PEN1 Drainage and Water Quality Master Plan

September 2022

PREPARED FOR

Peninsula Drainage District #1

PEN 1
Flood Protection

IN COLLABORATION WITH

City of Portland Bureau of Environmental Services

Parametrix

ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

PEN1 Drainage and Water Quality Master Plan

Prepared for

Peninsula Drainage District #1
1880 NE Elrod Drive
Portland, OR 97211

Prepared by

Parametrix
700 NE Multnomah, Suite 1000
Portland, OR 97232-4110
T. 503.233.2400 T. 360.694.5020 F. 1.855.542.6353
www.parametrix.com

September 2022 | 276-2903-026

CITATION

Parametrix. 2022. PEN1 Drainage and Water Quality Master Plan. Prepared by Parametrix, Portland, Oregon. September 2022.

CERTIFICATION

The technical material and data contained in this document were prepared under the supervision and direction of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.

EXPIRES: 12/31/2022

Prepared by Clara Olson, P.E.; Brandon Moss, P.E.; Seth Sokol, P.E.; Fran Cafferata Coe, C.W.B. (Cafferata Consulting); and Ryan Retzlaff (Brown and Caldwell)

Checked by Jennifer Murphy, P.E., C.S.E.; and Jeff Coop, P.E.

Approved by Jennifer Murphy, P.E., C.S.E.

ACKNOWLEDGEMENTS

Multnomah County Drainage District

- Mackenna Bell, P.E., Engineering Associate
- Elizabeth Edgar, P.E., Engineer
- Josh McNamee, Asset Maintenance Specialist
- Bill Owen, P.E., Deputy Directory/Chief Engineer
- Andrew Riggs, Senior Engineering Technician
- Carrie Sanneman, Environmental Program Manager
- Mindy Weimer, Engineering Associate
- Amber Ayers, Project Manager
- Aster Moulton, Public Affairs and Community Relations Specialist
- Evyn Mitchell, Senior Public Affairs & Communications Manager
- Mark Wilcox, Sr. Project Manager

Bureau of Environmental Services

- Julie Matney, Surface Water O&M, Environmental Specialist
- Kathy Balogh, Industrial Stormwater Program, Environmental Specialist
- Heidi Berg, Stormwater Risk Assessment, Environmental Program Coordinator
- Julia Bond, Watershed Regulatory Strategy, Environmental Specialist
- Melissa Brown, Watershed Regulatory Strategy, Environmental Specialist (Fisheries Biologist)
- Nancy Hendrickson, Watershed O&M, Division Manager
- Chris Prescott, Watershed Regulatory Strategy, Environmental Specialist
- Toby Query, Natural Areas O&M, Botanic Specialist
- Naomi Tsurumi, Priority Area Planning, Senior Environmental Planner
- Jade Ujcic-Ashcroft, Biological Sciences, Community Service Aide (Avian Biologist)

Parametrix

- Jennifer Murphy, P.E., Project Manager
- Clara Olson, P.E., Deputy Project Manager
- Julie Brandt, P.E.
- Kyle Bretherton
- Jeffrey Coop, P.E.

- Paul Fendt, P.E.
- Brandon Moss, P.E.
- Nikki Redden, EIT
- Seth Sokol, P.E.
- Chad Tinsley

Brown and Caldwell

- Ryan Retzlaff

Cafferata Consulting

- Fran Cafferata Coe
- James Butch

Partners

- Portland Parks and Recreation
- Port of Portland
- Metro

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF EXHIBITS

LIST OF TABLES

TABLE OF CONTENTS (CONTINUED)

LIST OF PHOTOGRAPHS

FIGURES

APPENDICES

TABLE OF CONTENTS (CONTINUED)

ACRONYMS AND ABBREVIATIONS

BES	City of Portland Bureau of Environmental Services
CCI	construction cost index
City	City of Portland
District	Peninsula Drainage District No. 1
DEQ	Oregon Department of Environmental Quality
DWQMP	Drainage and Water Quality Master Plan
FEMA	Federal Emergency Management Agency
I-5	Interstate 5
MCDD	Multnomah County Drainage District No. 1
NAVD 88	North American Vertical Datum of 1988
NRCS	U.S. Department of Agriculture Natural Resources Conservation Service
ODFW	Oregon Department of Fish and Wildlife
PAWMAP	Portland Area Watershed Monitoring and Assessment Program
PEN1	Peninsula Drainage District No. 1
PIR	Portland International Raceway
PS	pump station
SCADA	supervisory control and data acquisition
SDIC	Sandy Drainage Improvement Company
USACE	U.S. Army Corps of Engineers

EXECUTIVE SUMMARY

Peninsula Drainage District No. 1 (PEN1), in collaboration with the City of Portland Bureau of Environmental Services (BES), has developed this *Drainage and Water Quality Master Plan* (DWQMP) to present a clear understanding of the existing internal drainage system, to document current habitat and water quality conditions, and to provide an outline of improvements that address both existing and future needs.

This DWQMP evaluates the PEN1 operations and flood management capacity provided by pump stations and conveyance system infrastructure under Multnomah County Drainage District No. 1 (MCDD) management. Habitat and water quality deficiencies and opportunities for uplift are noted throughout the PEN1 District and in the immediately adjacent stretch of its receiving waterbody—the Lower Columbia Slough.

The PEN1 conveyance system includes a series of sloughs, roadside ditches, stormwater pipes, and pump stations that convey water through and out of the PEN1 District boundaries. The primary objectives of this DWQMP are (1) to characterize the watershed function and drainage system capacity within the study area, (2) to identify conveyance and watershed deficiencies and areas with the greatest opportunity for improvement, and (3) to develop prioritized operational and capital projects that address these deficiencies and opportunities and are to be incorporated into the PEN1 and City of Portland (City) capital improvement plans.

PEN1 Overview

The PEN1 boundary includes the Columbia River to the north, I-5 to the east, the Columbia Slough to the south, and North Portland Road and the Union Pacific Railway embankment to the west. PEN1 encompasses Heron Lakes Golf Course, Portland International Raceway (PIR), Vanport Wetlands, the Expo Center, portions of Interstate 5 (I-5), and several industrial businesses. PEN1 is bound on two sides (north and south) by flood control levees, an internal cross levee separating PEN1 from the adjacent Peninsula Drainage District No. 2 (PEN2) to the east, and the railroad embankment separating PEN1 from the west. A vicinity and overview map of the PEN1 District are provided as Figures 1 and 2.

The PEN1 basin conveyance system transports surface water via open channels, pipes, culverts, and pump stations. The western side of the basin contains the Heron Lakes Golf Course. The western drainage system starts at Force Lake and collects and conveys runoff and groundwater through a series of channels, pipes, and culverts routed along the interior side of the western and southern basin borders and discharges into the forebay of the PIR pump station (PS). The northern end of the basin has a stormwater system along Marine Drive that serves the industrial and business area. The collected runoff is discharged, via outfalls, directly north to the Columbia River. The eastern side of the basin contains the Expo Center, Vanport Wetlands, and PIR. There is a weir gate and effluent structure at the Vanport Wetlands PS to allow for seasonal control of the water level within the wetlands. The Vanport Wetlands PS conveys flow leaving the Vanport Wetlands and flow from the southern end of the Expo Center. Drainage from the eastern side of the basin runs through a series of pipes, culverts, and sloughs that discharge through Mud Slough to the forebay of the PIR PS. The only way for the water to be moved out of this system into the Columbia Slough is via the PIR PS.

