Appendix A:
Additional Site Information

APPENDIX A – ADDITIONAL SITE INFORMATION

This appendix provides an overview of the study site and the individual stormwater control and treatment facilities. In addition, photos are included to illustrate changes in vegetation over the study period and some of the wildlife that utilized the facilities. Additional information about the history of the South 356th Street Regional Detention Facility (RDF) retrofit is included in the project Quality Assurance Project Plan (King County 2016).

Overview

In 2013-2014, the City of Federal Way (the City) expanded the South 356th Street RDF to increase capacity and provide additional stormwater treatment (Figure 1). The City incorporated stormwater best management practices and followed design guidelines to the extent possible when designing the retrofit. However, like many facilities in highly developed watersheds, the limited available space and design of the existing RDF imposed constraints on the new design and construction. The resulting facility was designed to be effective at this site, and the components of this facility (two combined detention stormwater treatment wetlands [CDSTWs] and the bioretention facilities) do not necessarily represent other facilities with the same components. The CDSTWs and the bioretention facilities meet some of the specifications outlined in Ecology's and King County's stormwater manuals (Ecology 2012, King County 2009) (Tables 1 and 2), but not all designs criteria could be incorporated for the retrofit.

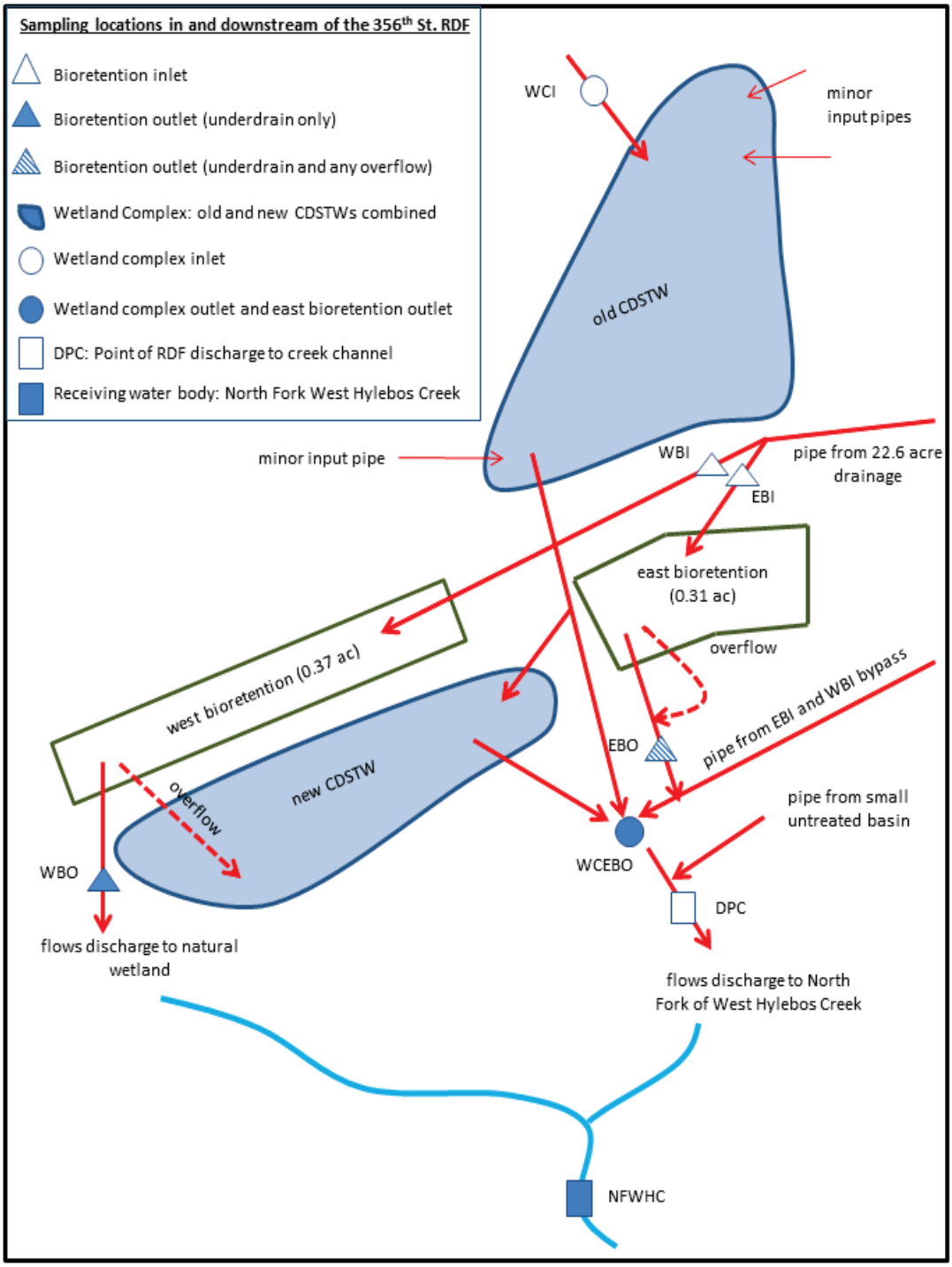

Figure 1. South 356th Street RDF flow paths, project sampling locations and general facility information (not to scale).

Summary of Flow Paths through the RDF

The majority of stormwater runoff delivered to the retrofitted and expanded South 356th Street RDF enters via two inlet pipes, one from the north and one from the east (Figure 1). The northern inlet drains approximately 189 acres of highly developed commercial, industrial, and residential areas within the City. Stormwater from this inlet is delivered to the northwest corner of the original combined detention and stormwater treatment wetland (old CDSTW) which is undersized given the growth in the City.

There are several additional pipes drain stormwater into the old CDSTW (labeled "minor input pipes" in Figure 1). The pipes were frequently checked during the study period and were typically dry or had minimal flows. A few instances there were turbid flows observed (Figure 2). Due to these minor flow inputs, samples collected at the inlet (WCI) may underestimate pollutants and flowing into the RDF. Likewise, flow volume estimates (calculated from WCI alone) may underestimate the total flow entering the wetland complex.

