6 days prior. The snowfall between January 10 and 11, 2017, resulted in approximately 8-12 inches of accumulation throughout the city. Unseasonably persistent cold temperatures preserved this snow until it melted during the storm when temperatures finally rose above freezing. The storm featured citywide peak 1-hour to 48-hour intensities that exceeded the 4-per-winter design storm.

- **February 3-6, 2017:** 206 MG discharged over 12.1 hours from the East and West Side Willamette River CSO Tunnels. The rainfall that led to the CSO discharges was generated by a 64-hour rainfall event that exceeded the 4-per-winter design storm and slightly exceeded the 1-per-5 winters design storm for the 24-hour duration. Rainfall was heavy at times throughout the entire combined area.

- **February 7-10, 2017:** 3,500 gallons discharged over 10 minutes from Carolina OF 03. The small CSO event was likely caused by debris temporarily blocking a diversion structure's delivery of flow to an interceptor during an event that exceeded the 4-per-winter storm criterion. This overflow incited the City to investigate the upstream system and resulted in a repair to a damaged trash rack in July 2017. This damage may have led to suspected debris intrusion into and remaining in the collection system, contributing to overflows at OF 03 at this and the next two events.

- **February 15-16, 2017:** 89.6 MG discharged over 6.4 hours from the East and West Side Willamette River CSO Tunnels. The storm leading to the CSO discharge exceeded the 4-per-winter design storm.
- **May 12-14, 2017:** 5,100 gallons discharged over 12 minutes from Carolina OF 03. Local peak rainfall statistics at the OPB raingage #214 exceeded the 1-per-10 summers levels for the 15-minute duration and the required 1-per-3 summers level for the 15- and 30-minute durations. The signature of flows in the system indicate that there may have been some influence from debris that contributed to the overflow during the rainfall event.

The entire historical record of CSOs discharged from the City's CSO facilities is provided in Appendix A.

2.2.1.1 How Well Were CSO Events Controlled?

System rainfall was very high during the current reporting period, amounting to around 50% higher than average. The system experienced seven overflows (two in the summer, five in the winter). Total discharge for the year was about 550 MG, which was about 4.7% of the wet weather volume handled by the combined and sanitary collection systems. This equates to 95.3% volume control, exceeding the average 94% level of control expected from the system.

2.2.1.2 Were Wet Weather Flows Maximized to the Plant?

During the five systemwide CSO events (October 13-17, 2016; November 24-25, 2016; January 17-18, 2017; February 3-6, 2017 and February 15-16, 2017), flows through the Swan Island CSO Pump Station (SICSO) were maximized to the greatest extent possible, but were limited from the theoretical maximum rates due to the CSO System Operating Plan's higher priorities of protecting the plant, preventing basement sewer backups, and preventing Columbia Slough overflows. During these heavy storm events, the integrated CSO system experienced bottlenecking of flow at the Peninsular Tunnel at N Mississippi & Knott Ave. Increased pumping at SICSO would have resulted in high hydraulic grade lines and endangered basements in the area.

2.2.1.3 Was System Storage Maximized?

Two of the seven events were due to a local system becoming overwhelmed from local rainfall (February 7-10, 2017, and May 12-14, 2017). The remaining five events happened after the tunnels were filled. For all non-CSO-sized storms (less intense than 4-per-winter or 1-per-3 summers), tunnel storage levels did not exceed more than 28% of the tunnel capacity. For the CSO-sized storms that did not overflow, tunnels peaked at 76% of the tunnel capacity.

2.2.2 Dry Weather Overflow Events

One blockage-induced dry weather overflow event from the combined system outfalls, through OF 52, was recorded in FY 2017. A description of this event is described in Section 4.3.1 under "6600 N Baltimore Avenue."

2.2.3 Control of Floatables and Debris

Portland maintenance crews inspect and clean the bar screen within the Sheridan overflow structure (OF 07B) following CSO discharge events when conditions allow.

With the substantial amount of rainfall in the Willamette River watershed during FY 2017, there were long periods of time when the bar screen structure was not accessible due to high river levels. The river level did not fall below safe levels between early October 2016 and late June 2017.

Table 4 Floatables Control System Event Maintenance Summary

CSO Event Date(s)	Maintenance Date	Location	Description of Maintenance
October 13-17, 2016		Sheridan OF07B	River level was too high to safely inspect
November 24-25, 2016		Sheridan OF07B	River level was too high to safely inspect
January 17-18, 2017		Sheridan OF07B	River level was too high to safely inspect
February 3-6, 2017		Sheridan OF07B	River level was too high to safely inspect
February 7-10, 2017		Sheridan OF07B	River level was too high to safely inspect
February 15-16, 2017		Sheridan OF07	River level was too high to safely inspect
May 12-14, 2017	7/21/17	Sheridan OF07B	Removed 25 gallons of debris (leaves and small sticks) from screen

2.3 Wet Weather Treatment Performance and Effluent Quality

2.3.1 CSO Facilities Operations

The CSO System's configuration did not undergo any major changes in FY 2017. Following FY 2016, this is the second year in a row where rainfall has greatly exceeded average yearly values. Influent volumes to CBWTP increased 9% from FY 2016, though the percentage treated by the secondary system remained at 86%. The percentage of captured CSO treated via secondary fell slightly from 58% in FY 2016 to 57% in FY2017. Overall BOD and TSS removal efficiencies continue to exceed 90% at the plant's two outfalls, OF001 and OF003, with each performing at 92% efficiency. These numbers indicate that the plant reliably exhibits satisfactory performance year after year.

About 10,269 MG was pumped, compared with the 11,187 MG total captured combined flow reaching the plant (see Table 6, in the row named *Captured CSO Flow, Volume (MG/yr)*), representing 92% of that captured volume. The 918 MG (8%) difference represents the combined flow volume directly reaching CBWTP via the combined collection gravity system. Table 5 shows the total volume pumped from the two major CSO pump stations in the system, SICSO (draining the Willamette River system) and the Influent Pump Station (draining the Columbia Slough system).

Table 5 FY 2017 Volume Pumped from CSO Tunnels

CSO Tunnel Pumping	Total Pumped Volume (MG)
Swan Island CSO Pump Station	
Forcemain 1 (Peninsular Dry Weather)	4,114
Forcemain 2 (Peninsular Wet Weather)	761
Forcemain 3 (Portsmouth Wet Weather)	3,316
Swan Island CSO Pump Station Subtotal	8,191
Influent Pump Station Total	2,078
Total Volume Pumped to CBWTP from Tunnels	10,269

2.3.2 Annual Treatment Performance for CBWTP

2.3.2.1 Annual CSO Treatment Characteristics

Key parameters for the treatment system's annual performance were derived from the NPDES permit for the CBWTP #101505, which specifies annual percent removal efficiencies[1]. These parameters were based on the City's No Feasible Alternative Analysis (NFAA) report, submitted to DEQ in 2009. Table 6 summarizes the main annual treatment performance measures for the CBWTP systems. This 6-year record provides a comparison of the performance against the average year model and permit values. Key parameters are in blue text. For FY 2017:

[1] See Schedule A of the permit.

- Secondary treatment during wet weather increased from FY 2016 to 119 MGD, 8% higher than the 110 MGD minimum required by the permit after FY 2014.
- Percent of wet weather flow treated through secondary exceeded the model target level (57% compared to 54%).
- BOD and TSS removal efficiencies for the wet weather system exceeded the permit's annual requirements: BOD removal was 66% compared to the permit's requirement of 50%, and TSS removal was 84% compared to the permit's requirement of 70%.

When evaluating wet weather treatment, BES asks three questions:

- **Were wet weather flows treated to a high quality?** Yes. This is according to the observed numbers in comparison with permit requirements. See Section 2.3.2.2.
- **Were flows to secondary treatment maximized?** Yes. See Section 2.2.1.2.
- **Were effluent limits achieved at OF001 and OF003?** Yes. The numbers indicate that the system is producing the proper annual treatment results.

Examination of the annual results indicate that the CSO system operations strategy continues to sustain desired performance and can handle various conditions throughout the year, especially with another year of distinctly above average rainfall. The City's use of CEPT continues to keep BOD and TSS discharges from the Wet Weather Treatment Facility at consistently reduced levels.

Table 6 CBWTP Annual Treatment Performance Data[2]

CBWTP Annual Treatment Performance								
Annual Treatment Characteristics	**Average Year Model / Permit**	*No CEPT* **FY 2012**	*With CEPT* **FY 2013**	*With CEPT* **FY 2014**	*With CEPT* **FY 2015**	*With CEPT* **FY 2016**	*With CEPT* **FY 2017**	**Trend**
Annual Rainfall Depth (inches/year)	37	46.8	40.2	40.0	33.9	53.4	59.5	
Flows to CBWTP								
Influent Volume (MG/Year)	28,300	28,800	26,625	26,549	25,760	30,665	33,544	
Dry Weather Sanitary Volume (MG/Year)	22,100	20,200	19,496	19,471	19,609	20,179	22,358	
Captured CSO Flow - Volume (MG/Year)	6,200	8,600	7,129	7,078	6,151	10,485	11,187	
Total Volume Treated Thru Secondary (MG)	25,443	25,662	24,197	24,002	23,221	26,301	28,765	
% of Plant Flow Treated Through Secondary System	90%	89%	91%	90%	90%	86%	86%	
WWTF (EWWPT) Events								
Rate to DW / Secondary During EWWPT (MGD)	100	120	126	112	112	117	119	
Number of Events / Year	32	29	22	27	27	39	41	
WWTF Volume / Year	2,857	3,138	2,429	2,546	2,540	4,363	4,779	
Amount of Captured CSO Treated via Secondary (%)	54%	64%	66%	64%	59%	58%	57%	
Duration of WWTF Events (hours)	919	706	668	904	591	1241	1,333	
Calendar Days of WWTF Discharges (days)	---	66	50	65	51	92	99	
Blended Effluent (OF001 & 003) Treatment								
BOD Loading (pounds / year)	2,510,000	4,000,000	2,957,783	3,472,307	4,176,834	3,871,106	4,554,872	
BOD Average Concentration (mg/l)	27	16.6	13.3	15.7	19.4	15.1	16.3	
Total Plant BOD Removal Efficiency (%)	---	93%	95%	94%	93%	93%	92%	
TSS Loading (pounds / year)	2,440,000	5,050,000	3,585,748	4,055,479	4,413,412	4,910,264	5,248,619	
TSS Average Concentration (mg/l)	27	21.0	16.1	18.3	20.5	19.2	18.8	
Total Plant TSS Removal Efficiency (%)	---	92%	94%	93%	92%	92%	92%	
Wet Weather Treatment Facility								
BOD TO Wet Weather Facility (pounds/year)	---	2,290,000	1,638,460	2,361,933	2,414,044	3,651,168	4,321,434	
BOD FROM Wet Weather Facility (pounds/year)	---	1,510,000	726,541	874,387	962,545	1,258,955	1,448,085	
Wet Weather BOD Removal Efficiency (%)	50%	34%	56%	63%	60%	66%	66%	
TSS TO Wet Weather Facility (pounds/year)	---	4,030,000	2,257,182	3,048,027	3,130,925	5,649,463	8,300,487	
TSS FROM Wet Weather Facility (pounds/year)	---	1,480,000	520,375	520,252	560,013	1,134,753	1,339,039	
Wet Weather TSS Removal Efficiency (%)	70%	63%	77%	83%	82%	80%	84%	

2.3.2.2 CBWTP Max-Month and Peak-Week Treatment Performance

Table 7 provides maximum 30-day treatment results for BOD and TSS. While the permit requires reporting of maximums on a calendar month basis, this evaluation uses a more stringent moving 30-day window analysis. Maximum 30-day concentrations and loadings for both BOD and TSS at the outfalls for the maximum 30-day period of the year (ending February 16, 2017) were well below the permit's monthly limits.

2 The permit average for "Rate to DW/Secondary During EWWPT (MGD)" rose to 110 MGD in 2014 (applicable for FY 2015 and onwards).

Table 7 FY 2017 Wet Weather Max-Month (30-days maximum solids loading) Treatment Performance[3]

Parameters	Maximum Monthly (30-Day)						
	Avg Concentration During Maximum Month for Mass Loading			Mass Loading			
	Permit Monthly (mg/l)	Max 30-Day (mg/l)	30-Day Avg Flow (MGD)	Permit Monthly (lbs/day)	Max 30-Day (lbs/day)	Date of 30th Day	Notes
Columbia Boulevard WWTP - Outfalls 001 and 003 Effluent Quality							
BOD5	30	18	157	45,000	24,108	16-Feb-17	12.5 in of rain, snow in 30 d
TSS	30	26	157	45,000	34,069	16-Feb-17	
Secondary Biological Treatment - 100 MGD Minimum Instantaneous							
BOD5	30	27	66	22,500	14,731	10-Oct-16	3.8/10.2 in of rain,snow in 30 d
TSS	30	20	110	22,500	17,540	13-Dec-16	
Wet Weather / CEPT System - Intermittent Discharges							
BOD5	45	16	121	22,500	16,218	16-Feb-17	12.5 in of rain snow in 30 d
TSS	45	18	121	22,500	17,886	16-Feb-17	

Table 8 provides peak 7-day treatment results for BOD and TSS. As in the previous discussion for the 30-day analysis, the permit requires reporting of peaks on a calendar week (Sunday to Saturday) basis. However, this analysis uses a more stringent moving 7-day window. Treatment performance for both 7-day BOD and TSS concentrations and loadings for the maximum period (ending November 27, 2016, for BOD and February 10, 2017, for TSS) were excellent, and these measures were well below the limits at the outfalls.

Table 8 FY 2017 Wet Weather Peak-Week (7-days maximum solids loading) Treatment Performance[3]

Parameters	Peak Week (7-Day)						
	Avg Concentration During Peak Mass Loading Week			Mass Loading			
	Permit Weekly (mg/l)	Max 7-Day (mg/l)	7-Day Avg Flow (MG)	Permit Weekly (lbs/day)	Max 7-Day (lbs/day)	Date of 7th Day	Notes
Columbia Boulevard WWTP - Outfalls 001 and 003 Effluent Quality							
BOD5	45	29	182	118,800	43,261	27-Nov-16	4.5/6.0 in of rain, snow in 7 d
TSS	45	30	257	118,800	64,153	10-Feb-17	
Secondary Biological Treatment - 100 MGD Minimum Instantaneous							
BOD5	45	27	110	37,500	24,807	26-Nov-16	4.5 inches of rain in 7 days
TSS	45	34	110	37,500	31,279	26-Nov-16	
Wet Weather / CEPT System - Intermittent Discharges							
BOD5	65	29	136	81,300	32,869	10-Feb-17	6.0 in of rain, snow in 7 d
TSS	65	36	136	81,300	41,452	10-Feb-17	

[3] As stated in the Discharge Monitoring Reports (DMRs), Portland applies the System-Based Performance Requirements for Secondary and WWTF as in-plant guidelines. Permit compliance is required only for the combined OF001 and OF003 effluent.

2.4 Wet Weather Treatment Performance for Enhanced Wet Weather Primary Treatment (EWWPT) Events

Wet weather treatment performance is best evaluated by examining the events in which the WWTF discharged treated effluent. These events are called Enhanced Wet Weather Primary Treatment (EWWPT) events to underscore that the wet weather flow diverted from the secondary system receives CEPT.

An EWWPT event begins when the WWTF starts discharging effluent, and ends after either of the following:

- WWTF discharge has ended AND the plant inflow remains below 80 MGD for 6 hours OR
- WWTF discharge has ended and no subsequent WWTF discharge occurs for 48 hours. This condition may occur when low level rainfall keeps plant inflows up, but Operations is able to send all inflows through secondary treatment.