The movement of surface water through PEN1 is highly controlled by local pump stations. All water within the PIR PS basin is pumped out of PEN1 to the Columbia Slough. The following pump stations were considered when developing this DWQMP:

- Vanport Wetlands Pump Station
- Portland International Raceway Pump Station

PEN1's internal drainage system has mixed ownership and maintenance responsibilities of drainage infrastructure. This DWQMP concentrates primarily on a defined critical conveyance network where PEN1 focuses operations. A significant portion of PEN1's operational activities and capital project expenditures on the critical conveyance network are focused on the removal of debris and blockages that impede the movement of water through open channels and pump stations. A map of the PEN1-defined critical conveyance network is included as Figure 3.

Background and Stakeholders

The conveyance of surface water through the study area is important to protect the economic health of the region. The four drainage districts—PEN1, PEN2, MCDD and SDIC—along the Columbia River protect $16 billion of annual economic activity and $7.3 billion in assessed property value. The levees associated with these four drainage districts reduce flood risk from the Columbia River, and the internal drainage network moves surface water away from the managed floodplain to protect public and private property from flooding during and after storm events.

This DWQMP provides a detailed plan of projects, programs, and further areas of study to operate an internal drainage system and efficiently move surface water through the PEN1 basin while also improving habitat and water quality conditions. PEN1 and associated stakeholders will need to be proactive in maintaining and replacing aging infrastructure including the pump station and the conveyance network consisting of pipes, culverts, and open channels. PEN1 also needs additional planning to address emergency response and system resiliency as the region experiences increased uncertainty and potential risks related to a changing climate and predicted seismic events.

PEN1 is heavily reliant on partner agencies including BES, City of Portland Parks and Recreation, the Port of Portland, and Metro for management and maintenance of the conveyance infrastructure. Many of the projects proposed in this DWQMP will require joint attention to fund and construct the required upgrades. The transition of PEN1 into the Urban Flood Safety and Water Quality District[1] may yield additional resources to support these recommendations.

Drainage and Water Quality Master Plan Process

The DWQMP process included developing criteria to evaluate the conveyance system, pump stations, water quality, and habitat within the PEN1 basin. For the conveyance system and pump stations, the criteria looked at the condition and the capacity of the existing systems and set guidelines for design of capital projects. For water quality, the criteria looked at existing land cover and shade presence and set guidelines for design of capital projects. For habitat, the criteria looked at the availability and conditions

[1] https://www.mcdd.org/who-we-are/ufswqd/

of nesting habitat, rearing habitat, food and forage habitat, cover and protection from predators, and connectivity between habitat types for safe dispersal, and set guidelines for design of capital projects.

Technical analyses and investigations were conducted to develop an understanding of the drainage system, habitat, and water quality conditions, including the conveyance system and pump stations that move water through and out of the district. The primary technical analyses to support this plan are discussed in Sections 3 through 6 of this DWQMP, including:

- Pump station condition evaluation including development of condition ratings for mechanical, electrical, communications, piping, and structural systems at each pump station.
- Conveyance system condition evaluation including information on the age, material, and known defects of the pipes and culverts that form the primary drainage pathways through the district. A capacity analysis of the northern portion of the PEN1 District along Marine Drive that drains to the Columbia River was not included in this plan. BES has an ongoing project to improve the outfalls along Marine Drive, and the remaining stormwater system in this area was redesigned and constructed in 1992. Drainage characteristics since that time have not changed appreciably, and the pipe capacities are assumed to be adequate.
- Pump and conveyance system capacity analysis including updating PEN1's XP-SWMM hydrologic and hydraulic model to simulate the drainage network under current conditions and predict how the system might function in the future.
- Review of water quality sampling data within and surrounding the PEN1 District.
- Review of existing habitat conditions including current species observed within the PEN1 District.

The technical analyses that informed this plan were primarily completed in 2021 and 2022. Following the technical analyses, the project team identified problem areas, evaluated potential project solutions, and developed an action plan of capital projects, operational adjustments, and future studies.

The master plan process also included public outreach and coordination through surveys to all PEN1 District property owners, meetings with partner agencies, and presentations to stakeholders for input and direction.

Recommended Actions

This DWQMP considers an integrated approach to managing the conveyance and pump station systems and improving water quality and habitat conditions throughout PEN1 basin. The recommended actions provide a long-term strategy to manage the storage, movement, and condition of water and habitat in the PEN1 basin. The following actions are recommended:

- Plan for redundancy improvements and replace the PIR PS and its discharge piping.
- Plan for redundancy improvements and replace the Vanport PS and its discharge piping.
- Replace or rehabilitate failing or undersized conveyance infrastructure in the critical conveyance network.
- Reduce flood risk and improve habitat through culvert removals.
- Improve debris management (e.g., debris barriers and trash rakes).
- Actively manage sediment and erosion issues.

- Improve habitat and water quality conditions through plantings, shoreline grading, and specific habitat element improvements.
- Improve habitat and water quality conditions at the forebay of the PIR PS.
- Improve habitat along the lower Columbia Slough.
- Actively monitor water quality problem areas through regular sampling.

Table ES-1 summarizes the capital projects recommended in this DWQMP. Project locations are shown in Figure 10. The recommendations will improve the PEN1 basin internal drainage system by efficiently conveying surface water, providing flood protection during peak storm events, improving water quality conditions, and enhancing habitat for local species.

Table ES-1. Recommended Capital Projects

CIP	Stakeholder Lead	Project	Location	Preliminary Cost Estimate	
				Low	High
DR #1	PEN1	PIR PS Replacement – with permanent generator	PIR PS	$8,630,000	$18,480,000
		PIR PS Replacement – with portable generator		$8,140,000	$17,430,000
DR #2	PEN1	Vanport PS Replacement – with permanent generator	Vanport PS	$2,230,000	$4,770,000
		Vanport PS Replacement – with portable generator		$2,040,000	$4,360,000
DR #3	PEN1	Golf Course Culvert Channel Daylighting	Northwest area of Heron Lakes Golf Course, near the western boundary of the PEN1 basin	$230,000	$490,000
DR #4	PEN1	Force Ave Channel Daylighting	N Force Ave, north of N Broadacre Dr	$950,000	$2,020,000
DR #5	PEN1	Mud Lake Discharge Culvert Replacement	Northeast area of Heron Lakes Golf Course, north side of Mud Lake	$450,000	$950,000
HWQ #1	BES	Plantings	PEN1 basin	$650,000	$1,390,000
HWQ #2	BES	Shoreline Grading	PEN1 basin	$1,530,000	$3,270,000
HWQ #3	BES	PEN1 Habitat Improvements	PEN1 basin	$17,000	$36,000
HWQ #4	BES	PIR PS Forebay Improvements	PIR PS	$2,200,000	$4,700,000
HWQ #5	BES	Lower Slough Habitat Enhancements	Lower Columbia Slough	$2,370,000	$5,070,000

BES = Bureau of Environmental Services; CIP = capital improvement plans; DR = Drainage; HWQ = Habitat and water quality; PEN1 = Peninsula Drainage District #1; PIR = Portland International Raceway; PS = pump station

Table ES-2 summarizes programmatic recommendations for PEN1 and the City of Portland. These are the operational actions with an annual funding need to monitor the condition of the conveyance system, perform preventative maintenance on pump stations, prepare for emergencies, and plan for future replacements before systems reach failure conditions. Detailed information about these programs and studies is provided in Section 8, Project Selection, of this plan.