The new CDSTW (Figure 1) was designed to provide additional detention volume and treatment to a portion of the discharge from the old CDSTW (Table 1). Inputs to the new CDSTW are exclusively from the old CDSTW, and a hydraulic model (XP-Storm) was used to size the new wetland. Outflows from the old CDSTW enter a catch basin via a large (48") pipe. Stormwater flows from the catch basin to either the new CDSTW, via a deep and relatively small (18") pipe, or away from the new CDSTW and towards the creek via another large (48") pipe (Figure 1). The catch basin and pipes were designed to direct low-to-moderate flows to the small pipe and thus to the new CDSTW. In contrast, under high flow conditions, the catch basin is designed to direct most of the water away from the new CDSTW and to the conveyance system leading to the discharge point to the stream (DPC). This design was intended to minimize the chance of flooding the new CDSTW and the adjacent streets. Therefore, stormwater treated by the RDF is a combination of water flowing from the north to the old CDSTW and water from the east that flows to the bioretention facilities. Some, but not all, of the water flowing through the old CDSTW will also flow through the new CDSTW. The CDSTWs effluents mix with the effluent from the east bioretention facility prior to discharging to the North Fork of West Hylebos Creek. The effluent from the west bioretention facility flows to the wetland downstream of the RDF (Figure 1).

Table 1. Properties of the old and new combined detention and stormwater treatment wetlands (CDSTW) at the RDF.

Properties	Old CDSTW (built 1997)	New CDSTW (built 2013–2014)
Applicable design manual codes	Most similar to Ecology T10.40 (2012 SMMWW, amended in 2014) and King County 6.4.4 (2009 and 2016 Surface Water Design Manuals)	Most similar to Ecology T10.40 (2012 SMMWW, amended in 2014) and King County 6.4.4 (2009 and 2016 Surface Water Design Manuals)
Surface area at weir overflow	2.5 acre (ac.)	1.07 ac.
Active storage	21 acre-feet (AF)	3.8 AF
Dead storage	Approximately 1 to 2 AF	1.05 AF
Average depth	7.8 feet (ft.)	6 ft.
Max depth	Does not exceed 8 ft.	Does not exceed 8 ft.
Infiltration expected?	No; lined	No; not lined but minimal infiltration expected due to highly impermeable native soils
Designed for detention	Yes, live storage is above seasonal high groundwater level	Yes, live storage is above seasonal high groundwater level
Designed for sediment storage	Sedimentation forebay that is >1 ft. deep	No, but because this is in series with old CDSTW, sediment loads are expected to be small
Wetland plants	Diverse community of native plants currently present	Native grass seed planted; other plants have become established and may be removed as needed (e.g., cattails)
Ratio of flow path length to width	At least 3:1	At least 3:1
Outlet control structure	Present, with grate	Present, with back slope
Additional features	• Oil/water separator • Low-flow channel • Outlet micropool • Low islands to support diverse community of native vegetation	• Small separator berm helps direct inflow away from outlet and avoid short circuiting
Deviations from current codes	• There is no distinct second cell • Inlets are not submerged • Undersized	• Small separator berm was not designed to promote plug flow or help create a distinct second cell • No area designed specifically for sediment storage • Inlet is not submerged but is designed to minimize resuspension of settled sediments • Undersized