Table 9 summarizes the WWTF events for FY 2017. The full, detailed list of the events is in Table 10.

Table 9 FY 2017 Enhanced Wet Weather Primary Treatment Events Summary

		CBWTP Flows		WWTF Flows				WWTF Effluent			
	Events	Avg Influent During EWWPT (MGD)	Avg Secondary Flow During EWWPT (MGD)	Avg WWTF Flow (MGD)	WWTF Discharge Volume (MG)	Duration of WWTF Discharge (hrs)	Calendar Days WWTF Discharge Occurred	Event BOD Load Discharged (lbs)	Event TSS Load Discharged (lbs)	EMC BOD (mg/L)	EMC TSS (mg/L)
Total	**41**				**4,779**	**1333**	**99**	**1,448,085**	**1,339,039**		
Average/Event		**208**	**119**	**78**	**117**	**32.5**	**2.4**	**35,319**	**32,659**	**36**	**27**

Key aspects for this year's WWTF performance include:

- Volume of EWWPT events was 4.8 billion gallons. This is about 14% of the total volume received at the CBWTP for the year (33.5 billion gallons; see Table 6).
- An EWWPT event was in progress during the year for about 1300 hours (15% of the year) and 99 calendar days (a little less than 2 days per week). Treatment throughout the WWTF continues to be highly intermittent.
- The average mean concentrations (EMC) for BOD of 36 mg/L and 27 mg/L for TSS is a further improvement over FY 2016, and compare very well with expected values for the CEPT system.

- Operators maintained an average of 119 MGD of flow through secondary treatment during EWWPT events, compared to the permit requirement of 110 MGD. This rate is 57% of the average flow rate reaching the plant during an EWWPT event (208 MGD).
- EWWPT events lasted just over 32 hours on average and typically occurred across 2.4 days. This is similar to events in FY 2016.

Table 10 Enhanced Wet Weather Treatment Events - Detailed Information

		CBWTP Flows		WWTF Flows				WWTF Effluent			
Date & Time Bypass Event Started	Event #	Avg Influent During EWWPT (MGD)	Avg Secondary Flow During EWWPT (MGD)	Avg WWTF Flow (MGD)	WWTF Discharge Volume (MG)	Duration of WWTF Discharge (hrs)	Calendar Days WWTF Discharge Occurred	Event BOD Load Discharged (lbs)	Event TSS Load Discharged (lbs)	EMC BOD (mg/L)	EMC TSS (mg/L)
9/17/16 13:45	1	157	109	78	27	8.3	1	14,095	8,375	63	38
10/7/16 4:15	2	222	121	91	24	6.3	1	4,555	2,970	23	15
10/9/16 8:15	3	219	121	89	101	27.3	2	22,182	15,405	26	18
10/13/16 6:30	4	250	121	120	319	63.5	3	86,315	90,441	32	34
10/16/16 20:00	5	166	116	45	58	31.3	3	12,842	9,609	26	20
10/20/16 14:45	6	254	129	117	18	3.8	1	5,844	6,459	38	42
10/21/16 21:30	7	265	120	134	34	6.0	2	11,619	5,688	42	20
10/26/16 7:00	8	170	118	45	45	24.0	2	13,997	7,866	38	21
10/31/16 6:00	9	182	120	55	14	6.0	1	2,660	1,619	23	14
11/5/16 15:00	10	282	126	134	108	19.3	2	30,381	23,219	34	26
11/14/16 9:45	11	228	123	95	136	34.3	2	36,739	29,314	32	26
11/20/16 22:45	12	180	119	55	3	1.5	2	1,609	1,886	56	65
11/22/16 18:00	13	261	122	133	122	22.0	2	47,285	55,459	47	55
11/24/16 11:45	14	230	115	92	336	87.5	5	87,178	98,014	31	35
12/4/16 2:00	15	261	123	150	101	16.3	1	15,673	18,148	19	21
12/5/16 12:00	16	237	119	108	19	4.3	1	8,419	3,400	53	21
12/9/16 15:45	17	192	117	69	174	60.5	4	53,336	49,425	37	34
12/19/16 11:15	18	236	118	110	167	36.3	2	50,105	56,022	36	40
12/23/16 6:15	19	164	120	12	1	1.3	1	74	179	14	34
12/26/16 23:00	20	183	120	56	19	8.3	2	5,146	2,455	32	15
1/8/17 17:00	21	202	117	75	94	30.0	2	31,218	19,483	40	25
1/17/17 19:00	22	226	119	86	398	111.5	6	168,810	168,498	51	51
2/3/17 16:15	23	262	120	115	806	167.8	8	241,731	296,735	36	44
2/15/17 10:45	24	234	118	99	630	153.0	7	179,765	169,788	34	32
2/26/17 12:00	25	145	119	24	8	8.3	1	2,336	1,511	34	22
3/3/17 21:15	26	222	119	92	10	2.5	1	3,893	1,756	49	22
3/5/17 23:30	27	155	113	33	135	97.3	6	56,324	28,248	50	25
3/11/17 11:30	28	251	119	113	24	5.0	1	6,228	4,822	32	24
3/13/17 13:15	29	201	116	74	392	126.8	6	125,011	87,413	38	27
3/21/17 22:45	30	178	121	32	2	1.8	2	913	1,095	46	55
3/23/17 23:45	31	176	113	58	186	77.5	5	50,261	32,412	32	21
3/29/17 10:15	32	161	119	30	2	1.8	1	354	335	20	19
4/6/17 10:30	33	200	119	71	10	3.5	1	3,560	1,424	41	17
4/12/17 3:45	34	169	120	42	33	19.0	1	11,131	3,617	40	13
4/18/17 2:30	35	149	120	19	2	2.8	1	730	524	41	29
4/19/17 21:30	36	204	120	75	23	7.5	2	3,797	920	20	5
4/23/17 23:30	37	240	122	108	111	24.8	3	24,335	18,179	26	20
4/26/17 10:45	38	161	129	24	2	2.0	1	330	280	20	17
5/13/17 13:00	39	237	120	100	57	13.8	2	17,117	12,916	36	27
5/16/17 0:30	40	195	120	65	16	6.0	1	5,645	1,747	42	13
6/15/17 18:30	41	203	119	73	11	3.5	1	4,521	1,365	51	15
Total	**41**				**4,779**	**1,333**	**99**	**1,448,060**	**1,339,022**		
Avg/Event		**208**	**119**	**78**	**117**	**33**	**2.4**	**35,319**	**32,659**	**36**	**27**

BOD and TSS removal efficiencies compared to event volume are shown in Figure 4 (BOD) and Figure 5 (TSS). Small events tend to have higher BOD and TSS concentrations, and larger volume events have lower concentrations. The CEPT system achieves better than 50% BOD and 70% TSS removal efficiencies on an overall basis. For the first time since CEPT was instituted, all wet weather events this fiscal year placed above the target efficiencies, as seen on the charts.

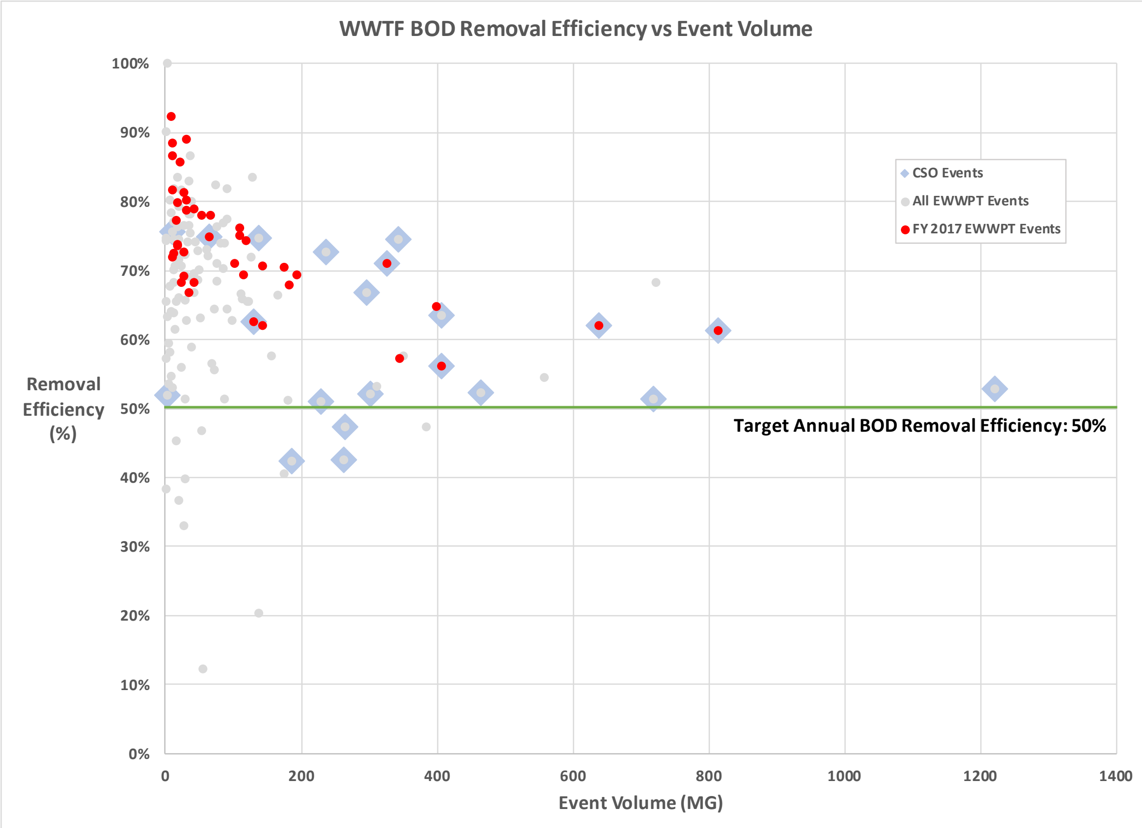


Figure 4 WWTF BOD Removal Efficiency vs. Event Volume

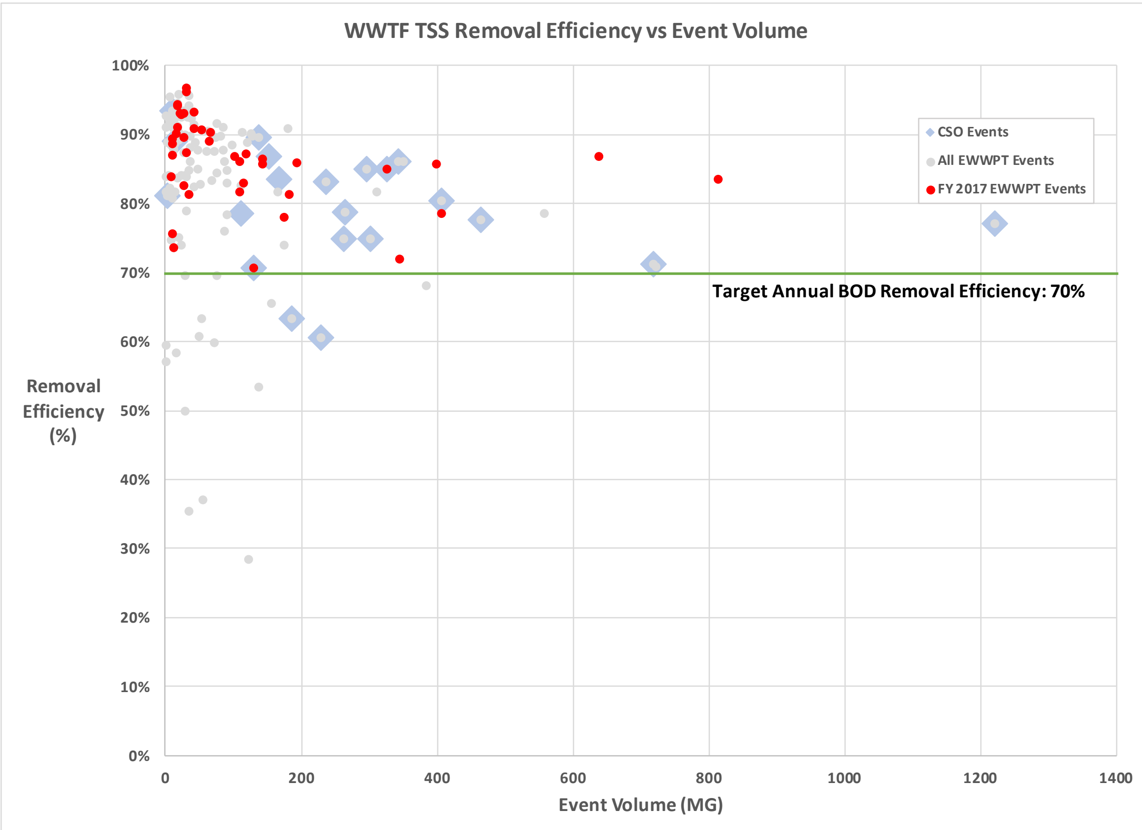


Figure 5 WWTF TSS Removal Efficiency vs. Event Volume

2.5 CSO System and Water Quality Monitoring

2.5.1 CSO Discharge Sampling

Portland completed the permit requirements of obtaining 5 event samples for the current permit cycle (8 were retrieved: 2 near Outfall 46, and the remaining near Outfall 36). These samples were reported in the *FY 2013* through *FY 2016 Annual CSO and CMOM Program Reports*. For details about this sampling program, please see Section 8.2 of the *FY 2015 Annual CSO and CMOM Program Report*.

2.5.2 Willamette River Instream Water Quality Sampling

Figure 6 through Figure 10 show the water quality trends along the Portland stretch of the Willamette River for five parameters: zinc, lead, copper, TSS, and *E. coli*. These metals and bacteria parameters are the pollutants of concern for Portland CSO discharges. The sampling results indicate similar performance to FY 2016 and prior.