Table ES-2. Recommended Programs

Program	Timeline
CCTV Inspection and Condition Assessment Program	Conduct over 5 years
Pump Station Testing and Monitoring	Ongoing cost per year (average)
Districtwide Debris Barrier Program	10 years
Ongoing Periodic Pump Rebuilds	10 years
Sediment Management Plan	Annually
Beaver Management Program	Annually
Flow Control Requirements Evaluation	One-time study
Pump Station Structural Evaluation and Resiliency Study	One-time study – shared throughout MCDD
Access and Easement Needs Study	One-time study
Water Quality Monitoring	Ongoing cost per year (average)
Sediment Load Source Evaluation	Annually
Levee Seed Mix Evaluation	One-time evaluation
Heron Lakes Golf Course Vegetation Management Evaluation	One-time evaluation
Water Quality Sampling and Assessment of Stormwater to Marine Drive Right of Way	One-time evaluation

An important next step for PEN1, BES, and other stakeholders will be to establish a plan for funding these projects and program needs. In addition to current funding sources, PEN1 and BES should seek new revenue streams or grant funding opportunities related to emergency preparedness, flood protection, and watershed health.

1. INTRODUCTION

Peninsula Drainage District No. 1 (PEN1) has developed this *Drainage and Water Quality Master Plan* (DWQMP) to present a clear understanding of the existing internal drainage system, to document current habitat and water quality conditions, and to provide an outline of improvements that address both existing and future needs. This DWQMP addresses PEN1 operations and flood management capacity for pump stations and conveyance system infrastructure under Multnomah County Drainage District No. 1 (MCDD) management. This plan also notes habitat and water quality deficiencies throughout the PEN1 District and in the immediately adjacent stretch of its receiving waterbody—the Lower Columbia Slough.

The PEN1 conveyance system includes a series of sloughs, roadside ditches, stormwater pipes, and pump stations that convey water through and out of the PEN1 District boundaries. The primary objectives of this DWQMP are (1) to characterize the watershed function and drainage system capacity within the study area, (2) to identify conveyance and watershed deficiencies and areas with the greatest opportunity for improvement, and (3) to develop prioritized operational and capital projects that address these deficiencies and opportunities and are to be incorporated into the PEN1 and City of Portland (City) capital improvement plans.

2. BACKGROUND AND OVERVIEW

2.1 Area Background

The PEN1 District is an approximately 1,000-acre subbasin located in the Columbia River floodplain. The District is approximately 1.4 miles wide (east to west) and approximately 1 mile long (north to south). Its boundaries include the following:

- Columbia River to the north
- Interstate 5 (I-5) to the east
- Columbia Slough to the south
- North Portland Road and the Union Pacific Railway embankment to the west

A vicinity map of the PEN1 basin is included in Exhibit 2-1 below and as Figure 1.

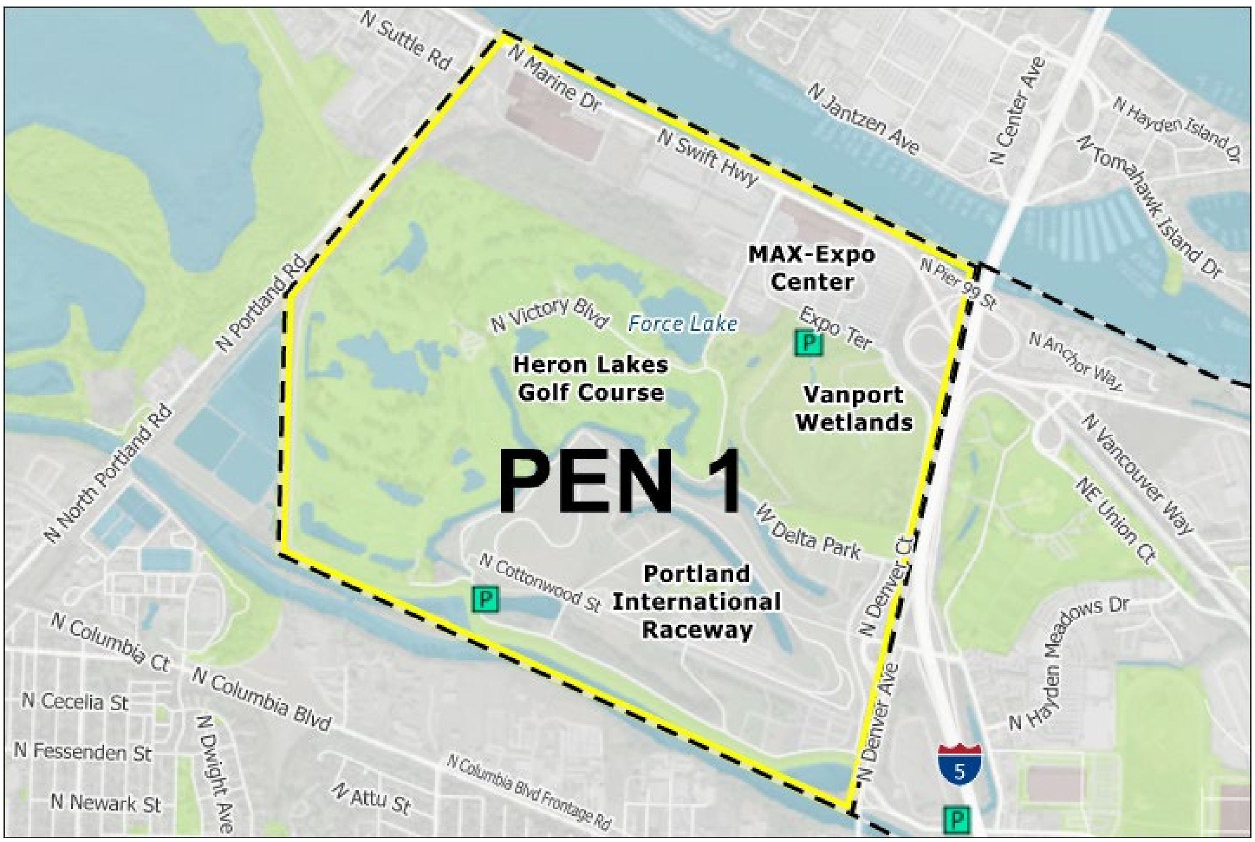


Exhibit 2-1. PEN1 Basin

The northern and southern boundaries are flood-control levees, and the eastern boundary is an internal cross levee separating the PEN1 District from Peninsula Drainage District No. 2 (PEN2) to the east. The railroad embankment located on the western boundary has held back high water during flood events in the past, but it was not constructed to be an engineered levee. The railroad companies that own it are unwilling to recognize its flood-control function, and it does not meet federal levee safety standards.