Figure 2. Turbid discharge from a minor pipe to old CDSTW on October 20, 2016.

The eastern pipe delivers previously untreated stormwater runoff to two bioretention facilities. Prior to the RDF expansion, runoff from a 22.6 acre area to the east bypassed the RDF and discharged to a catch basin just upstream of the discharge point to the creek (DPC) (Figure 1). This runoff now drains to two bioretention facilities. The bioretention facilities are underdrained, and filtered water is eventually discharged to the creek (from the east bioretention facility) or surrounding natural wetlands (from the west bioretention facility).

Description of Retrofitted BMP Design

Combined Detention and Stormwater Treatment Wetlands in Series

The City designed both the old and new CDSTWs to attenuate flows and provide stormwater treatment. Although neither CDSTW was designed to meet all specifications of the combined detention and stormwater treatment wetlands, they meet many of the current specifications for this type of BMP (Table 1). The "as built" drawings of the old and new CDSTWs are included in Appendix B of the QAPP.

Constructed in 2013-2014, the new CDSTW increased capacity of the entire RDF by approximately 5 acre-feet (AF) (Table 1). The old CDSTW provides effective pretreatment for stormwater entering the new CDSTW, therefore the required "first cell" per the Ecology design manual was eliminated for the new CDSTW. Design of the new CDSTW was constrained by limited available space and the existing BMPs, but was designed to meet as a number of the specifications described in Ecology's Stormwater Management Manual for Western Washington (SWMMWW; Fei Tang [City of Federal Way, Engineer] consulted Washington State University (2012) which was later incorporated into the amended 2012 Ecology SWMMWW) and King County's Surface Water Design Manual (2009) (Table 1). The new CDSTW is not lined and due to impermeable native soils, it has low infiltration rates. These conditions result in standing water throughout the year. After several failed attempts, the slopes of the new CDSTW were successfully seeded with a marsh seed mix in fall 2015 and grasses were thriving during the 2016-2017 monitoring period (Figure 3 and 4).

Figure 3. The new CDSTW under construction, March 31, 2014.

Figure 4. Established plants and prolific algae in the new CDSTW, July 7, 2016.

Bioretention Facilities

The bioretention facilities were constructed in 2013-2014 according to the Draft 2012 Low Impact Development Technical Guidance Manual for Puget Sound (WSU, 2012). The east and west bioretention facilities are similar except for differences in some of the plant types and the west bioretention underdrain does not extend over the whole bioretention facility (Table 2, Figures 5-9). In addition, overflow from the east bioretention facility drains into an overflow pipe and then into the same pipe that the underdrain flows into (Figure 1). In contrast, overflow from the west bioretention facility flows into the new CDSTW (Figure 1). The outlet of the west bioretention facility drains to a natural wetland (Figure 1).

Table 2. Physical description of east and west bioretention facilities at the South 356th Street RDF.

Properties	West Bioretention Facility	East Bioretention Facility
Size (acre)	0.37	0.31
Storage Capacity (AF)	0.28 before overflow, 0.6 max.	0.25 before overflow, 0.69 max.
Max Depth (ft.)	1 before overflow, 2 max.	1 before overflow, 2.5 max.
Soil	In eastern half: 30 in of BSM[1], topped with 3 in. of coarse compost[2]; In western half: 33 in of top soil Type A BSM (60%sand/40% compost), topped with native swale seed mix and soil amendment A BSA[3]	30 in of BSM[1], topped with 3 in of coarse compost[2]
Vegetation Types	In eastern half: Pacific crabapple, Pacific wax myrtle, dwarf arctic willow, salmonberry, Douglas spirea, redtwig dogwood, black gum; In the western half: native swale grasses	Pacific crabapple, black gum, redtwig dogwood, salmonberry, dwarf arctic willow, black twinberry, daggerleaf rush
Extent of Underdrain	Underdrain installed in west half only; material used included 8 in. wide Smart Drain™ belts that connect to PVC pipes	Underdrain installed throughout; west half is made of standard PVC underdrain; east half is made of 8-in. wide Smart Drain™ belts that connect to PVC pipes