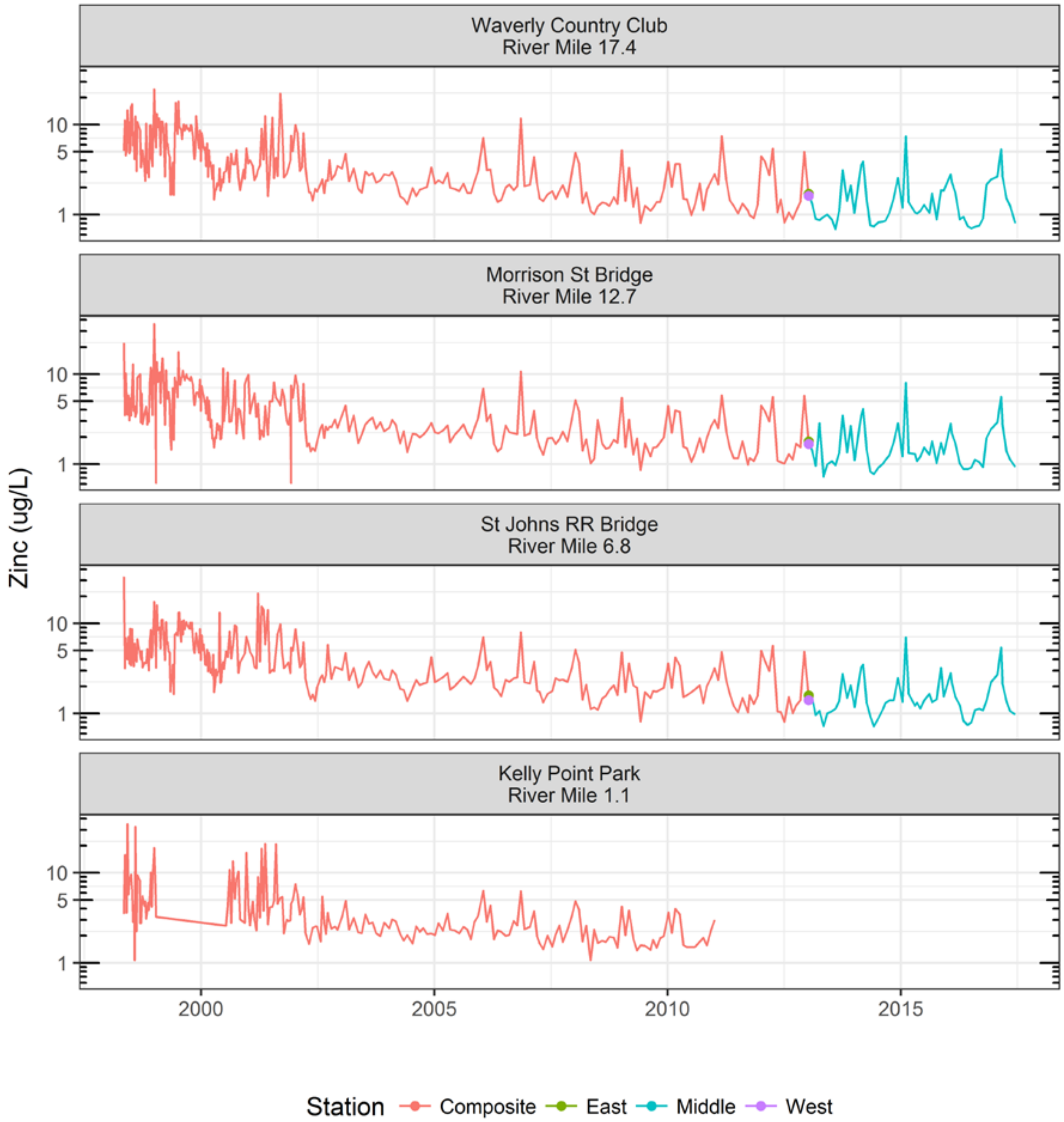


Figure 6 Willamette River Monitoring Results for Zinc[4]

[4] Mixing with the Columbia River at the Kelly Point Park site was deemed to not be useful as an indicator of water quality in the Willamette River, so this site ceased to be monitored in 2011.