Conveyance of surface water through and to the exterior of the PEN1 District helps manage and reduce the flood risk to the business, public, and recreation facilities located within the PEN1 District. The district levees provide a measure of protection from Columbia River flooding, and the internal drainage network moves surface water through the district and to the Portland International Raceway (PIR) Pump Station (PS) for pumped discharge into the Columbia Slough. This helps reduce the chance of flooding inside the PEN 1 District during and after storm events.

2.1.1 Founding and Development

Before the PEN1 District was formed, the area was part of the Columbia River floodplain. It contained a natural system of stream channels, lakes, and wetlands that flooded annually. For generations, Indigenous people relied on the floodplain along the Columbia River for trade, travel, and seasonal food gathering. Leading up to the mid-nineteenth century, disease epidemics spread by European settlers had a devastating impact on the Native communities in Oregon. This, coupled with forced relocation of Indigenous people following the Indian Removal Act of 1830, paved the way for European colonists to begin occupying and managing the floodplain.

In 1902, Congress passed the federal Reclamation Act, which authorized the government to aid with the development of irrigation projects for agricultural purposes. Farmers and other local business interests established four drainage districts along the south shore of the Columbia River in 1917: PEN1, PEN2, Sandy Drainage District (which later became the Sandy Drainage Improvement Company or SDIC), and MCDD. They began building embankments to reduce the impacts from the river’s annual flood cycle to enable year-round agricultural activity and other forms of development. Dikes, drainageways, and pumping stations were eventually installed to reduce the chance of flooding in the area, and Force Lake was drained between the 1920s and 1960s to make more room for agriculture. Transmitter towers were installed in the 1930s, and a transmitter building was constructed by 1935 (radio station KGW-AM) on the site of the current Vanport Wetlands.

Following Congressional passage of the Flood Control Act of 1936, the U.S. Army Corps of Engineers (USACE) worked with the four drainage districts to build an interconnected system of engineered levees that were tied into the existing railroad embankment on the western side of the PEN1 District. USACE has made periodic investments in the four drainage districts’ infrastructure since that time.

Today, PEN1 operates as a special district under Oregon Revised Statute 547 with its own board of supervisors. Following the 1996 flood, PEN1 began delegating full operations and maintenance responsibilities to MCDD through an intergovernmental agreement. MCDD works closely with partner agencies including the City of Portland, Metro, and the Port of Portland to maintain and operate the PEN1 drainage system.

2.1.2 Major Riverine Flood Events

Major riverine flood events in the waters adjacent to the PEN1 District have resulted from precipitation and rapid snowmelt, which raise the water level of the Columbia River and Slough. Columbia River flood waters are partially managed via several upstream dams, and management is subject to provisions in the Columbia River Treaty—an international agreement between Canada and the United States. This report considers major riverine flood events as those that have exceeded the 100-year storm event of 31.4 feet. The four drainage districts have experienced four 100-year events and one 500-year event since they were founded (see Table 2-1). A 100-year event has a 1 percent chance of occurring within any given year, and a 500-year event has a 0.2 percent chance of occurring in any given year. All flood stages below are given in North American Vertical Datum of 1988 (NAVD 88). The levee crest is approximately at 38.7 feet (NAVD 88)

Table 2-1. Major Riverine Flood Events in the Four Drainage Districts

Year	Flood Event	High Water Stage (feet NAVD 88)	Cause
1933	100-year	31.6	• Rapid spring snowmelt
1948	500-year	36.3	• Rapid snowmelt • Failure of the railroad embankment
1956	100-year	32.9	• Heavy rainfall • Rapid snowmelt
1964	100-year	33.0	• Heavy rainfall • Rapid snowmelt
1996	100-year	32.5	• Heavy rainfall • Rapid snowmelt • Drainage ditch bank failure

2.1.3 Impacts of World War II

In 1941, Henry Kaiser opened the Oregon Shipbuilding Corporation on the Willamette River near the PEN1 District to build ships to bolster Britain's war effort. As America's involvement in the war grew, Kaiser built two more shipyards in the Portland area. To help supply the shipyards with workers, Kaiser recruited countrywide resulting in almost 100,000 new residents moving to the Portland area. The influx of new workers led to a housing shortage in the Portland and Vancouver area. In response, Kaiser worked with the federal and local governments to quickly construct a temporary housing development in the district. The community was named Vanport.

Around the same time, in the northeast corner of the PEN1 District, the Pacific International Livestock Center (now the Expo Center) was used as a temporary internment camp for up to 4,000 Japanese Americans in 1942. They were housed in extremely poor conditions for several months before being relocated to concentration camps in California and Idaho.

2.1.4 Vanport and the Aftermath of the 1948 Flood

The city of Vanport was located outside of the city of Portland in what was unincorporated Multnomah County. Vanport was designed as a temporary housing solution for wartime shipbuilders at Henry Kaiser's corporation and was constructed in 1942. At its height, Vanport was the second largest city in Oregon with over 40,000 residents. Kaiser recruited people of all races, and Vanport soon became the most racially diverse city in Oregon. After the war, many residents left Vanport. Nearly a third of the remaining population was Black, which was primarily due to racist redlining policies in Portland that made it difficult for Black residents to find permanent housing elsewhere (BPS 2019).

On May 30, 1948, the levees failed in three locations after holding back high waters for multiple weeks. Two of the failures, the railroad embankment failure and the Denver Avenue levee (which is now Interstate Avenue), impacted the PEN1 basin, and river water flooded Vanport. More than 18,000 residents were displaced by the floodwaters, and at least 15 people died. Vanport was completely destroyed by the flood and never rebuilt. The site was eventually redeveloped into PIR, Heron Lakes Golf Course, and several industrial and commercial properties. In 1999, the Port of Portland purchased the Vanport Wetlands property and subsequently removed the radio transmitter towers and building and restored over 65 acres of wetland habitat as compensatory mitigation for wetland impacts at several other Port-owned properties.