[1] All specifications in section 8-02.3(4)A for Bioretention Soil Media (BSM) quality and application (WSDOT, 2010) were met.

[2] All specifications in Section 9-14.4(8) Special Provisions for compost (WSDOT, 2010) were met.

[3] All specifications in Section 8-02.3(6) Special Provisions for BSA (WSDOT, 2010) were met.

Figure 5. The west bioretention facility pre-planting, March 31, 2014.

Figure 6. Established vegetation in west bioretention facility (on left) and new CDSTW (on right), March 24, 2016.

Figure 7. Immature vegetation in east bioretention facility prior to initiation of stormwater sampling, February 16, 2016.

Figure 8. Mature vegetation in east bioretention facility, April 27, 2017.

Figure 9. Mature grasses in the west bioretention facility, April 27, 2017.

Both bioretention facilities were originally built using Smart Drain™ underdrains, which are designed to facilitate draining without clogging (www.smartdrain.com). The entire east bioretention facility is underdrained. Originally, the entire underdrain network was constructed using Smart Drain™ strips connected with PVC collector pipes. The PVC pipes are not perforated except where the Smart Drain material is joined to them. However, initial observations indicated the facility was not draining and in summer 2015, the Smart Drain™ underdrain in the western half of the facility was replaced with a traditional perforated pipe underdrain. The facility drained much more quickly after the change, and it typically drained much more quickly than the west bioretention (see Appendix J).

The west bioretention facility, a network of Smart Drain™ strips were used in combination with PVC collector pipes in the western half of the facility. The Smart Drain™ strips direct water to the centerline PVC pipe. The eastern half of the west bioretention facility is not underdrained. During the study period, water was retained in the west bioretention facility for hours to days following storm events. It is unclear if the held water is because Smart Drain™ strips were used or because half of the system has no underdrain.

Due to space limitations at the site, the bioretention facilities were undersized. Ecology recommends that 91% of the stormwater in this basin be treated for flow control (using WWHM). A WWHM model was not developed; however, the City ran a single event model (XP Storm) on an expanded time scale and estimated that approximately 89% of stormwater would be treated (Fei Tang, personal communication).

Site as a habitat for wildlife

Wildlife, including a diverse assemblage of birds, inhabited the RDF during the study period. Waste from some of the larger and more abundant birds (Canada geese, ducks; Figure 10) may have been a significant source of nutrients within the South 356th St. RDF during the study period.

Figure 10. Canada geese in the new CDSTW, July 7, 2016.

Changes to the RDF following the study

Road construction in the spring and summer of 2017 altered the pathway for water flowing to the bioretention facilities. Instead of flowing through several grass ditches before reaching the facilities, the water now flows through pipes under a sidewalk (Figure 11 and 12). The sidewalk construction also made it much more difficult or impossible to access the EBO, WCEBO and WBO sampling locations.