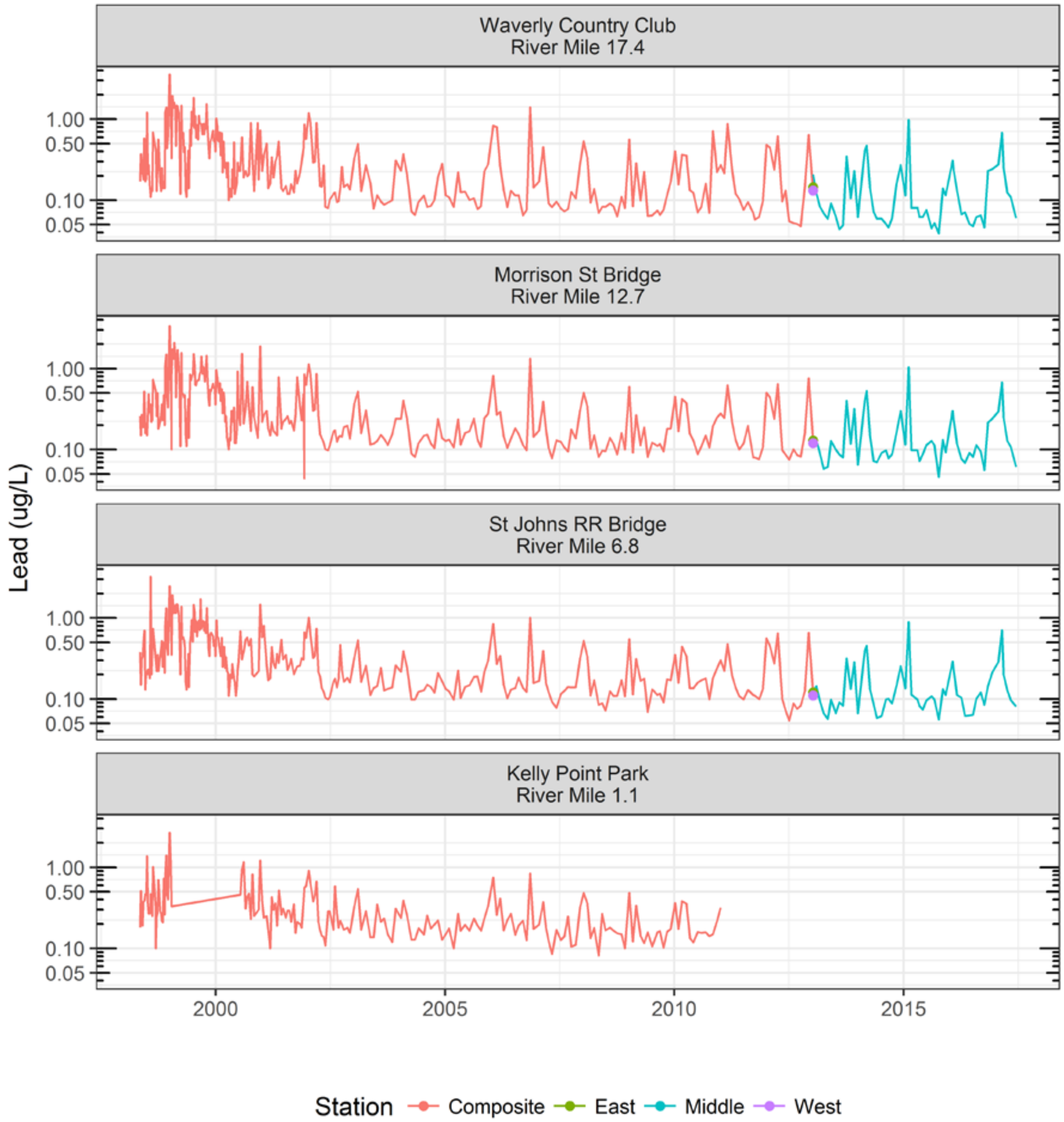


Figure 7 Willamette River Monitoring Results for Lead

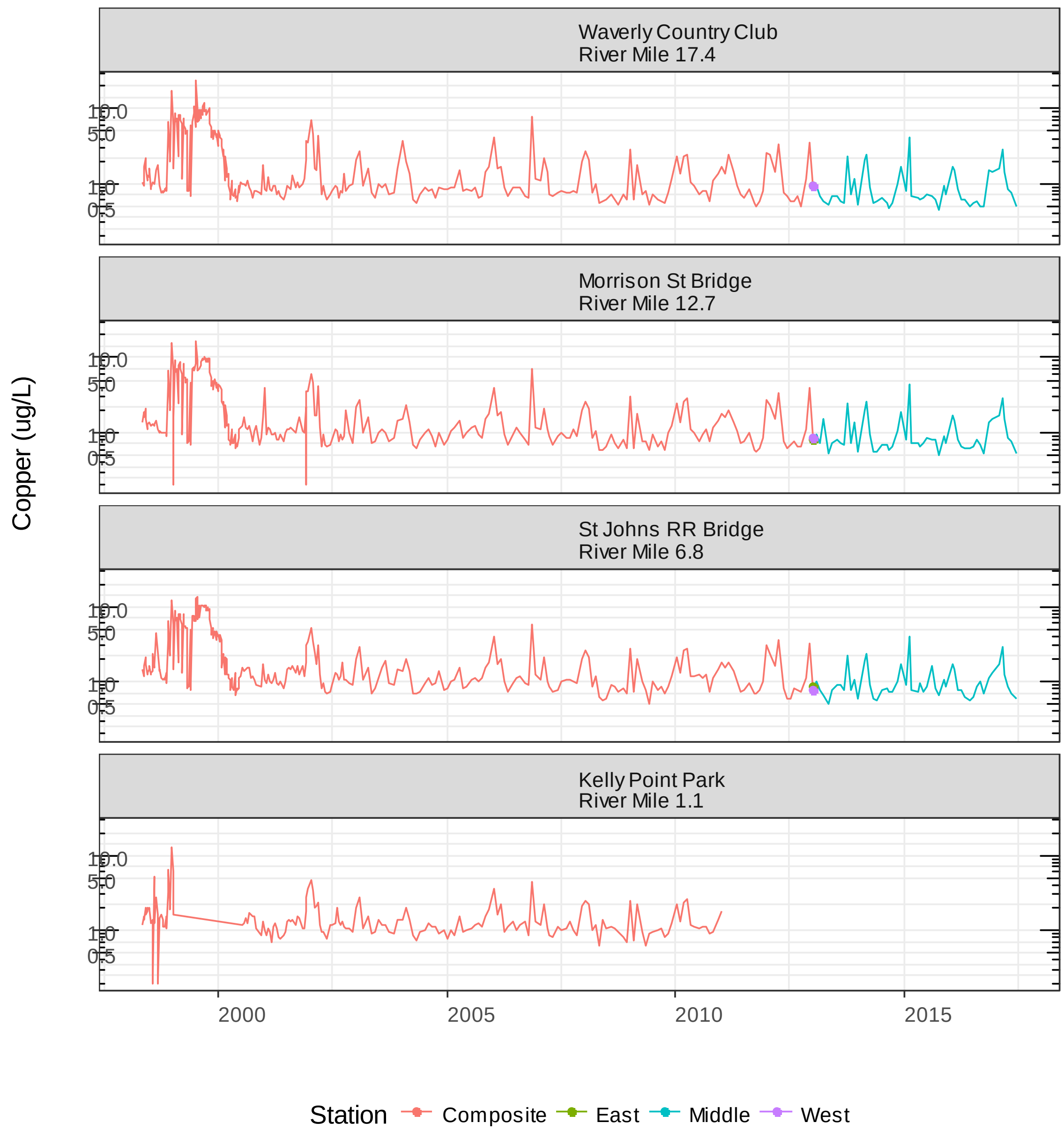


Figure 8 Willamette River Monitoring Results for Copper

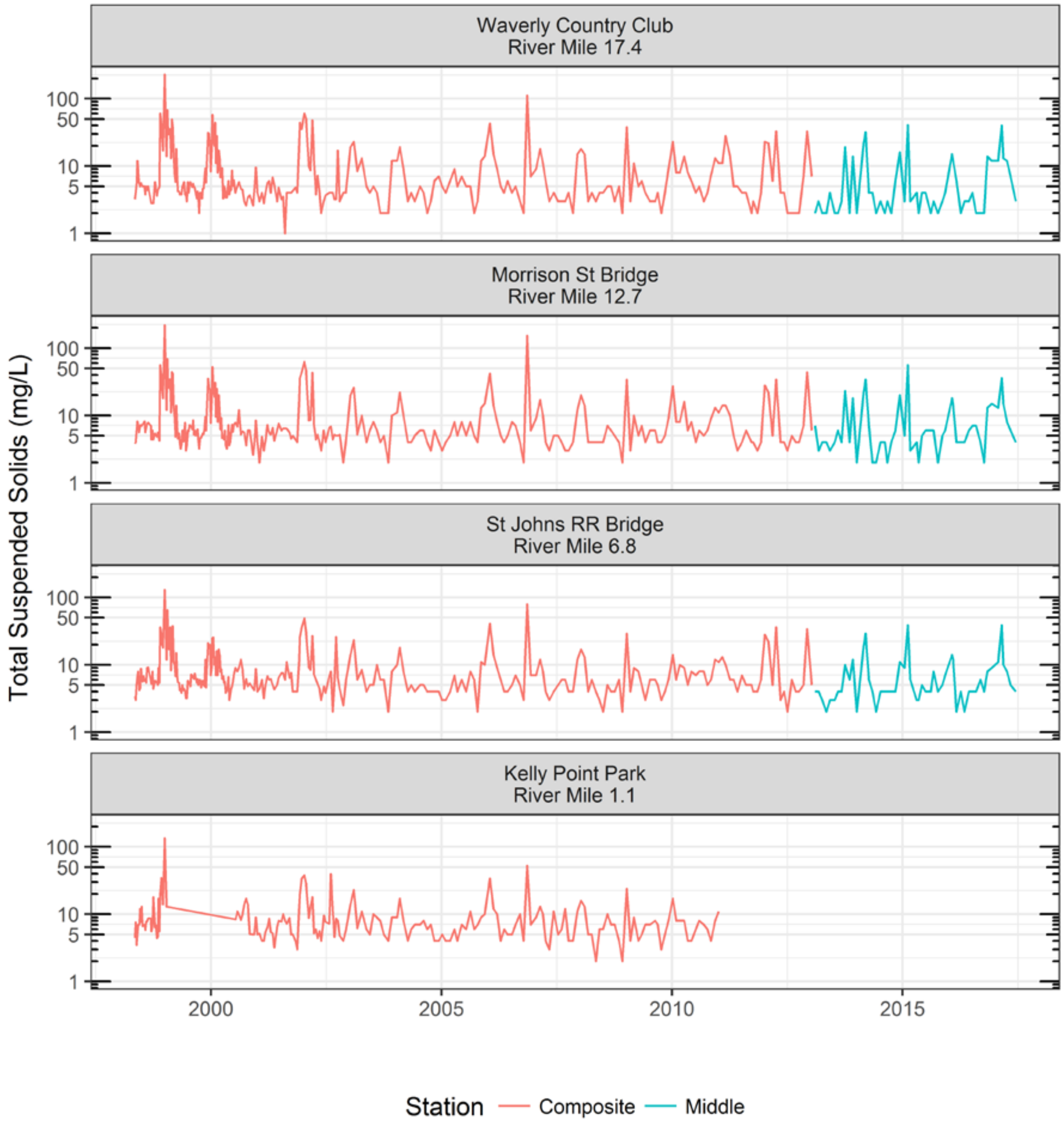


Figure 9 Willamette River Monitoring Results for TSS

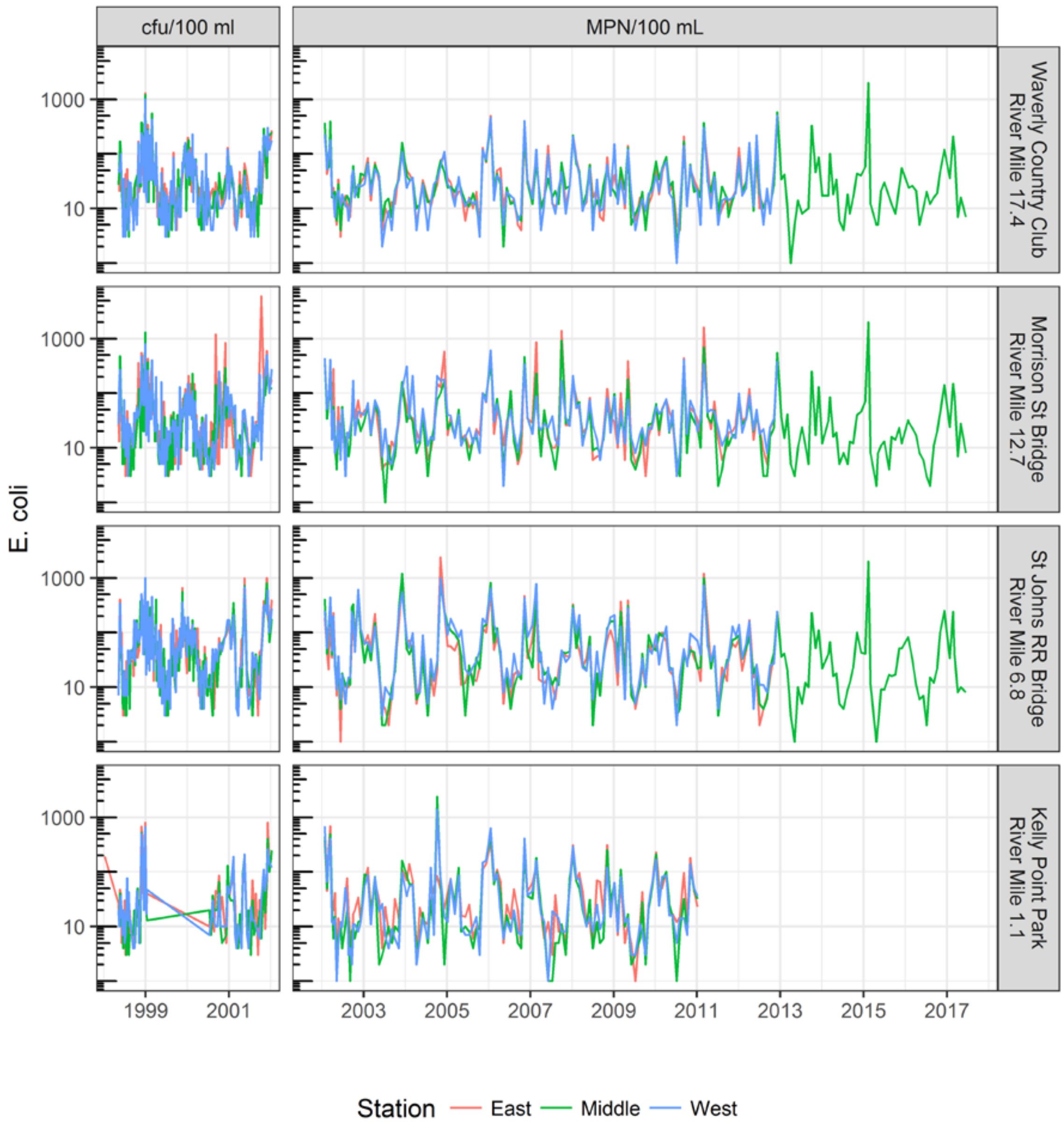


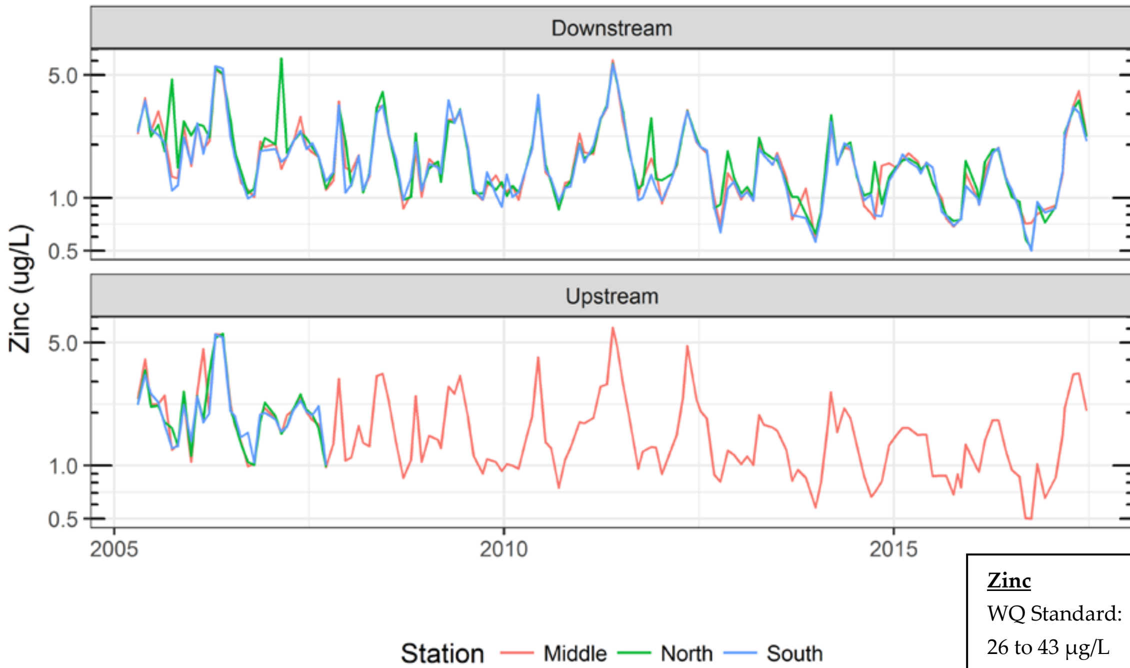
Figure 10 Willamette River Monitoring Results for E. coli

2.5.3 Columbia River Instream Water Quality Sampling

Figure 11 through Figure 15 show measurements of the main parameters of interest related to wet weather treatment and the Columbia River: Zinc, Lead, Copper, TSS, and *E. coli*. These charts compare the measurements upstream and downstream of the combined mixing zone. The charts also include the relevant numeric water quality standard for each parameter except for TSS, which is not a toxic. For the metals, the range of chronic water quality standard values is based on the measured total hardness of the river, which varies from a low of 45 to a high of

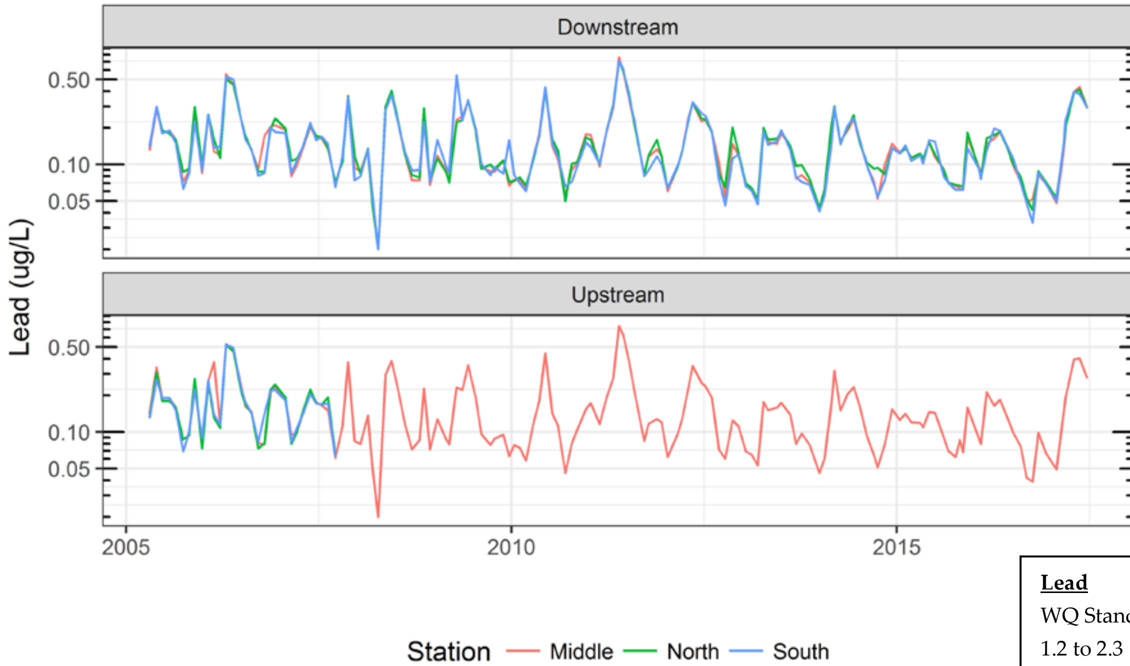
78. The charts show the reasonable range of chronic standards based on the hardness values measured in the river during the sampling period.

All parameters are well within the numeric water quality standards. There is little difference between the upstream and downstream measurements.



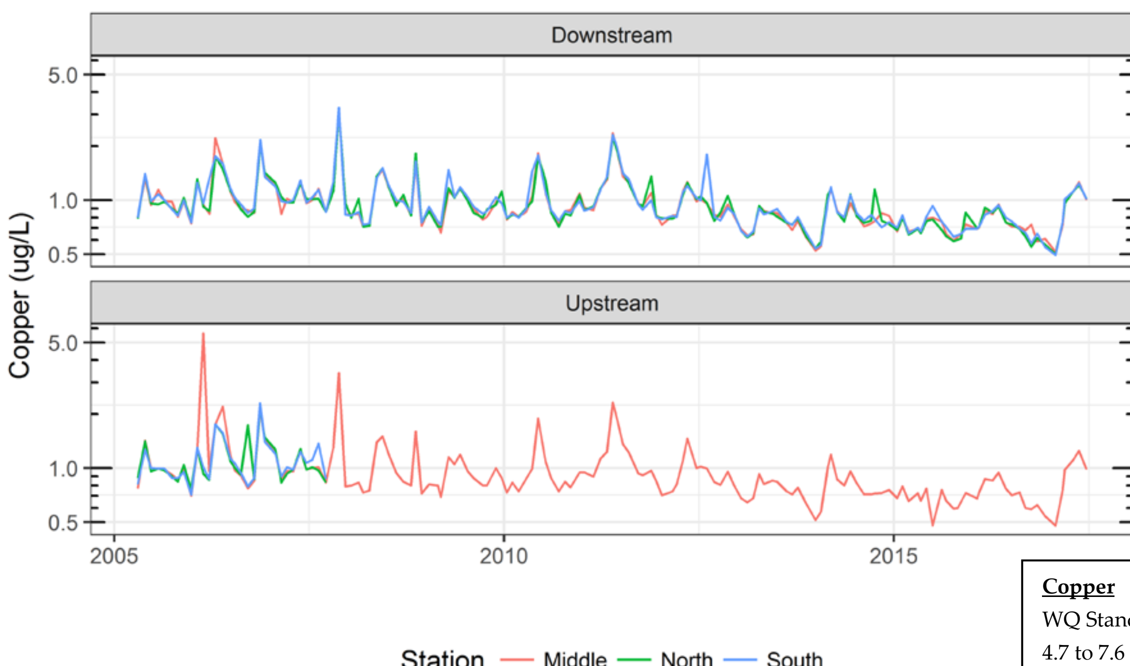
<u>Zinc</u>
WQ Standard:
26 to 43 µg/L
chronic hardness
range

Figure 11 Columbia River Mixing Zone Sampling for Zinc



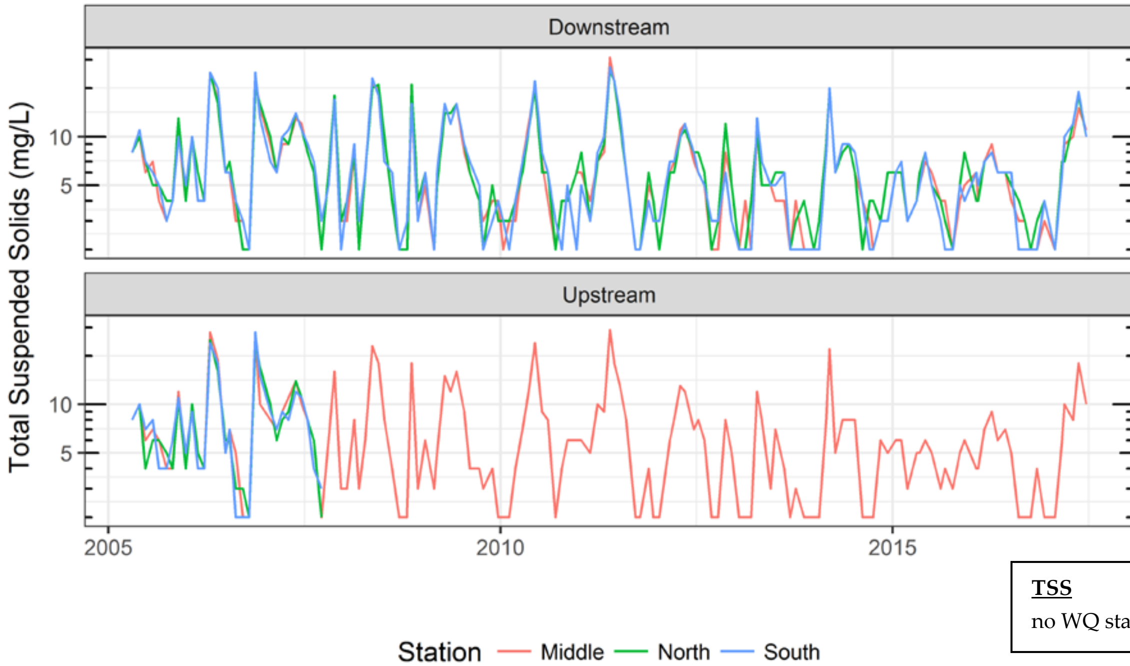
Lead
WQ Standard:
1.2 to 2.3 µg/L
chronic hardness
range

Figure 12 Columbia River Mixing Zone Sampling for Lead



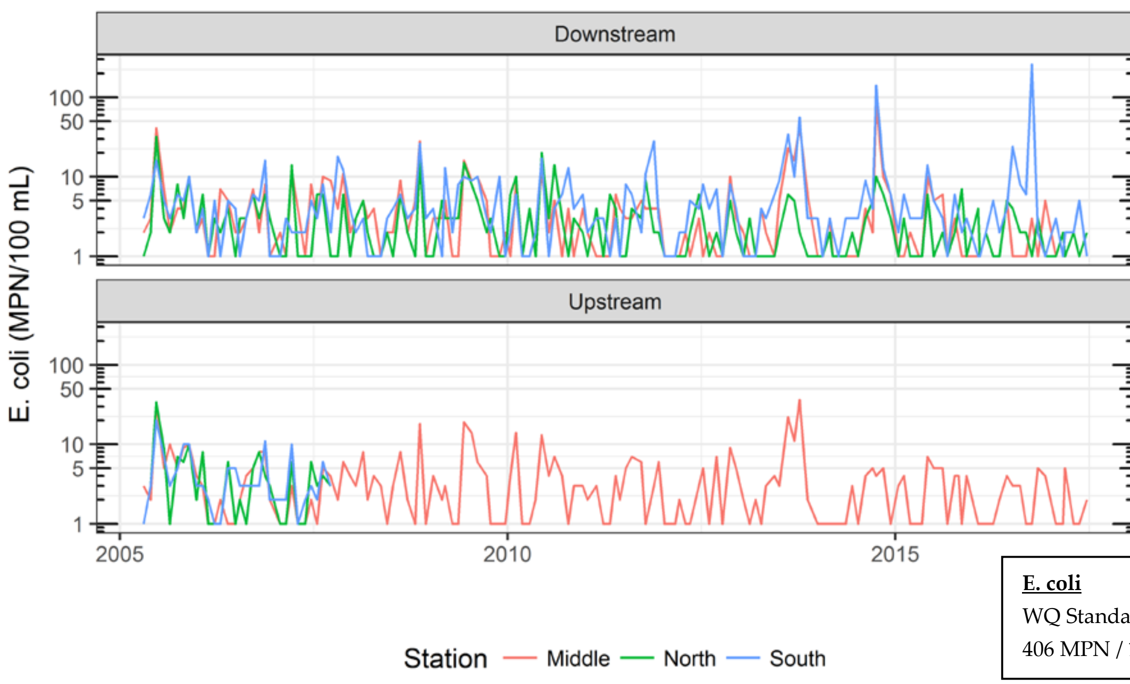
Copper
WQ Standard:
4.7 to 7.6 µg/L
chronic hardness
range

Figure 13 Columbia River Mixing Zone Sampling for Copper



TSS
no WQ standard

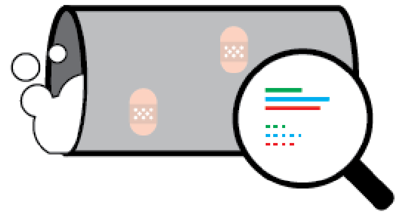
Figure 14 Columbia River Mixing Zone Sampling for TSS



E. coli
WQ Standard:
406 MPN / 100 mL

Figure 15 Columbia River Mixing Zone Sampling for E. coli

Section 3 CMOM Program Implementation



The City of Portland's CMOM program is designed to ensure that components of the collection system are cleaned and inspected at the right frequency and that preventive maintenance and repairs are performed to cost-effectively reduce the number of sewer releases, extend the useful life of the City's sewer infrastructure, and properly manage collection system operations. This annual summary for FY 2017 provides a brief overview of collection system operation and maintenance programs and practices as context for evaluation of the effectiveness of CMOM activities. Section 4 of this report includes sewer release analysis and performance.