2.1.5 Present-Day Community Assets

The PEN1 District does not currently host any residential areas; it is composed of commercial, industrial, recreational, historic, and ecological properties including the following:

- Portland Expo Center – Occupies approximately 5 percent of the PEN1 basin.
- Diversified Marine Incorporated (which has potential legacy contamination concerns), Graphic Packaging International, Harsch Investment Properties, Peninsula Terminal Company, and Flint Ink, and several other businesses – Located along the northern part of the PEN1 District, these properties make up approximately 8 percent of the PEN1 basin.
- PIR – The raceway welcomes over 400,000 visitors annually (City of Portland) and makes up approximately 22 percent of the PEN1 basin.
- Heron Lakes Golf Course – The golf course welcomes 140,000 visitors annually and includes the Force Lake area. The golf course makes up approximately 42 percent of the PEN1 basin.
- Vanport Wetlands – The wetlands occupies approximately 12 percent of the PEN1 basin.
- TriMet Expo Center MAX Station (Yellow Line), Expo Center Park and Ride, and Delta Park/Vanport MAX Station (Yellow Line) – These facilities make up approximately 2 percent of the PEN1 basin. The MAX Yellow Line had over 66,000 riders in 2020 and over 160,000 riders in 2019.
- I-5 Interchange at NE Martin Luther King, Jr., Boulevard and Marine Drive West – These facilities make up approximately 3 percent of the PEN1 basin.
- Historic City of Vanport – This area occupies approximately 82 percent of the current PEN1 basin.

2.2 Watershed Overview

PEN1 is an approximately 1,000-acre subbasin in the Columbia Slough Watershed. The PEN1 District and subbasin is bound by the Columbia River to the north, I-5 to the east, the Columbia Slough to the south, and North Portland Road and the Union Pacific Railway embankment to the west. The total impervious surface, pervious surface, and open channels and water bodies within the PEN1 basin are included in Table 2-2 below.

Table 2-2. PEN1 District Surface Areas

Surface Type	Area (acres)
Impervious Surface	230
Pervious Surface	690
Open Water Bodies	60

The Columbia Slough Watershed, roughly 32,700 acres in size, contains the four drainage districts and extends from Fairview Lake in Fairview to the confluence of the Willamette and Columbia Rivers (BES 2005). The watershed supports a wide range of wildlife, as well as 4,200 businesses and 170,000 residents. The Columbia Slough is located south of and parallel to the Columbia River and consists of approximately 31 miles of waterway extending from Fairview Lake on the east side to the Willamette River on the west; it drains approximately 40,000 acres. Land use in the watershed includes heavy and light industry, residential, agricultural and the Portland International Airport. The slough also serves as one of the Portland's largest open spaces and wildlife habitat areas. The slough is a remnant of the historical Columbia River Floodplain and was originally a vast complex of wetlands, marshes, and side channels. Much of the slough is now a highly managed water system with dikes, levees, and pumps that provide flood control.

2.2.1 Watershed Features and Resource Areas

The majority of runoff within the PEN1 District, with the exception of runoff from the northern industrial area that drains directly to the Columbia River, is directed to the PIR PS located at the center of the district's southern border. The PIR PS discharges into the Columbia Slough.

The PEN1 basin is divided into seven general resource areas that provide varying habitat for wildlife in the region (included as Figure 14). The seven habitat areas are Heron Lakes Golf Course, Force Lake Area (including the wooded area and Heron Rookery), PIR, Vanport Wetlands, the lower Columbia Slough, a dog park, and the Northern industrial and Portland Expo Center area. These resources are discussed in further detail in Section 3, Existing Conditions.

2.2.2 Climate and Rainfall

Pacific Northwest climate is characterized by cool wet winters and warm dry summers. Most rainfall occurs between October and April. Per National Weather Service National Oceanic and Atmospheric Administration data for the period between 2001 and 2021, December is the wettest month with an average of 7.1 inches of rainfall. July and August are the warmest and driest months with average high temperatures of 97 and 98 degrees Fahrenheit, respectively, and less than 1 inch of rain per month. The average annual precipitation for the Portland metropolitan area ranges from 37 to 43 inches, with an average of 4.5 inches of snowfall annually. Based on the U.S. Geological Survey (USGS) Columbia IPS Rain Gage, located at 5001 N Columbia Boulevard just south of the PEN1 basin at the Columbia Boulevard Wastewater Treatment Plant, the average annual rainfall has ranged from 26.4 to 61.2 inches between 2001 and 2021; 2004 received 26.4 inches and 2012 received 61.2 inches of rainfall. The average rainfall at the USGS Columbia IPS Rain Gage between 2001 and 2021 was 39 inches (USGS 2022).

In December 2015, the Portland metro area experienced a large rainfall event that delivered more than 5 inches of rain over a 3-day period and 2.81 inches in one 24-hour period. This event was estimated to be between a 50- and 100-year frequency event because of the intensity and nature of the rainfall. These severe events are expected to occur more frequently as the climate changes.

2.2.3 Topography

PEN1 basin topography is characterized as relatively flat with elevation changes from around 0.5 to 25 feet. In general, the lower elevations are in the southern portions of the basin, and the highest elevation areas are near Marine Drive at the north end of the basin. The levee crest is approximately at 38.7 feet. All elevations reported in this DWQMP are expressed in NAVD 88.

2.2.4 Soils

The U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Soil Survey online tool was used to gather soils information for the PEN1 basin (NRCS n.d.). Soils are an important watershed characteristic for evaluating potential runoff rates and volumes. Soils are generalized into four categories or hydrologic soil groups, which approximate soil runoff potential. These groups are A, B, C, and D, where A soils are characterized by high rates of infiltration and low runoff potential and D soils are characterized by low rates of infiltration and high potential for runoff. The NRCS Soil Survey also identifies open waterbodies and separates that area from dry land. Most of the soils in the PEN1 basin are hydrologic soil group C soils with pockets of C/D type soils. Type C soils have a slow infiltration rate when thoroughly wet and moderate to high runoff potential. Additionally, there is high seasonal groundwater in the PEN1 basin. This indicates that stormwater runoff does not effectively infiltrate into the soil below, and as a result most stormwater runoff generated in the basin is discharged to the public collection and conveyance systems.

Table 2-3 lists the NRCS hydrologic soil groups, as well as the open waterbodies by percent coverage within the district boundary.

Table 2-3. District Soil Types

Hydrological Soil Group	Acres	Percent
C	894.3	91.7
C/D	7.6	0.8
Water	73.3	7.5
Total	**975.2**	**100**

2.3 Drainage System Overview

The PEN1 basin conveyance system transports surface water to the Columbia Slough via the PIR PS. Conveyance features within the basin include open channels, pipes, culverts, an internal pump station (Vanport PS) and an external pump station (PIR PS). The interior of the PEN1 basin is roughly divided along Force Avenue and Mud Slough into two sides. The western side of the basin contains the Heron Lakes Golf Course. The western drainage system starts at Force Lake and both collects and conveys runoff and groundwater through a series of channels, pipes, and culverts routed along the interior side of the western and southern basin borders, discharging into the forebay of the PIR PS. The northern end of the basin has a stormwater system along Marine Drive that serves the industrial and business area. The collected runoff is discharged, via outfalls, directly north to the Columbia River.

The eastern side of the basin contains the Expo Center, Vanport Wetlands, and PIR. There is a weir gate, effluent structure, and pump station at the Vanport Wetlands to allow for seasonal control of the water level within the wetlands. Drainage from the eastern side of the basin runs through a series of pipes, culverts, and sloughs that discharge through Mud Slough to the forebay of the PIR PS. The only way for the water to be moved out of this system is via the PIR PS. A map of the drainage system in the PEN1 basin is included in Figure 2.