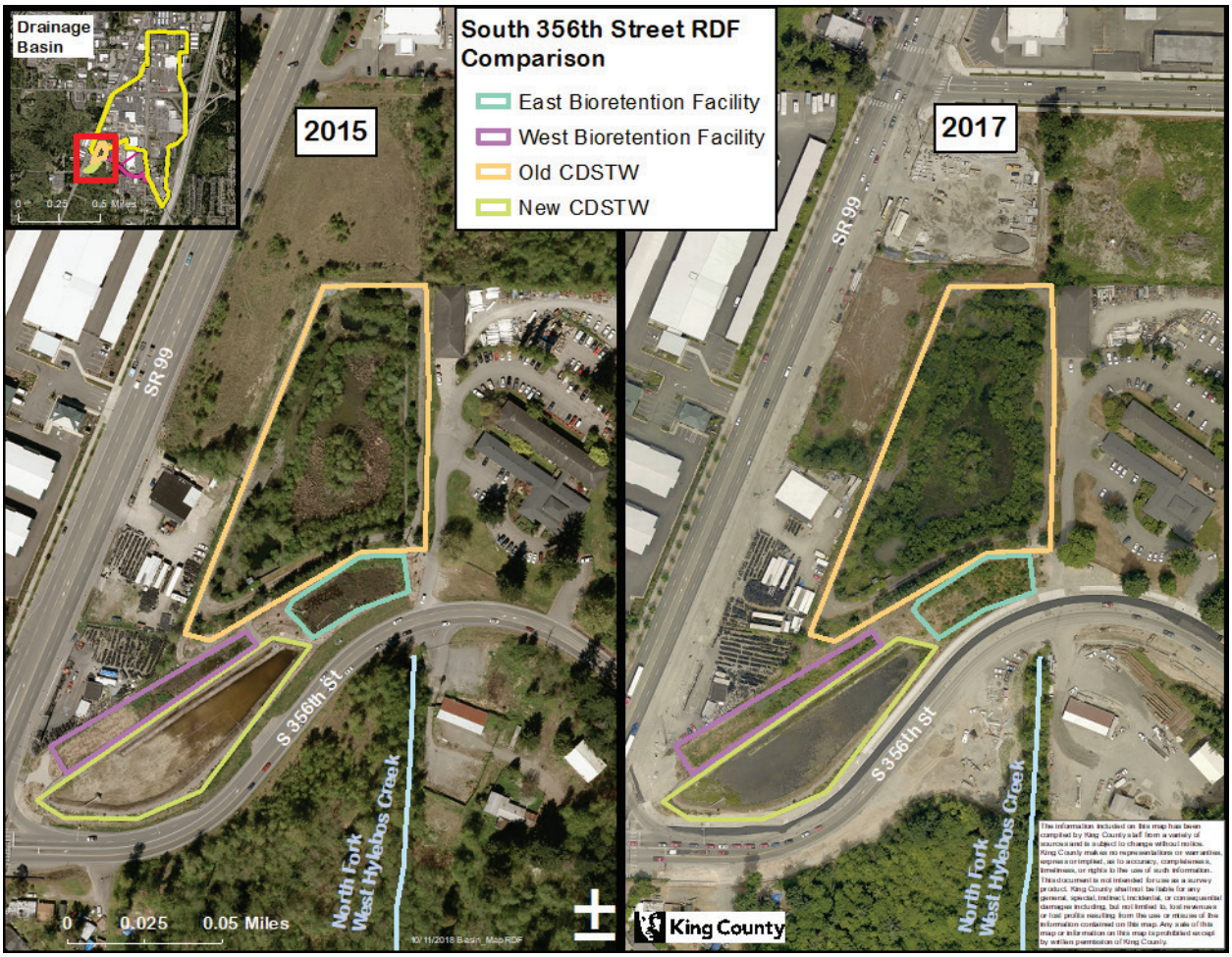

Figure 11. Aerial photos of the South 356th St. RDF in 2015 and 2017. Note new sidewalk on north side of S. 356th St. in 2017.

Figure 12. Ditch along South 356th Street that carried stormwater runoff to bioretention facilities during the study period. In summer 2017 the ditch was replaced by pipes and a sidewalk after the study.

Appendix A References

Ecology. 2012. Stormwater Management Manual for Western Washington (SWMMWW). Publication No. 12-10-030.

King County. 2009. King County, Washington Surface Water Design Manual. Prepared by King County Department of Natural Resources and Parks.

King County. 2016. King County, Washington Surface Water Design Manual. Prepared by King County Department of Natural Resources and Parks.

King County. 2016. Quality Assurance Project Plan: Effectiveness Monitoring of the South 356th Street Retrofit and Expansion Project, Federal Way, WA. Prepared by Kate Macneale, Water and Land Resources Division. Seattle, Washington.

WSDOT (Washington State Department of Transportation). 2010. Standard Specifications for Road, Bridge, and Municipal Construction. M 41-10.

WSU (Washington State University). 2012. Draft 2012 Low Impact Development Technical Guidance Manual for Puget Sound. Written by Curtis Hinman (WSU Puyallup Research and Extension Center) with support from the Puget Sound Partnership.