3.1 Collection System – Gravity Sewers Operation and Maintenance

BES has programs in place to ensure that gravity sewers and manholes are properly inspected, cleaned, and repaired. Closed-circuit television (CCTV) inspection activities are key for an accurate determination of the structural and operational condition of collection system assets. Cleaning helps maintain asset condition and hydraulic capacity, enhances the effectiveness of inspections, and helps to control odors. Repairing structural deterioration protects the community's infrastructure investment, can extend an asset's useful life, and reduces the potential for catastrophic failures.

3.1.1 Sewer Inspections and Cleaning

The *Collection System Inspection and Cleaning Plan* submitted to DEQ in December 2012 provides detailed information about the City's "needs-based" maintenance strategy for prioritizing maintenance, inspection and cleaning activities and expenditures. The inspection and cleaning programs contain both preventive maintenance and unplanned work.

In FY 2017, the sewer inspection program inspected 680,684 lineal feet (129 miles) of mainline sewer pipe, which corresponds to approximately 7% of the mainline sewer system. Sewer mainlines are inspected for general preventive maintenance, special investigations in support of the chemical root and grease management programs, in response to sewer problems, and to support asset reinvestment projects through the Capital Improvement Program (CIP). In

FY 2017, approximately 92% of the work orders in the inspection program were considered planned work, including general preventive maintenance and support of the City's CIP Sewer Rehabilitation Program. The CCTV inspection program provides the pipeline condition assessment information that is instrumental to the risk prioritization process used to drive the CIP Rehabilitation Program work. In addition to mainline sewer inspections, the City completed 455 service lateral inspections in FY 2017.

In FY 2017, the sewer cleaning program cleaned 1,141,409 feet (216 miles) of sewer pipe, which corresponds to approximately 11% of the mainline sewer system. The sewer cleaning program includes preventive maintenance, accelerated cleaning in grease management areas, support for the root treatment program, special investigations related to collection system problems, and support of CIP projects.

In FY 2017, 96% of mainline cleaning work orders were considered planned maintenance; that is, the cleaning was performed for general preventive maintenance, to support a planned CCTV inspection, cleaning of grease management areas, and cleaning to support root treatment activities.

In support of BES's integrated approach towards overall watershed health, Maintenance Engineering and Watershed Services staff conducted stream walks and data analysis to assess external factors that might affect sewer pipes near streams. The Lowell Creek walk, conducted in June 2016 (FY 2016), started at 4422 SW Westdale Drive and terminated approximately 500 feet south of the intersection of SW Hamilton Street and SW Shattuck Road. The walk followed approximately 3,000 lineal feet of 8-inch sanitary-only mainline sewer. The Woods Creek walk, which occurred during June 2017 (FY 2017), started near the intersection of SW Plum Street and SW Wood Parkway and terminated near the intersection of SW 49th Avenue and SW Garden Home Road. This walk followed approximately 2,900 lineal feet of 8-inch and 10-inch sanitary-only mainline sewer. BES is evaluating the data collected to assess the usefulness of external visual inspection and observations of site conditions in conjunction with other preventive maintenance activities and to develop a standardized, repeatable condition assessment approach for this type of inspection moving forward.

3.1.2 Sewer Assessment and Repairs

Maintaining the wastewater collection system in good repair is a core service BES provides to its ratepayers. The City has a well-established sewer and manhole repair program. Priority codes in Hansen[5] are assigned when work orders are created. The priority codes are used when scheduling and assigning work and to help manage the backlog of open work orders to ensure that repairs are completed according to their relative risk and consequence of failure (e.g., top priority is given to Sanitary Sewer Overflow (SSO) and hazard-related repairs). The *CMOM Program Report* includes descriptions of sewer repair maintenance activities and equipment.

During FY 2017, for minor urgent or emergency repairs BES relied preferentially on services from City crews for sewer cleaning, investigation, inspection, and repair. However, for larger urgent or emergency projects BES Maintenance Engineering coordinated closely with BES Engineering Services to conduct work under the Maintenance Capital Contract Program or emergency CIP projects.

City maintenance crews completed mainline sewer repairs totaling 10,100 lineal feet. Approximately 62% of these repairs were considered unplanned. Repairs are considered unplanned if the work is in direct response to a collection system problem, such as a sewer release or surface cavity, or if the severity of the problem is significant enough to warrant the deployment of repairs within a week. The majority of planned repairs occur either from defects identified by the preventive maintenance CCTV inspection program or when additional repairs on a line are made in conjunction with an unplanned repair. Repairs on mainline sewers are typically localized spot repairs where pipe sections are excavated and replaced or renewed using cured-in-place pipe (CIPP) liners.

City crews completed over 588 service lateral repairs totaling approximately 7,930 lineal feet. Approximately 65% of these repairs were unplanned. Unplanned service lateral repairs are typically in response to a sewer system problem such as a sewer backup or a positive dye test from a sewer investigation. Planned service lateral repairs generally occur in conjunction with adjacent repairs on mainline sewers. Service lateral repairs typically involve the complete replacement or renewal of the lateral and the addition of a cleanout at the curb for improved future maintenance.

3.1.3 Root Management and Control Actions

Portland is renowned for its urban forest and must balance the need to protect both trees and sewer infrastructure. During FY 2017, BES Maintenance Engineering continued to manage the chemical root control program using third-party service providers who apply dense herbicidal foam that kills roots on contact without harming trees or surface vegetation. The City's Root

[5] *Hansen* refers to Infor Public Sector, © 2016 Infor. All rights reserved. www. infor.com

Control Program uses a priority ranking system so that sewers with the greatest need for chemical root treatment are addressed first. During FY 2017, 298,000 lineal feet (56 miles) of mainline sewer were chemically treated for roots. In addition to chemical root foaming, City crews utilize mechanical root saws to locally remove roots in support of sewer inspection and cleaning activities as well as in response to sewer system problems.

3.1.4 Grease Management and Control Actions

In FY 2017, six sewer releases from the City-maintained sewer system were attributable to grease. This low number emphasizes the effectiveness of the Portland's program to control fats, oils, and grease (FOG), which was described in the *City of Portland Grease Management and Control Program* document that was included in the *CMOM Program Report*.

The *Cut Through the FOG Program* significantly updated its outreach and educational materials to more equitably inform food service customers impacted by our program. The *Cut Through the FOG* web page (https://www.portlandoregon.gov/bes/54538) and fact sheets were updated with versions in six additional languages. The program completed production on three multilingual videos and published them to the web page. The videos are intended to educate food service employees on the proper way to clean a grease trap, kitchen best management practices, and how to manage their sewer costs. They also contain information on how FOG can negatively impact the sewer system and what food service customers need to do to prevent its discharge and stay in compliance.

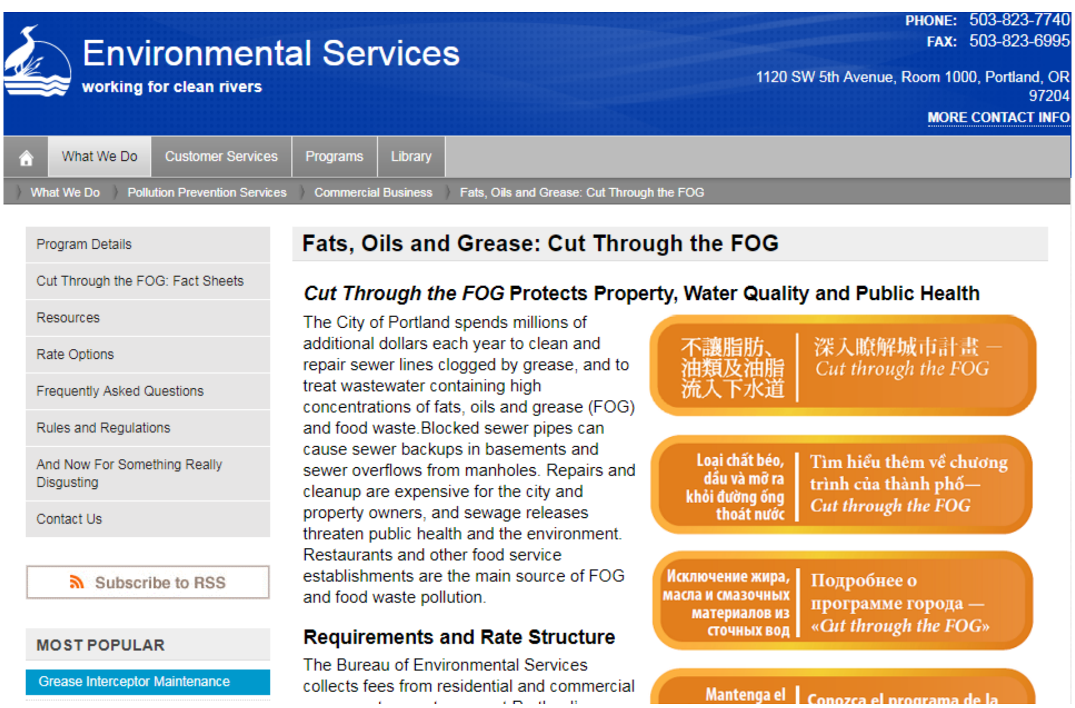


Figure 16 Cut Through the FOG Website

Areas of the collection system vulnerable to FOG buildup and blockages are managed on a more frequent preventive maintenance and cleaning cycle. In FY 2017, 53,687 lineal feet (10 miles) of FOG-related sewer cleaning was conducted, including 43,815 lineal feet (8 miles) of cleaning in designated Accelerated Grease Cleaning Areas. Over 48,000 lineal feet (9 miles) of mainline sewer received FOG-related CCTV inspections during FY 2017.

The FOG management program has continued to proactively inspect food service establishments to ensure that grease interceptors are installed correctly, in a proper state of repair, and are cleaned at the proper frequency. FOG enforcement actions in FY 2017 are summarized in Table 11.

Table 11 FOG Enforcement Activities in FY 2017

Description	Number	Requirement
Warning Notice	272	Increase grease removal device cleaning frequency
	56	Repair or replace grease removal devices
Notice of Violation with Civil Penalties/ Cost Recovery	27	Plumb all fixtures to a grease interceptor
	18	Service grease interceptor at prescribed cleaning frequency
	4	Make required grease interceptor repairs
	2	Remove illicit food cart connection to City sewer or install grease interceptor

The FOG Coordination Team continues to meet quarterly to improve FOG-related activities performed by work groups responsible for FOG inspection and compliance, maintenance engineering, sewer cleaning and maintenance, pump station operations and maintenance, and asset management and data management. Based on CCTV inspection results and similar information, the FOG Coordination Team determines areas that are cleaned at an accelerated frequency.

The Pollution Prevention Plan Review Section is an important component of BES's control of FOG. In FY 2017 the Pollution Prevention Plan Review Section required 81 food service establishments to plumb all kitchen fixtures to grease interceptors per current Oregon Plumbing Specialty Code due to new development, redevelopment, or enforcement requirements.

3.1.5 Manhole Inspection

BES continued the second tier of the risk-based manhole inspection in FY 2017. As described in the *Collection System Inspection and Cleaning Plan* submitted to DEQ in December 2012, Tier 2 manhole inspections are more detailed in nature than the routine Tier 1 manhole inspections performed during inspection of associated mainline sewers. The Tier 2 manhole inspections focus on the manholes considered to be at the greatest risk of failure, prioritized by age and material. The Tier 2 manholes are primarily those constructed of brick and monolithic concrete. In FY 2017, 500 manhole inspections were completed. Inspections identified the need for some minor repairs but in general the manhole inspections have shown that the manholes are predominantly in good condition. The majority of the defects found have been loose/rusted steps, missing mortar, light to medium deterioration of the bench/channel, all of which can be repaired by City maintenance crews, as needed. Of the Tier 2 manholes inspected in FY 2017, 17 were identified for repair and one for replacement; work orders have been written.

3.1.6 Winter Storms and Landslides

Severe winter weather and record-breaking rain disrupted routine sewer maintenance activities during FY 2017. Crews and equipment responded to approximately eight snow and/or freezing rain events between early December 2016 and mid-January 2017. Additionally, Portland Airport received 10.36 inches of rain in February 2017, the highest monthly total since recording began in 1940. Major rain storms also occurred in October 2016. The extraordinary winter conditions triggered 59 landslides that affected the right of way—many more than in a typical year. BES engineers and stormwater staff worked with City maintenance crews on 15 sites to stabilize landslides. Typical stabilization activities included rerouting surface storm water away from the impacted area, investigating adjacent sewer and stormwater assets for damage, and/or making repairs. Some of these site activities took place over a number of months and required regular maintenance or inspection to confirm the site condition did not deteriorate.

Section 4 Sewer Release Analysis and Performance

The City of Portland's *Sewer Release Response Plan* (SRRP), submitted to the Oregon Department of Environmental Quality (DEQ) in December 2011 and adopted on January 1, 2012, establishes the process for responding to sewer releases from the City's combined and sanitary sewer system and reporting to DEQ as required by the National Pollutant Discharge Elimination System (NPDES) permit. The *CMOM Program Report* further describes the organizational structure for implementing the SRRP.

BES has a long history of implementing best management practices for collection system operation and maintenance to reduce the number and severity of sewer releases. Under the CMOM program, additional emphasis is placed on understanding why releases have occurred and how to prevent future releases.

4.1 Sewer Release Tracking and Reporting

The BES Spill Protection and Citizen Response (SPCR) Section is responsible for coordination of the overall response to sewer release events, maintaining official City sewer release records, and reporting releases to DEQ. BES SPCR routinely provides SRRP training to ensure that every report of a sewer release is dispatched for immediate response and investigation, reported as required by the NPDES permit, and documented completely and accurately. Each month, SPCR prepares the report of sewer releases that is submitted to DEQ with the monthly discharge monitoring report for the Columbia Boulevard Wastewater Treatment Plant.

BES maintains sewer release data within the Hansen computerized maintenance management system (CMMS), allowing service call information to be connected with follow-up actions and work history of assets. Better data controls have been added to help manage work orders, such as more specific problem codes and standardization of planned and unplanned maintenance work types. Well-defined work order priority codes are used to ensure that work related to sewer releases receives top priority. The resources the City uses for operation and maintenance planning are explained in the *CMOM Program Report*.

BES has developed a standardized list of causes to facilitate tracking and analysis of sewer releases, as shown in Table 12. BES further categorizes weather-related sewer releases, as shown in Table 13, to more directly associate these releases with the City's levels of service established through the BES Asset Management Improvement Program.