2.3.1 Key Drainage Areas

Key internal drainage areas across the PEN1 basin are listed below. Land cover is shown in Figure 8, and land cover impacts to water quality are discussed in Section 3.3, Water Quality.

- The Expo Center – This property is owned and operated by Metro. Southern portions of this property (Lower Lot 2, Lower Lot 3, and Upper Lot 3) and N Expo Road have been improved, and they drain to infrastructure managed by PEN1 via a ditch in the northeastern corner of the Vanport site. Localized flooding has been observed along the N Expo Road ditch.
- Marine Drive Industrial Area – The other portions of the Expo Center property and the remaining industrial properties along Marine Drive drain directly to the Columbia River. Many of these properties have private stormwater systems that are regulated by either Oregon Department of Environmental Quality (DEQ) Industrial Stormwater Discharge Permits or the BES Maintenance and Inspection Program.
- PIR – This is owned by the City of Portland, managed by Portland Parks and Recreation, and operated as a self-supporting recreational enterprise.
- Heron Lakes Golf Course – This property is owned by the City of Portland Parks and Recreation.
- Vanport Wetlands – This property is owned and managed by the Port of Portland. The site is managed to provide compensatory wetland mitigation for unavoidable wetland impacts at other Port properties.

2.3.2 Pump Stations

There are two pump stations within PEN1: Vanport PS and PIR PS shown in Figures 2 through 6. The Vanport PS conveys water from the Vanport Wetlands and Expo Center into a series of open channels, culverts, pipes, and Mud Slough to discharge to the forebay of the PIR PS. The Vanport PS has a single pump and discharge pipe. The pump is controlled with a rod-mounted float and two limit switches that monitor the forebay level to turn the pumps on and off.

The PIR PS is an external pump station that pumps water out of the PEN1 basin to the Columbia Slough. It was originally constructed in 1940 and had two pumps with a combined discharge pipe. The station has since been modified; there are currently two vertical turbine pumps—each with its own dedicated discharge pipes to the Columbia Slough. The pumps are controlled with floats, a pressure transducer, and an associated programmable logic controller that monitors the forebay level to turn the pumps on and off. The station is coordinated through a supervisory control and data acquisition (SCADA) system to allow PEN1 staff to monitor water levels and manage station operations.

The Vanport PS and PIR PS conditions are further detailed in Section 3.2, Pump Stations.

2.3.3 Critical Conveyance Network

PEN1 staff identified the need to map all PEN1-maintained infrastructure and define the critical conveyance routes for internal drainage systems in October of 2018. The resulting critical conveyance network can be used as a filter to determine which infrastructure to include in the MCDD Asset Registry and to identify which areas should be considered for improvements under the District Capital Improvement Program. The mapped critical conveyance network was developed by the District Operations and Engineering Teams through a collaborative workshop process that is documented in the technical memorandum, *Defining Critical Conveyance Routes within Internal Drainage Systems in PEN1, PEN2, MCDD, and SDIC* (see Appendix A) (MCDD 2018).

The PEN1 District's internal drainage system has mixed—and often unclear—ownership and maintenance responsibilities. Identifying the critical conveyance network was not intended to define or establish ownership of any infrastructure, but simply to define where PEN1 conducts work and what parts of that drainage system are most critical to moving surface water through the District. The critical conveyance network includes portions of the piped conveyance system, open channels, culverts, and pump stations. A map of the critical conveyance system is included as Figure 3.

Critical water surface elevations were provided by MCDD in the technical memorandum *Critical Elevation Selection for PEN1 Drainage and Water Quality Master Plan* (MCDD 2021), and is included in Appendix A of this plan. A map of the PEN1 District and its critical water surface elevations is included in Figure 4. The critical water surface elevations comprise data for operational access and structure protection. Operational access applies to pump stations and other maintenance locations. Structure protection applies the Federal Emergency Management Agency (FEMA) floodplain standard that finished floors should be one foot above the 100-year storm event water surface elevation. The base flood elevation within the PEN1 basin is 14 feet. The Flood Insurance Rate Map (FIRM) panels for the basin are included as Appendix B. The critical water surface elevations in the PEN1 basin also include protection of other physical assets such as roadways.

2.3.4 Recent, Current, and Planned Projects

The District and the City of Portland are continually working to upgrade existing elements of the drainage system, replace deteriorated systems, and improve water quality and habitat conditions within PEN1. Drainage, habitat, and water quality related projects recently completed, ongoing, or planned by the District or partner agencies are listed below.

2.3.4.1 Recent Projects

- BES revegetation sites along the Columbia Slough, at Heron Lakes Golf Course, and along the waterways at PIR, 1996–2020
- BES Lower Columbia Slough Refugia Project, 2015
- MCDD/PEN1 Vanport PS pump rebuild and 15 HP motor replacement, 2020
- MCDD/PEN1 PIR PS Pumps #1 and #2 pump and motor rebuilds, 2020
- MCDD/PEN1 PIR PS SCADA communications upgrade, 2020
- MCDD/PEN1 stormwater conveyance fall protection installations, 2021

2.3.4.2 Current Projects

- BES tends the vegetation associated with the privately owned forested wetland north of Heron Lakes Golf Course.
- Portland Parks and Recreation monitors and maintains the pollinator plots within Heron Lakes Golf Course in collaboration with the Columbia Slough Watershed Council.
- The BES Outfall Decommissioning and Rehabilitation Project will rehabilitate or decommission 15 City-owned and 2 Metro-owned outfalls along Marine Drive that received a poor rating during a recent USACE Rehabilitation and Inspection Program review.

- The Port of Portland monitors and maintains habitat improvements that were made to Vanport Wetlands post-compliance.

2.3.4.3 Planned Projects

- BES is planning to relocate the Force Lake sanitary pump station and is planning associated wetland restoration.
- Heron Lakes Golf Course is planning the following projects:
  - Improve and expand the parking lot
  - Build a new clubhouse
  - Establish an outdoor event area
  - Build a new and expanded cart barn
  - Build bathrooms on the Great Blue Course
  - Replace cart paths
- USACE Portland Metro Levee System projects are listed below (USACE 2021). See Figure 13, USACE Portland Metro Levee System (PMLS) Project Proposed Future Impacts, for more information.
  - Construct setback levee along western edge of golf course and floodwall that runs to the northwest corner of the basin.
  - Conduct PIR PS redundancy (electrical panel) upgrades such as for emergency generator connections.
  - Widen the levee along the southern edge of the PEN1 basin and slough.
  - Replace approximately 700 linear feet of floodwalls near I-5 in the northeast corner of the PEN1 basin with 1,400 linear feet of floodwalls, which would include several flood closures to retain access to Diversified Marine and Pier 99. This project is not anticipated to significantly impact the existing drainage system and functionality.
- MCDD/PEN1 PIR PS structural upgrade.
- MCDD/PEN1 PIR PS replacement.
- MCDD/PEN1 PIR PS SCADA system telemetry equipment replacement.
- MCDD/PEN1 Vanport PS replacement.
- Metro will rehabilitate or decommission two Metro-owned outfalls along Marine Drive that received a poor rating during a recent USACE Rehabilitation and Inspection Program assessment.
- Oregon and Washington Departments of Transportation I-5 Bridge Replacement.