Table 12 Sewer Release Cause Descriptions

Sewer Release Cause	Description
Structural Defect	Release caused by a physical failure of the pipeline
Equipment Failure	Release directly resulting from equipment failure typically either at a pump station or during a bypass pump around
Maintenance	Release caused by a City-related maintenance activity
Weather Event	Release caused by hydraulic capacity issues associated with weather (there are three subcategories described in Table 13)
Grease	Release caused by a blockage due primarily to grease
Debris	Release caused by a soft blockage due to sediment or other material
Roots	Release caused by a blockage due primarily to roots
Water Bureau Break	Water main break that surcharges the BES collection system
Cause Unknown	A release where the investigation does not identify a specific cause

Table 13 Weather-related Sewer Release Terminology

Term	BES Definition
Hydraulically overloaded system	Rainfall less than or equal to the 5-year, 24 hour storm (the BES level of service is to prevent sewer releases to surface waters for all storm events up to a 5-year frequency)
Extreme weather	Rainfall in excess of the 5-year, 24-hour storm but less than or equal to the 25 year, 6-hour storm
Force majeure	Rainfall exceeds 25-year storm (the BES level of service is to convey sewer to prevent releases to buildings or streets up to a 25-year storm frequency)

4.2 Sewer Release Key Performance Indicators

Striving for continuous improvement is a cyclical process of evaluating current practices, identifying needed improvements, and measuring performance. BES has developed a set of key performance indicators to gauge the effectiveness of the CMOM program.

4.2.1 SSOs per Hundred Miles of Pipe

SSOs provide a good measure of the overall effectiveness of maintenance programs for controlling roots, fats, oils, and grease, structural failures, and pump station performance. By tracking SSOs per 100 miles of sewer, BES has a succinct metric for gauging overall success toward minimizing SSOs.

As of the end of FY 2017, BES owned and maintained approximately 1,914 miles of main line sanitary and combined sewers, and 683 miles of sewer laterals. The City is typically responsible for maintaining the portion of the service lateral extending from the main sewer to the curb. During FY 2017, the City experienced 180 sewer releases over the 2,597 miles of collection system, which is approximately 6.9 releases per 100 miles of sewer.

Sewer release data is updated by BES SPCR as more complete information becomes available and investigations are conducted, and thus totals in this report reflect current records and may not match previous years' reports and/or monthly discharge monitoring report submittals. A comparison with previous fiscal years is shown in Figure 17.

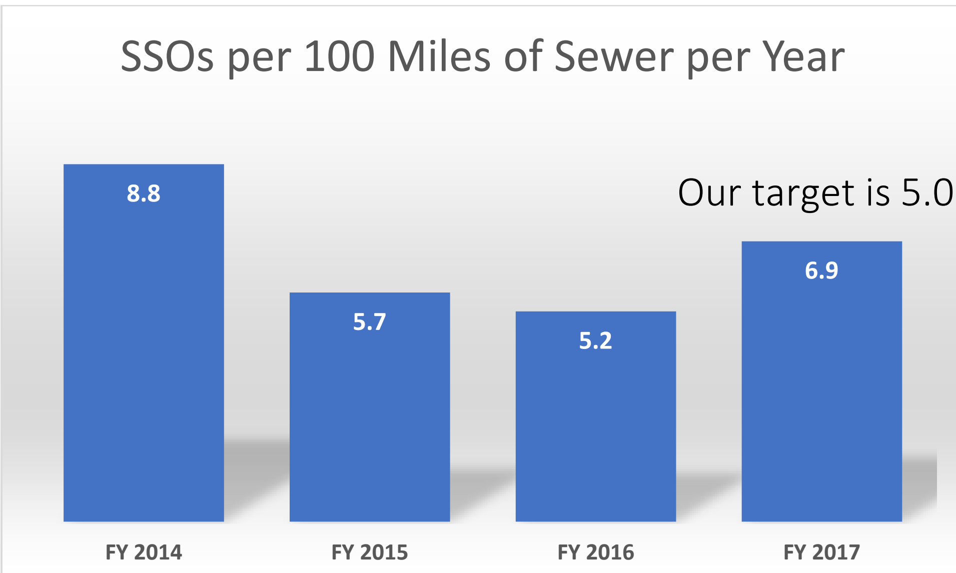


Figure 17 SSOs per Mile of Sewer

4.2.2 Response to Urgent Health and Safety-Related Service Requests

The City's goal is for a sewer emergency crew to be on site within 2 hours of receiving the initial call reporting an urgent sewer release. BES SPCR is responsible for maintaining electronic records of sewer releases, and their records are used to assess the response time of the on-site emergency crew. Under certain circumstances, such as when the caller is reporting a release that occurred in the past or is requesting to meet the City crew at a prearranged time, a sewer release is considered non-urgent, and the 2-hour on-site response goal does not apply.

Response time performance for FY 2017 is shown in Table 14. Response times were within the 2-hour response time target during all months except October, when response time was affected by the large number of calls associated with the severe storms. A comparison with previous fiscal years is shown in Figure 18.

Table 14 SSO Response Time and Counts for FY 2017

FY 2017 Total Urgent Calls Sewer Release Calls	Number of Calls	Percent of Total
Urgent Calls with Response Time Less Than 2 Hours	434	94
Urgent Calls with Response Time 2 Hours or More	27	6
Total	461	100

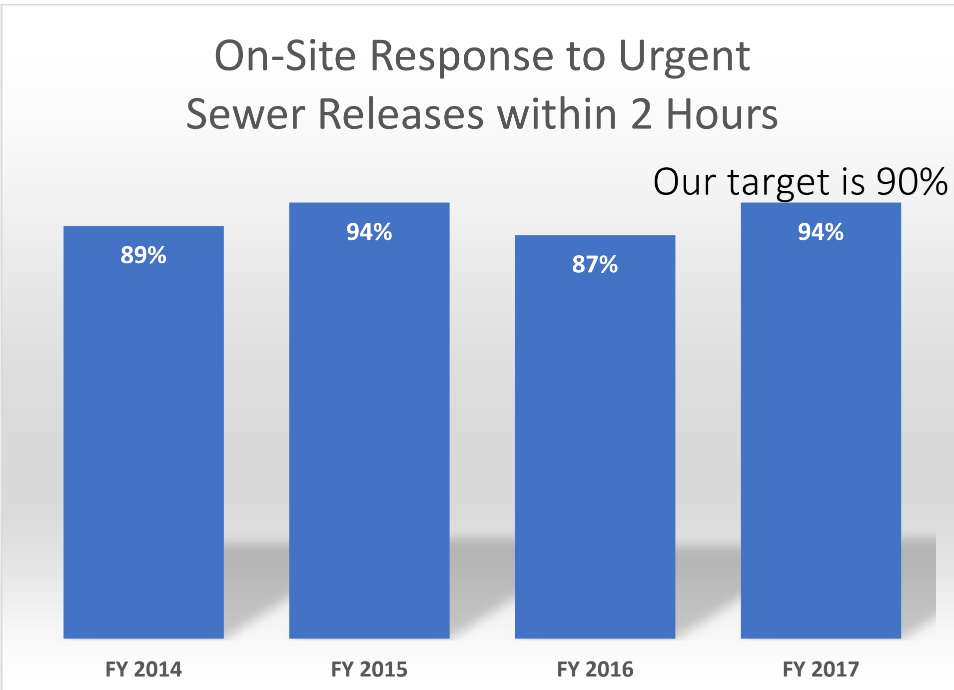


Figure 18 SSO Response Time Comparison

4.3 Analysis of Causes and Locations of Sewer Releases

During FY 2017, the City experienced 180 releases from the sanitary and combined sewer systems. There were 39 additional weather-related release events in FY 2017 that exceeded the design capacity of the collection system (referred to as *force majeure*) and were intentionally excluded for the purposes of analyses and tracking trends, although these releases were included in reporting to DEQ.

A chart comparing the causes of releases in FY 2014 through FY 2017 is shown in Figure 19. The release data shown are for releases due to problems in the City-maintained portion of the collection system (excluding releases due to causes resulting from problems in privately-owned sewers or laterals). The locations of the sewer releases in FY 2017 are shown on the map in Figure 20.

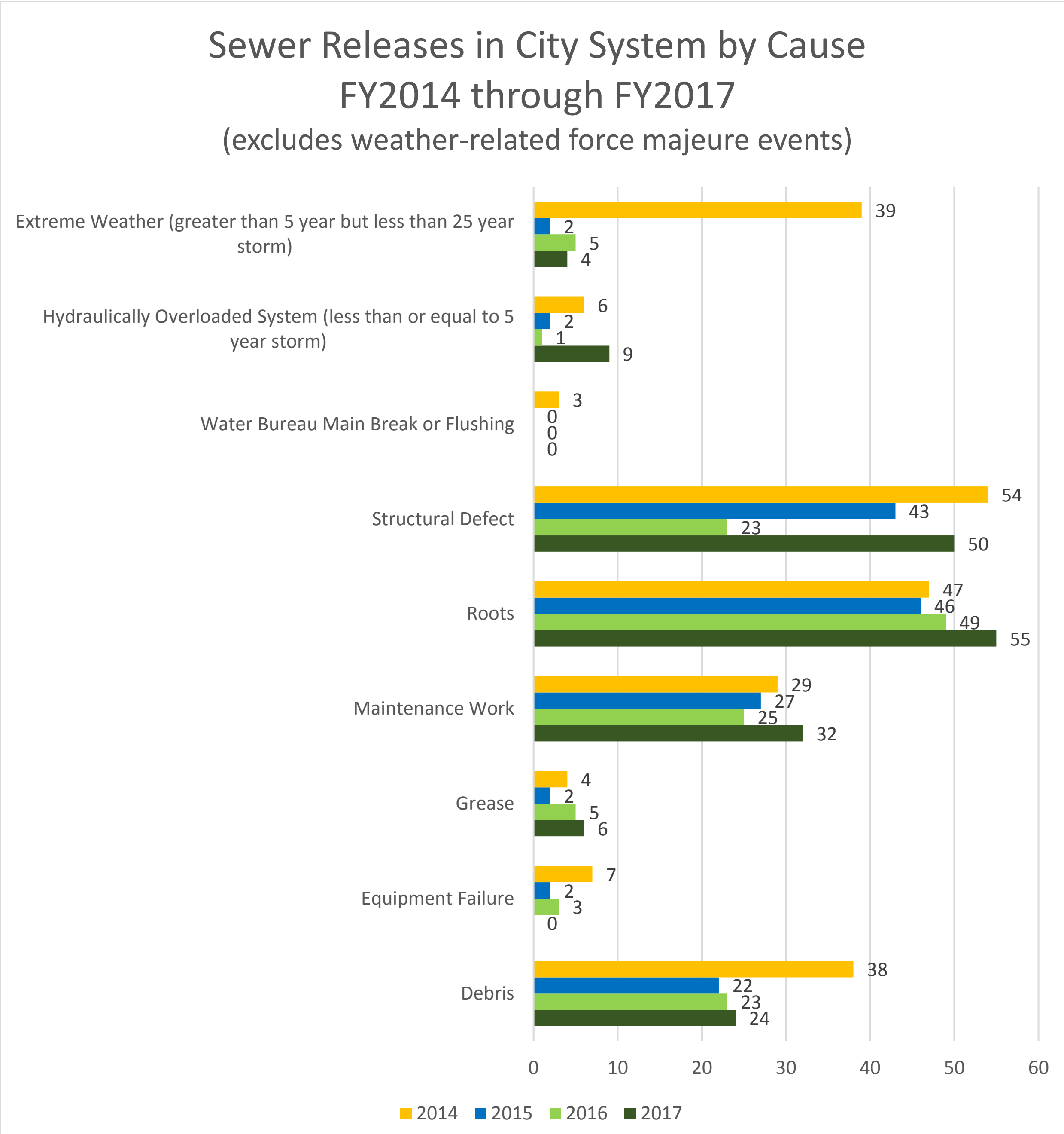


Figure 19 Comparison of Causes of Sewer Releases in FY 2014 through FY 2017

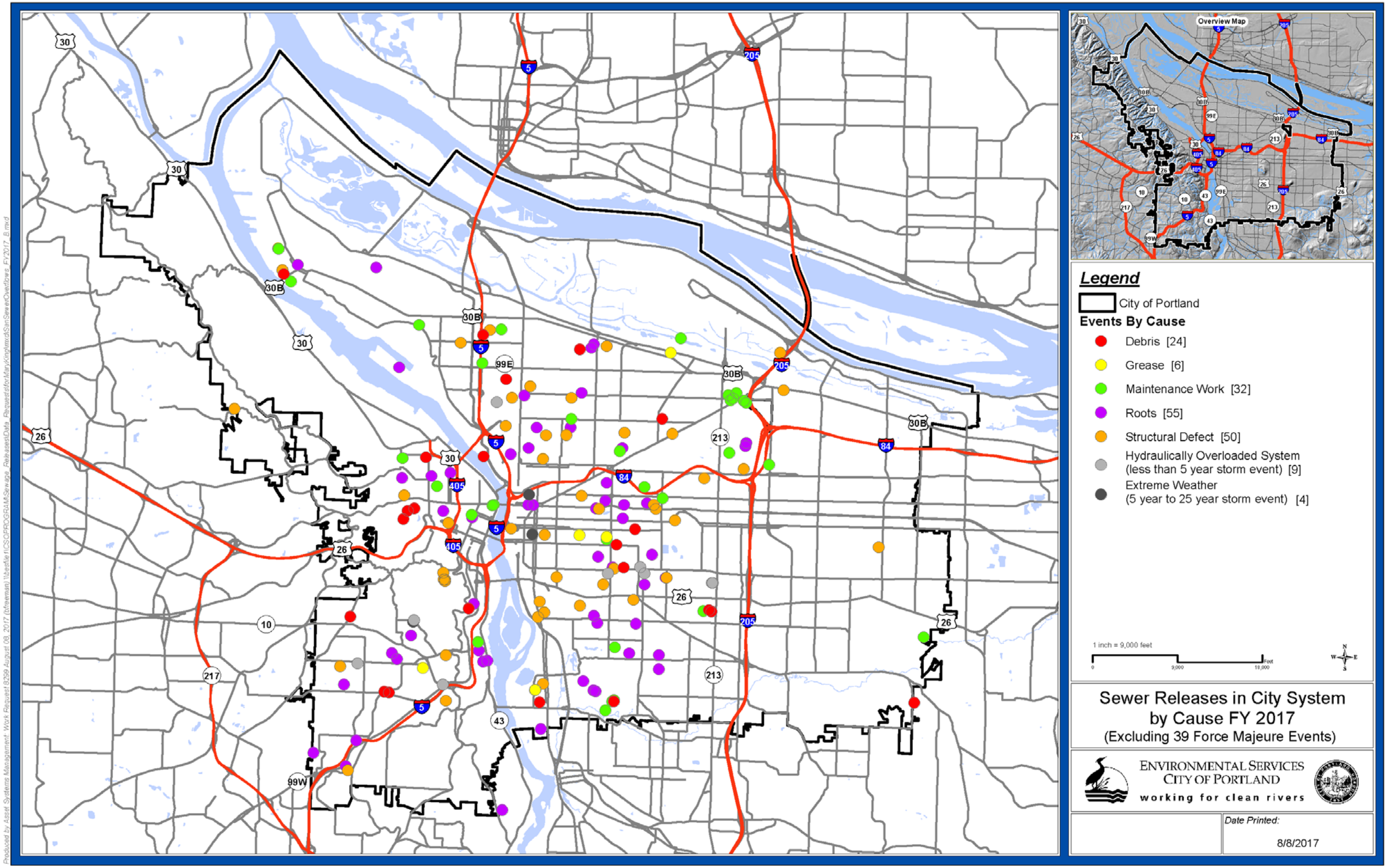


Figure 20 Sewer Releases in City System by Cause, FY 2017

In addition to the rigorous investigatory research conducted by BES SPCR to determine the cause of sewer releases, improvements have been made to facilitate the use of the Hansen CMMS to track initial and actual problem codes on work orders. This enhanced capability provides a clearer understanding of the underlying reasons why a problem occurred or why work on (or near) an asset was required. For example, a work order may have an initial problem code "REL" for a release, or "SBU" for a sewer backup such as a plugged line. An actual problem code such as "GRS" (for grease) or "ROOTS" is also recorded on the work order and is typically based on the findings of the field crew, supervisor, or engineer.