2.4 Regulatory Framework

Multiple governmental entities operate in the geographic area that falls under PEN1 jurisdiction. Across these agencies, there is no single clear set of standards that would dictate the basis of evaluation or the planning framework related to level of service for this DWQMP. The following documents, standards, and regulations provide some guidance and have influenced the development of the planning framework for this DWQMP.

2.4.1 Legal Authorities

PEN1 has legal authority to operate as a drainage district as outlined in Oregon Revised Statues (ORS) Chapter 547. In addition, the PEN1 has legal obligations to provide service to the landowners and stakeholders within its management area. These obligations include compliance with ORS and/or intergovernmental agreements (IGAs) with other partner agencies.

ORS 195 and 547 provide the framework for drainage districts for irrigation or drainage, water supply or flood control, and local government planning coordination. Responsibilities include the following:

- Planning and coordination of the urban service with other urban services (ORS 195)
- Planning and construction
- Maintaining service facilities
- Determining authority of a drainage district for irrigation or drainage (ORS 547)

2.4.2 Partner Agencies

Local partner agencies that fall within the PEN1 jurisdiction include the City of Portland, Port of Portland, Metro, and the Oregon Department of Transportation (ODOT). PEN1 does not own or take ownership of most conveyance infrastructure within its jurisdiction, and instead it relies on partner agencies to maintain, repair, or replace conveyance infrastructure assets and ensure they are designed and sized appropriately. However, PEN1 maintains overall control of the conveyance network by operating the pump stations that drive water through and out of the district.

Each partner agency has different design standards, and these different standards have the potential to create drainage-related inconsistencies when evaluating the existing drainage and conveyance system.

IGAs and legal agreements with local agencies provide additional guidance for maintenance and operations of facilities. Current IGAs that may impact the planning framework include the IGAs with the City of Portland and the Port of Portland. For the most part, IGAs guide the level of maintenance, pump station activities, and some water level requirements but do not outline requirements related to the design or evaluation of pump stations or conveyance features.

2.4.3 State Agency Guidance

At the state level, the ODOT *Hydraulics Design Manual* (2014) is the guiding document for designing drainage facilities associated with state highways. ODOT identifies the recurrence interval of the design storm to be used for the design of each type of drainage feature (bridges, culverts, piped conveyance systems, energy dissipators, etc.). In addition to the identified design storm recurrence intervals, all culverts and bridges are required to be analyzed for impacts during the base flood (100-year recurrence interval), and the 100-year design flood recurrence interval should be used for facilities in floodplains subject to federal National Flood Insurance Program regulations (ODOT 2014).

The ODOT *Hydraulics Design Manual* provides design guidelines for channels, culverts, bridges, energy dissipators, storage facilities, storm drainage (piped conveyance systems), and water quality. Design guidance is not provided for pump stations, as ODOT policy is to convey water along or away from highways with the least disturbance to natural conditions.

2.4.4 Federal Agency Guidance

The level of service for flood protection and water levels is guided largely by FEMA FIRMs. FIRMs are based on an interior drainage study and the resulting water surface elevations. FIRMs provide the maximum water surface elevation the drainage system should allow during the 100-year design event. The latest FIRMs were adopted in November 2010 (FEMA 2010).

The Code of Federal Regulations (CFR) at 44 CFR §44 65.10(b) provides the floodplain management criteria under FEMA's National Flood Insurance Program for areas protected by levee systems. Specifically, it requires that the areas inundated be identified during the 100-year flood, that inundation extents be identified, and that the water surface elevation for all areas where flood waters have a depth of more than one foot also be identified (44 CFR §65.10(b)(6)). An identified 100-year flood inundation map has been created for the district that shows the 100-year water surface elevation. Throughout the district, the 2010 FIRM shows that the 100-year water surface elevation is mapped at 14.0 feet.

USACE has several guidance documents that are applicable to this DWQMP, including:

- USACE Engineer Manual 1110-2-1413, *Hydrologic Analysis of Interior Areas,* states that the interior drainage system is to enhance the national economy and secondarily enhance the environment, social well-being, and regional development (USACE 2018). The manual does not outline specific standards for evaluating or designing the interior drainage system beyond the requirement to maintain the maximum water surface elevations below the base flood elevations during the 100-year design event.
- USACE Engineer Manual 1110-2-2902, *Conduits, Culverts, and Pipes*, includes design considerations for recommended piping materials that should be considered in conjunction with local agency standards when designing new conveyance systems (USACE 1998).
- USACE Engineer Manual 1110-2-3102, *General Principles of Pumping Station Design and Layout* describes pump station design and layout principles (USACE 1995). This guideline recommends that the number and size of stormwater pumps at a given pump station should be determined by an economic study. The study should consider the risk and impacts of a pump failure and the need for redundancy in the pumping system (i.e., whether the pump station should be designed with full pumping capacity even in the event of a single pump failure). EM 1110-2-3102 also includes guidelines for pump controls, sump (wet well) design, trash racks, pressurized discharge lines, and station auxiliaries.
- USACE Engineer Manual 1110-2-3104, *Structural and Architectural Design of Pumping Stations*, provides general guidance for architectural design and specific design guidance for structural loading (USACE 1989).
- USACE Engineer Manual 1110-2-3105, *Mechanical and Electrical Design of Pumping Stations*, is a detailed guideline for selecting equipment and designing the systems within flood-control pumping stations (USACE 1999). This guideline is an important reference for PEN1 when upgrading pump stations or pump station components.

2.4.5 Water Quality Regulatory Framework

Multiple cities, the drainage districts, Multnomah County, Metro, and the Port of Portland have overlapping management responsibilities in the watershed. These management responsibilities can create measurable improvements in water quality, habitat, safety, recreation, and education and outreach. Over a century of industrial, agricultural, and urban development along the Columbia Slough has resulted in widespread degradation within the watershed. In 1996, the Columbia Slough was placed on the DEQ Section 303(d) list of waterbodies that do not meet water quality standards. In 1998, DEQ issued a Total Maximum Daily Load (TMDL) for the slough for multiple water quality limiting parameters including bacteria, temperature, dissolved oxygen, pH, phosphorus, chlorophyll *a*, and toxics (DDT/DDE, dieldrin, dioxins, PCBs, and lead).[2] The TMDL strategy identifies loading capacity and load allocations for these various pollutants. The City of Portland has developed a TMDL implementation plan that identifies key management strategies to reduce TMDL pollutants from nonpoint (i.e., diffuse) sources and improve water quality.

The City of Portland and its co-permittee, the Port of Portland, implement stormwater management programs under a DEQ permit issued under the federal Clean Water Act. The permit is formally called the Phase I National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System (MS4) Discharge Permit. The permit requires each co-permittee to develop and implement a comprehensive stormwater management plan that describes measures the co-permittee will implement throughout the permit term to control pollutant discharges to the storm sewer system. There are over 200 MS4 outfalls discharging to the Columbia Slough.