These problem codes supplement the City's customized coding system used to characterize CCTV operators' observations and the degrees of severity (for structural defect, debris, roots, grease, etc.), as explained in the *CMOM Program Report* and the *Collection System Inspection and Cleaning Plan*. This broader array of information sources will become more useful over time as asset histories can be more closely aligned with system performance.

Structural Defects. Releases due to structural defects increased in FY 2017, after trending downward in FY 2015 and 2016. There were 34 releases from structurally defective laterals, 15 from mainline sewers, and one from a manhole in FY 2017. As part of the City's CIP sewer rehabilitation program, poor condition mainline sewers are identified for repair. The laterals connecting to those pipes are inspected during the design process and included for replacement or rehabilitation if structurally deficient. The risk of releases associated with structural defects should decrease as the large number of sewer repair, rehabilitation, and replacement CIP projects currently in design or under construction are completed.

Maintenance. In FY 2017, there were 32 releases associated with maintenance activities, compared to 29 in FY 2014, 27 in FY 2015, and 25 in FY 2016. Sixteen releases were associated with sewer cleaning operations; most of these releases were "bowl water" from toilets and the volume was less than 10 gallons (one of these releases was attributed to a BES contractor jetting a line during a sewer repair project). While precautions are taken to prevent these "blow back" occurrences, some private plumbing systems lack adequate venting and the configuration of some City sewers makes it very challenging for cleaning equipment operators to work in some locations. Special precautions, such as using cleaning nozzles with steeper jet angles and running lower pressures, are taken in areas prone to blow back.

Sixteen maintenance-related releases were associated with sewer repairs. Three releases involved CIPP liners installed by City crews. One release involved a repair that inadvertently cutoff service to a lateral due to a non-conforming sewer connection. Two releases occurred when sewer lines were damaged during maintenance activities conducted by the City's Water Bureau. Six maintenance-related releases were associated with work by sewer contractors working for the City. One release was associated with failure of a BES contractor's flow-diversion pumping system. An additional release attributable to maintenance activities involved a metal sleeve installed in an earlier Capital Improvement Program sewer lining project that became dislodged (likely during sewer cleaning) and blocked a sewer lateral. Private contractors working on City assets caused two maintenance-related releases.

Debris. There were 24 releases caused by debris in FY 2017, compared to 38 in FY 2014, 22 in FY 2015, and 23 in FY 2016. Severe winter storm flows typically carry debris into the combined sewer system, and the low number of debris-related releases appears to validate the effectiveness of the City's risk-based approach to sewer cleaning. This risk-based approach includes accelerated frequency of cleaning sewers that have a higher potential for sediment and debris accumulation. Additionally, BES has continued to conduct public outreach to try to minimize sewer backups and releases associated with disposable wipes and similar products.

Roots. During FY 2017, of the 55 releases caused by roots, 18 were in sewer mainlines and 37 were in service laterals. To reduce the risk of future root intrusion, City crews installed CIPP liners or excavated and replaced the majority of laterals where releases occurred in FY 2017.

4.3.1 Sewer Releases to Surface Water in FY 2017

Sewer releases to surface water occurred at 15 locations in FY 2017. The circumstances of these release events are described below. Although volume estimates are not always available, they are included in each event below when possible.

6240 NE 60th Avenue (release to the Columbia Slough): On August 27, 2016, grease and rags blocked the main sewer resulting in a release of approximately 50 gallons of sewage that entered a storm sewer inlet that discharges to the Columbia Slough. The main sewer was placed on an accelerated cleaning schedule.

2040 SW Vermont Street (release to Stephens Creek): On December 2, 2016, sewage discharging from a manhole on the property of the Shadow Hills Apartment Complex flowed across the ground approximately 30 feet to where it reached Stephens Creek. Subsequent CCTV investigation determined the cause to be a grease blockage. The volume of the release was estimated at 24,000 gallons.

6242 SW Burlingame Avenue (release to an unnamed creek that drains to the combined sewer system): On January 5, 2017, a main sewer was damaged by a fallen tree during a storm event. BES hired a contractor to remove the 24-inch diameter tree. The damaged sewer was repaired on January 27, 2017. The volume of the release was estimated to be greater than 400 gallons.

4718 SW Shattuck Road (release to an unnamed tributary to Fanno Creek): On January 17, 2017, sewage discharged from manhole ACF891 due to a debris blockage in the main sewer. The line was jet rodded and the blockage was relieved. The volume of the release was estimated at 5,000 gallons.

7529 SW Barbur Boulevard (release to Stephens Creek): Heavy rain on January 18, 2017, caused a sewage release from a manhole. Flow from the manhole crossed Barbur Boulevard and entered the storm sewer system, which conveys flow to Stephens Creek. The volume of the release was estimated at 4,000 gallons. Although a City maintenance crew observed and removed roots in the downstream sewer segment, the cause of the release was attributed to the weather event that occurred at that time.

1111 SW Marquam Street (release to stream in Marquam Park that drains to the combined sewer): In January 2017, significant rainfall occurred causing land instability in the area of Marquam Park. On January 19, 2017, City crews found that a large landslide had crossed the creek and possibly affected the main sewer at that location. *E. coli* sampling and dye testing indicated the main sewer had been compromised. The sewer was repaired and additional dye tests confirmed that the main sewer line was sealed. The volume of the release is unknown, but was estimated to be greater than 400 gallons.

7830 SW 35th Avenue (release to storm sewer that flows to Arnold Creek, and then Tryon Creek): On January 20, 2017, a sewer emergency crew responded to sewage release from a basement clean out. While investigating, the crew inspected sanitary manhole ACX078 and found that it was surcharged and blocked with rocks and debris. According to information supplied by the occupant of 7830 SW 35th Avenue, a plumber hired to investigate slow-draining toilets had removed the clean-out cap in the basement, resulting in sewage coming out into the basement at 10 gallons per minute. The occupant used a pump to pump sewage from the basement and discharged it to storm sewer inlet AQM863. The storm sewer leads to Arnold Creek, and then Tryon Creek. The estimated volume of the discharge was 12,000 gallons.

3216 SW Nebraska Street (unnamed creek that flows to Fanno Creek): On January 23, 2017, sewage from a manhole flowed down SW Nebraska Street and entered the storm sewer system, which discharges to an unnamed creek that eventually reaches Fanno Creek. The cause of the release was roots in the main sewer. The volume of the release was estimated at 7,750 gallons. Roots were cut out of the main sewer to restore hydraulic capacity, and a cured-in-place liner is scheduled to be installed in the main line segment in September 2017.

4748 SW Vermont Street (release to Vermont Creek): On February 5, 2017, sewage from manhole AQS193, located on a private road, flowed onto the ground. The flow crossed adjacent property and then entered Vermont Creek. The cause of the release was a weather event; a nearby rain gage recorded 2.41 inches of rainfall that day. The volume of the release was estimated at 3,600 gallons.

2540 SW Sunset Boulevard (release to Fanno Creek): On February 16, 2017, manhole ACG793 overflowed during heavy rain. Sewage entered the storm sewer system that discharges to Fanno Creek. The volume of the release was estimated at 900 gallons. BES is conducting a flow monitoring study to better understand the flow characteristics in this basin.

822 N River Street (release to the Willamette River): Debris blockage in the main sewer caused a release out of two locations on private property on February 22, 2017. Sewage flowed over the ground to the Willamette River. The debris blockage was removed using Vactor® equipment. The volume of the release was estimated at 100 gallons.

4135 NW Devoto Lane (release to Mill Creek): On April 1, 2017, a piece of PVC pipe (not from the collection system itself) blocked the main sewer causing two manholes to overflow. One manhole is located in NW Devoto Lane; sewage from this manhole flowed to the storm sewer system that daylights to a ditch that flows to Mill Creek. The second manhole is located in a vegetated area south of NW Thompson Road; sewage from this manhole flowed down a vegetated steep slope to Mill Creek, about 500 feet away. The volume of the release was estimated at 20,000 gallons.

3342 SW Illinois Street (release to tributary to Fanno Creek): On April 2, 2017, sewage from manhole ACM027 ran down the backyard of this residence to SW Illinois Street, where it continued until it entered the stormwater system which leads to a tributary to Fanno Creek. The volume of the release was estimated at 675 gallons. The release was caused by roots in the main sewer. The main sewer was cleaned and inspected on April 3, 2017, and roots were removed from the line.

6600 N Baltimore Avenue (release to the Willamette River): On April 11, 2017, a broken piece of clay sewer pipe blocked diversion manhole AAE560, causing flow to pass over the diversion dam into the storm sewer, eventually discharging to the Willamette River at Outfall 52. The volume calculated by BES Engineering was 24,500 gallons. CCTV camera equipment was used to inspect all of the nearby sewer main, and work to repair a damaged manhole trough was completed on June 2, 2017.

7500 SE 162nd Avenue (release to Clatsop Creek): On May 12, 2017, rocks in the main sewer resulted in an accumulation of debris that caused approximately 1, 750 gallons of sewage to overflow from a sanitary manhole. The flow reached a storm system inlet that leads to Clatsop Creek. A City crew used a Vactor® truck to remove the blockage, which stopped the release.

4.4 Conclusions and Follow-Up Actions for Sewer Release Reduction

The City of Portland's CMOM program is now being fully implemented. Shifting toward risk-based operation and maintenance of the collection system should, over time, result in a positive trend toward planned, proactive maintenance and fewer sewer releases. BES continues to develop and improve the Hansen CMMS to facilitate work prioritization and asset management in the gravity collection system. Although BES's CMOM program effectively incorporates the essential elements and best management practices for proper operation and maintenance of the collection system, analysis of sewer releases in FY 2017 has highlighted several opportunities for potential improvement.

Roots in service laterals receive some degree of treatment during application of root foaming agents in sewer mainlines. However, the amount of treatment varies and is not a reliable treatment for service laterals. Typically, when City crews repair service laterals because of releases caused by roots, cleanouts at or near the curb are routinely installed to facilitate future maintenance, including chemical root treatment.

The majority of structurally-defective laterals where releases occurred in FY 2017 have been repaired by City crews using CIPP liners or were excavated and replaced. To proactively prevent sewer releases from laterals, CIP projects for replacement, repair, and rehabilitation of sewer mainlines also include inspection and repair/replacement of service laterals based on the risk of structural or operational failure. The City will continue to utilize opportunities for making cost-effective improvements to laterals.

BES anticipates that the number of releases attributable to structural defects will gradually decrease as significant capital reinvestment in the sewer system is accomplished and CIP projects under construction and in design are completed. These projects to replace, repair, and rehabilitate collection system assets that pose the highest risk and consequence of failure will position the City to be better able to provide proactive rather than reactive maintenance. The methodology used for risk-based prioritization of CIP projects was presented in the *Collection System Assessment and Rehabilitation Plan* that was submitted to DEQ in December 2012.

Overall, continued implementation of the *BES System Plan—Combined and Sanitary Sewer Elements*, dated March 2012, will address condition and capacity risks in both the combined and separated sanitary sewer systems. The System Plan's consolidated system-wide approach for prioritizing reinvestment and business risk reduction through CIP projects should also reduce the potential for sewer releases.

Section 5 Maximization of Storage in the Collection Systems

One of the Nine Minimum Controls, *Maximization of Storage in the Collection Systems,* ensures that combined sewage is kept within the sewer system using existing in-system storage. This optimizes the volume sent to enhanced wet weather treatment, increasing the volume treated by the biological secondary processes and reducing the number and volume of CSO events. While this control originally focused on keeping sewers free of blockages, removing relatively clean stormwater from the collection system also contributes to maximizing available storage and conveyance capacity. The programs documented here also have the added benefits of increased visibility of these efforts and public education opportunities.

5.1 Private Development and Redevelopment

BES's Stormwater Management Manual (SWMM) applies to all development and redevelopment proposals that create or redevelop over 500 square feet of impervious area.

In FY 2017, implementation of the SWMM in combined sewer basins led to construction of stormwater facilities at 766 properties, managing 73 acres of private impervious area onsite, thereby reducing stormwater volume into the combined system.

City staff are implementing a newly revised SWMM that went into effect August 2016.

5.2 Private Property Retrofit Program

Installation of stormwater facilities on private property continues in the Private Property Retrofit Program. Guided by BES's 2012 Combined Sewer System Plan and its Capital Improvement Program, this program researches opportunities with private property owners to voluntarily retrofit or install on-site stormwater facilities to keep runoff out of the combined sewers. The reduced runoff helps reduce local sewer capacity problems and reduce CSO volumes. For more information, see previous Annual CSO and CMOM reports (FY 2014 and FY 2015).

For FY 2017, 1.8 acres of impervious surfaces were managed by 59 private property stormwater retrofit projects. Two examples of this year's retrofits are shown in Figure 21 and Figure 22 below.

Figure 21 FY 2017 Example Retrofit #1

Figure 22 FY 2017 Example Retrofit #2

5.3 Ecoroofs

Ecoroofs replace conventional roofing with a layer of vegetation over a growing medium on top of a synthetic, waterproof membrane. An ecoroof significantly decreases stormwater runoff, saves energy, reduces pollution and erosion, absorbs carbon dioxide, and reduces heat island effects.

The City of Portland strongly supports the installation of ecoroofs through the City's Green Building Policy, SWMM, and developer floor area ratio bonuses in specific portions of the city.

As of June 2017, Portland has over 469 ecoroofs installed throughout the city, managing almost 28 acres of roof. Approximately 369 of those ecoroofs are in the combined sewer area. During FY 2017, 5 new ecoroofs were installed in the combined sewer area, managing approximately 0.9 acres of roof. This roof area represents 930,000 gallons of rainfall to the combined system annually, and Portland's monitoring data indicate that approximately 465,000 gallons are retained by the roofs and returned to the atmosphere through evapotranspiration.

5.4 Public Right-of-Way Development and Redevelopment

As of June 2017, Portland has implemented over 1,900 green streets in the right-of-way, with approximately 940 in the combined sewer area. The *Post-2011 Combined Sewer Overflow Facilities Plan* identifies specifically how Portland will continue to implement both public and private stormwater controls to further reduce stormwater entering the combined sewer system and thereby increase the storage available for capturing CSO discharges.

During FY 2017, 22 new green street facilities were installed in the combined sewer area. The projects were implemented by a variety of BES CIP projects and PBOT street projects that incidentally required stormwater management. Collectively, these facilities manage approximately 2.0 acres of impervious area that generates 2.0 million gallons of stormwater to the combined sewer system annually. Based on the City's performance monitoring of green street facilities, these facilities will remove approximately 1.4 million gallons of runoff annually from the combined sewer system through infiltration and evapotranspiration.

Section 6 System Reinvestment and Risk Reduction

The City of Portland, Bureau of Environmental Services' asset management program is founded on strategically reducing risk through cost effective investments. The City has improved its methods for calculating risk and making cost effective decisions to reduce risk through investment activities. This section discusses how the City is valuing existing risk in the collection system and how its investments reduce risk to meet levels of service.

6.1 FY 2017 Reporting Methodology, Changes and Improvements

Risk in mainline pipes is generally determined by inspections and hydraulic modeling.

Pipe inspections provide the condition data used to determine the risk of structural failure. The inspections include routine maintenance inspections to determine the structural condition of the pipes, and post-repair acceptance inspections to ensure that repairs meet designated standards and/or contract specifications. Structural risk of laterals is assumed based on quantity of lateral repaired.

Hydraulic modeling is done to determine the risk of capacity failure, specifically to determine the likelihood of basement and surface flooding with respect to the Bureau's adopted levels of service.

System risks change over time as a result of the following:

1. **Capital Improvement Program:** Capital projects repair or rehabilitate existing assets or introduce new ones reduce capacity (level of service) risk and structural (mortality) risk in the system.
2. **Maintenance:** Maintenance work orders seek to reduce structural risk in the system by applying targeted repairs or emergency replacements and rehabilitation on high-risk assets.
3. **Change in pipe condition due to aging:** Inspections provide more accurate information about pipe condition than simple age-based assumptions. Changes in risk can be due to actual aging as indicated by consecutive inspections, or due to the inspection-based

condition of pipes varying from the age-based assumed condition. Since actual pipe condition can be better than the age-based assumed condition, risks can decrease for a particular pipe when it is first inspected.

4. **Unexpected changes to hydrologic conditions:** In general, future development conditions are modeled to allow BES to provide sufficient capacity to meet anticipated hydrologic conditions in the future. Future conditions are largely defined by the City's currently adopted Comprehensive Plan. In some instances, development may occur that is different than was set in the Comprehensive Plan. These changes may have a positive or negative effect on capacity risk.

Items 1 and 2, above, are the focus of this section.

The City of Portland has been working diligently over the past fiscal year on developing a risk reporting methodology for pipe rehabilitation. The methodology relies on existing internally-developed asset management and project tracking systems. These systems underwent significant changes and upgrades over the past year, but they need to be further adjusted to enhance risk reduction reporting.

The methods used to quantify structural risk based on pipe condition were also significantly modified over the past year. The risk values are generally smaller when calculated using the new method. The most significant change is the method assumed for emergency repair. The old calculation assumed that emergency repairs would only include repairing 10 feet of the pipe that has failed. This led to an assumption that over the life of the pipe, the City would repeatedly repair 10 foot segments of the same pipe without regards to the condition of the whole pipe. The new calculation better reflects actual maintenance practices, as it assumes that emergency repairs could repair more than a single 10-foot section. The emergency repair could repair spots in poor condition, line the whole pipe or replace the whole pipe.

In addition, the City is in the process of improving risk calculations for large diameter (36-inch or larger vertical and/or horizontal dimension) pipe assets. The risks for large diameter assets assume different failure scenarios and rehabilitation methods, compared to smaller diameter pipes. Results presented in this report apply to smaller diameter pipes (less than 36-inch diameter).

6.2 FY 2017 Activity for Risk Reduction

Risk reduction is the present value of the cost of repairing or replacing infrastructure, thereby deferring failure, and its related consequences, to the expected life of the repair or replacement.

Risk reduction for capital work is now reported on a calendar year basis as fiscal year reporting is delayed due to construction during the summer and end of the fiscal year. Risk is not reported for investments in correcting non-conforming sewers (e.g. sewers not constructed to current standards).

6.2.1 Risk Change Due to Capital Improvements and Inspections

Capital improvement projects are designed and installed to resolve capacity and mainline structural risk. Resolution of both types of risk are included in the risk reduction calculations. The changes in capacity and structural risk due to rehabilitation is summarized in Table 15. This data is currently incomplete and the actual risk reduction is likely much higher. BES is continuing to work on improving the data systems required to develop these risk reductions more accurately.

Table 15 Risk Change Due to Capital Improvement Projects with Available Data

Type	Value
Total Risk Reduction Due to CIP Investment in Repaired/Replaced Pipe	$11,369,000

The Capital Improvement Program completed ten projects in the sanitary and combined collection system during the 2016 calendar year. These projects repaired and rehabilitated 320 sanitary and combined sewer gravity mains.

6.2.2 Risk Change Due to Maintenance Activity

Maintenance repairs reduce risk in the collection system and involve localized repairs on sewers and the replacement of service laterals. The Hansen system showed approximately 10,100 lineal feet of work on sewer main assets and 588 laterals replaced.

Table 16 Risk Change Due to Maintenance Activity with Available Data

Type	Value
Total risk reduction due to maintenance activity	$12,516,000

Section 7 Update of the Public Notification Program

The goals of the CSO public notification program are to:

1. Make the public aware that the City has a combined sewer system that can overflow.
2. Explain what a CSO is and how it impacts water quality and can threaten public health.
3. Inform the public when a CSO has occurred and warn against contact with the receiving waters.
4. Raise public awareness of the benefits to the community of the City's investment in CSO Control.

When the CSO Policy was adopted, this element of the NMC, *Public Notification*, focused mostly on outreach through brochures and public meetings and posting warnings at public access points on the Willamette River and Columbia Slough. Changing communication technology provides additional tools for public notification.

Portland's CSO notification procedures changed with completion of its CSO implementation program in December 2011. Throughout the 20-year program, the City relied on its HYDRA System to measure rainfall and trigger the CSO notification process. As of December 2011, all combined sewer outfalls that can discharge are monitored and public notification takes place when an overflow is measured at a specific location.

7.1 Changes in Public Notification/River Alert Program

Much of the program remains the same, as reported in the *FY 2015 Annual CSO and CMOM Report*. Twitter is now also used to issue CSO notifications on https://twitter.com/BESPortland. Tweets are re-tweeted by PublicAlerts.org.

7.2 Communications Implementation Plan Activity

A step in the Public Notification plan, per NPDES Permit #101505, Schedule A.3.b(8) and Schedule F, Sections B.7 and B.8, was inadvertently omitted. This step was the opening of sign boards warning the public of an active CSO on the Willamette River at outfalls with signboards. This step was omitted for these six events:

- October 13-17, 2016
- November 22-25, 2016
- January 17-18, 2017
- February 3-6, 2017
- February 7-10, 2017
- May 12-14, 2017

The protocol to open these signboards, which involved the BES Public Information Officer (PIO) contacting a contractor to open the 10 signboards on the Willamette as soon as possible after the beginning of the discharges and for at least 48 hours after the end of the overflow, was inadvertently omitted. This omission was due to several changes in the PIO position's staffing during the fiscal year.

The other procedures in the plan were completed, including:

- Public outreach via notification of news media outlets and social media
- Updates to the City website
- Updates of the River Alert hotline

After the procedures were investigated, the following corrective actions will be implemented in following CSOs:

- All 10 signboards will be opened whenever any outfall on the Willamette River discharges a CSO,
- The City will report on this public notification work as part of the CSO compliance letter sent to DEQ after every overflow, and
- Roles and responsibilities will be better defined in the plan.

Appendix A CSO Event History

When reporting on *how the Portland CSO system has performed*, the City of Portland usually refers to the number of events and the size of overflows that have occurred since the system became fully operational in December 2011. From that standpoint, BES has validated and reported 24 permitted events from the Willamette River and Columbia Slough facilities.

Prior to December 2011, the Amended Stipulation and Final Order from DEQ required the City of Portland to eliminate most overflows to the Columbia Slough by December 1, 2000. Another 16 outfalls (represented by a mix of outfalls from the West Side and East Side of the Willamette River) were controlled by December 1, 2006.

Columbia Slough CSO Events since October 2000

This table presents the CSO events to the Columbia Slough since the Columbia Slough CSO system became fully operational in October 2000. There were no CSO events to the Columbia Slough in FY 2017. Winter events are shaded in blue, and summer events are shaded in yellow. All events were valid under the NPDES permit at the time.

Table 17 Columbia Slough CSO Events since October 2000

CSO Discharge Events			Storm Characteristics			System Totals		West Side Totals	
Event #	Dates of Storm / Overflow Events	Description	6-Hour Rainfall (inches)	12-Hour Rainfall (inches)	24-Hour Rainfall (inches)	Overflow (MG)	Duration (hours)	Overflow (MG)	Duration (hours)
1	May 26, 2012	> 100-year, 30-minute storm	-	-	-	0.022	0.20	0.022	0.20
2	December 5-13, 2015	25-year, 3-6 hour storm	2.04	2.61	3.19	0.01	0.15	0.01	0.15

Willamette River CSO Events from December 2006 to December 2011

Table 18 presents the CSO events to the Willamette River since the West Side Willamette River CSO Tunnel became fully operational in December 2006 until the full Willamette system became operational in December 2011. Winter events are shaded in blue, and summer events are shaded in yellow. All events were in compliance with the requirements of the NPDES permit and the 1994 Amended Stipulation and Final Order in effect at the time.

Table 18 Willamette River CSO Events, December 2006-December 2011

CSO Discharge Events*			Storm Characteristics			System Totals		West Side Totals	
Event #	Dates of Storm / Overflow Events	Description	6-Hour Rainfall (inches)	12-Hour Rainfall (inches)	24-Hour Rainfall (inches)	Overflow (MG)	Duration (hours)	Overflow (MG)	Duration (hours)
1	Dec 14, 2006	4-per-Winter Storm	0.82	1.17	1.60	66.85	18.37	66.85	18.37
2	Jan 3, 2007	4-per-Winter Storm	0.69	1.04	1.54	5.15	4.35	5.15	4.35
3	Dec 2-3, 2007	> 5-year 24-hour Winter Storm	0.97	1.76	3.09	154.5	26.85	154.5	26.85
4	Nov 12, 2008	4-per-Winter Storm	0.76	1.02	1.38	8.1	4.1	8.1	4.1
5	Jan 1-2, 2009	5-year Winter Storm	1.12	1.52	2.73	122.60	21.58	122.60	21.58
6	May 4, 2009	3-year Summer Storm (3-6 hr duration)	0.94	1.02	1.18	5.26	1.05	5.26	1.05
7	Nov 7, 2009	2-per-Winter Storm	0.93	1.22	1.51	9.60	2.92	9.60	2.92
8	June 6, 2010	3-year Summer Storm	1.07	1.25	1.43	26.02	3.08	26.02	3.08
9	Nov 17, 2010	1-per-Winter Storm	1.03	1.56	1.77	11.48	5.58	11.48	5.58
10	Dec 8-12, 2010	5-year Winter Storm	1.43	1.52	2.34	41.82	8.92	41.82	8.92
11	Dec 28, 2010	2-per-Winter Storm	0.57	0.89	1.58	6.85	5.50	6.85	5.50
12	Jan 15-16, 2011	1-per-Winter Storm	0.94	1.21	2.13	26.27	8.92	26.27	8.92
13	Feb 27-Mar 4, 2011	1-per-Winter Storm	1.15	1.70	2.41	75.98	28.25	75.98	28.25
14	Nov 21-23, 2011	5-year Winter Storm	1.44	1.66	2.24	115.96	6.25	115.96	6.25

Willamette River CSO Events since December 2011

This table presents the CSO events to the Willamette River since the Willamette River CSO Tunnel system became fully operational in December 2011. FY 2017's events are listed in the bold box below. Winter events are shaded in blue, and summer events are shaded in yellow. All events were valid under the NPDES permit at the time.

Table 19 Willamette River CSO Events, December 2011 to June 2017

CSO Discharge Events			Storm Characteristics			System Totals		West Side Totals		East Side Totals	
Event #	Dates of Storm / Overflow Events	Description	6-Hour Rainfall (inches)	12-Hour Rainfall (inches)	24-Hour Rainfall (inches)	Overflow (MG)	Duration (hours)	Overflow (MG)	Duration (hours)	Overflow (MG)	Duration (hours)
1	January 17-21, 2012	> 5-year 12-hour Winter Storm	1.48	2.15	2.32	304.90	10.30	86.40	10.30	218.50	10.30
2	May 26, 2012	> 100-year, 30-minute Storm	-	-	-	0.17	0.42	-	-	0.17	0.42
3	November 17-21, 2012	5-year, 24-hour Winter Storm	1.22	1.65	2.44	176.40	9.50	44.00	9.50	132.40	9.30
4	November 24, 2012	3-per Winter, 24-hour Storm	0.61	1.09	1.49	0.50	0.80	0.50	0.80	-	-
5	May 23, 2013	3-year, 12-hour Summer Storm	0.90	1.22	1.50	26.30	2.30	11.90	2.30	14.40	1.80
6	September 27-30, 2013	10-year, 24-hour Summer Storm	1.20	1.41	2.08	88.50	7.00	27.00	7.00	61.50	5.40
7	March 25-30, 2014	2-per Winter, 12-hour Storm	0.89	1.26	1.53	43.10	3.00	14.30	3.00	28.70	3.00
8	June 15-16, 2014	3-year, 30-minute Summer Storm	-	-	-	0.03	0.20	-	-	0.03	0.20
9	October 22-23, 2014	10-year, 24-hour Summer Storm	1.42	1.68	2.11	69.4	3.92	13.41	3.50	56.00	3.92
10	December 4-6, 2014	5-year, 3-hour Winter Storm	0.95	1.37	1.56	1.6	1.57	0.05	0.27	1.52	1.57
11	January 17-18, 2015	1-per Winter, 24-hour Storm	0.97	1.50	2.04	91.6	7.98	15.15	6.75	76.43	7.98
12	March 14-15, 2015	1-per Winter, 48-hour Storm	1.05	1.80	2.41	78.9	6.48	16.61	5.92	62.31	6.48
13	October 30-November 2, 2015	50-year, 2-hour storm	1.94	1.98	2.55	190.5	6.35	30.24	4.88	160.05	6.35
14	November 16-17, 2015	1-per Winter, 1-hour storm	0.80	0.85	1.37	0.03	0.17	-	-	0.03	0.17
15	December 5-13, 2015	25-year, 3-6 hour storm	2.04	2.61	3.19	638.7	15.60	134.86	13.33	503.83	15.60
16	December 16-19, 2015	1-per Winter, 3-48 hour storm	1.11	1.56	2.37	145.8	11.00	26.79	9.70	118.99	10.30
17	May 19, 2016	3-year, 30-minute Summer Storm	-	-	-	0.02	0.18	-	-	0.02	0.18
18	October 13-17, 2016	> 100-year, 1-2 hour storm	1.56	1.81	2.09	0.92	0.63	0.89	0.63	0.03	0.33
19	November 22-25, 2016	5-year winter, 3-hour storm	1.20	1.81	2.47	210.5	17.00	49.36	16.10	161.15	16.60
20	January 17-18, 2017	2-per-winter, 1-day storm	0.61	1.03	1.78	93.5	8.90	20.82	7.50	72.70	8.90
21	February 3-6, 2017	5-year winter, 1-day storm	0.81	1.48	2.53	206.0	12.10	53.07	11.5	152.95	12.1
22	February 7-10, 2017	4-per-winter, 1-day storm	0.51	0.82	1.36	0.0035	0.17	0.0035	0.17	-	-
23	February 15-16, 2017	1-per-winter, 1-2 day storm	0.80	1.25	1.98	89.6	6.4	25.61	5.8	63.98	5.8
24	May 12-14, 2017	>10-year summer, 15 minute storm	0.43	0.68	0.75	0.0051	0.20	0.0051	0.20	-	-

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