Industrial and agricultural land use in the watershed and industrial and stormwater discharges to the slough resulted in widespread contamination of slough sediments. The relatively low sediment concentrations generally reflect impacts from pervasive and legacy sources in the surrounding urban environment. Contaminants in Columbia Slough, including PCBs and pesticides, bioaccumulate in fish to the extent that the Oregon Health Authority issued an advisory to reduce potential risks from eating resident fish. Since 1993, BES and DEQ have been working together to investigate environmental conditions in the slough and implement actions to reduce contaminant discharges and improve watershed health. BES's Columbia Slough Sediment Program is responsible for meeting the requirements of the state's environmental cleanup law. The requirements are outlined in the 2005 DEQ Record of Decision for Slough Sediments (DEQ 2005) and the 2021 Intergovernmental Agreement between the City and DEQ (BES 2021).

2.5 Development Patterns

The PEN1 basin contains Heron Lakes Golf Course, PIR, Vanport Wetlands, the Expo Center, and businesses along the northern basin boundary. The majority of the PEN1 basin is fully developed and is not expected to change significantly in the future. However, the northern industrial area, Expo Center, and I-5 areas may be redeveloped in the future. Metro is currently exploring redevelopment opportunities at the Expo Center and the impacts of the future I-5 Bridge replacement are not known at this time. In addition, Portland Parks and Recreation is currently in the process of applying for Heron Lakes Golf Course to be included on the National Register of Historic Places, and the golf course was identified as historically significant by USACE. Future development in PEN1 is expected to be limited.

[2] DDE = dichlorodiphenyldichloroethylene; DDT = dichlorodiphenyltrichloroethane; PCB = polychlorinated biphenyls

2.6 Operations

MCDD operations staff are responsible for maintaining the pump stations and movement of water through the PEN1 District. Operations are primarily focused on monitoring pump functions, maintaining the pump stations, adjusting the Vanport Wetlands slide gate, and clearing debris and other blockages from the conveyance system. Operations staff routinely repair and rebuild pump station components to extend the life of the pumps, and they continually engage in projects to improve pump station structures.

The operations staff maintains 7 miles of ditches and sloughs in the PEN1 basin. These are often connected or interrupted by culverts at roadway crossings and closed conveyance (pipe) systems. All conveyance system elements need to be maintained for long-term performance.

PEN1 has a regular maintenance program that is followed throughout the year. Some of the activities are listed below.

- Regular inspections/maintenance of pump stations and pump station infrastructure
  - Outfall/intake inspection
  - Electrical review and inspection
  - Debris removal at the intake
  - Maintaining all moving parts including trash rakes
- Maintenance of the small and large ditches and sloughs
  - Brush removal
  - Mowing and general upkeep of the vegetation
  - Removing, modifying, working with blockages such as beaver dams or debris jams
- Identifying areas of potential sedimentation and planning accordingly
  - Inspection of culverts/pipes and other conveyance infrastructure
  - Removal of debris at inlets
- Regular inspection of passive infrastructure such as diversions, weirs, beaver deceivers, etc.
- Annual review of critical conveyance elements such as the cross-levee culverts and gates

PEN1 does not own any land within the basin. PEN1 relies on the cooperation of the many landowners and partner agencies to provide operational access to the critical conveyance network. These partners include:

- City of Portland Parks and Recreation
- Port of Portland
- Metro
- Marine Drive businesses

3. EXISTING CONDITIONS

The following section describes the existing conditions within the PEN1 basin. A photo log of various areas throughout the PEN1 basin can be found in Appendix C.

3.1 Drainage Infrastructure

Drainage infrastructure within the PEN1 basin includes open channels, culverts, and piped conveyance networks in addition to two pump stations: the Vanport PS and PIR PS. Pump station conditions are further detailed in Section 3.2, Pump Stations.

3.1.1 Critical Conveyance Network – Material and Size

PEN1 identified the critical conveyance network (see Figure 3) which includes over 8,800 linear feet (1.7 miles) of pipe and culvert segments and 37,200 linear feet (7.0 miles) of open channel conveyance. These systems are largely owned by partner agencies or private property owners. Through data sharing with partner agencies, field investigations, and field survey, PEN1 has cataloged pipe material for much of the critical conveyance network as shown in Table 3-1. However, approximately 5,800 linear feet of the piped network (over 50 percent of the pipe and culvert system) do not have a recorded material type.

Table 3-1. PEN1 Critical Conveyance Material Summary

Material Type	Total Length (linear feet)
Concrete Pipe	517
Corrugated Metal Pipe	1,210
Corrugated Steel Pipe	515
Ductile Iron Pipe	55
Flanged Concrete Pipe	448
High Density Polyethylene	242
PVC Pipe	34
Unknown	5,849
Open Channel	37,224

Source: MCDD Asset Registry

The pipes and culverts in the critical conveyance network vary in size (see Table 3-2). Pipe diameter has been recorded for most of the critical conveyance system. For 1,300 linear feet of the piped network (18 percent of the pipe and culvert system), there is no recorded diameter. Where the pipe size is unknown, it is assumed to be 12 inches in diameter or smaller because mapping efforts have been focused on the larger portions of the drainage network. The largest culverts are 60 inches in diameter and are immediately upstream of the Vanport PS and the PIR PS.

Table 3-2. PEN1 Critical Conveyance Size Summary

Pipe Diameter (inches)	Number of Segments	Total Length (linear feet)
Unknown	18	2,962
6	1	34
8	3	714
12	3	572
16	3	175
18	3	373
24	10	911
27	1	186
30	8	1,285
36	4	914
48	1	392
60	2	352
Total pipe/culvert	**57**	**8,870**

3.1.2 Age of Infrastructure

Little information is documented regarding the age of the existing conveyance system infrastructure. There is a general understanding that most of the existing pipes and culverts were installed when development occurred, and available data from partner agencies confirms this understanding. Pipe age is generally recorded for recent public roadway projects and developments from 1980 and forward (see Figure 5). However, there are large portions of the PEN1 basin where storm drainage systems were installed prior to electronic recordkeeping, or they were installed by private owners without records. The oldest pipes and culverts in the basin are the least likely to have recorded age information and are the most likely to be experiencing deterioration.

3.2 Pump Stations

PEN1 operates two pump stations—Vanport PS and PIR PS—to pump the runoff generated from the contributing drainage area. Condition evaluations were previously performed in 2015 and 2016 for both stations; the pump stations were visited again as part of the current work to determine pumping capacities and provide additional condition assessment. The following summarizes past condition-evaluation work and documents the assessment completed as part of the current work for both stations.

3.2.1 PIR Pump Station

Pumps 1 and 2 in the PIR PS are maintained and rebuilt regularly to maintain performance.

A 2016 condition evaluation determined an overall weighted score of 3.2/5[3] indicating poor condition (Parametrix 2016, Parametrix 2017). The evaluation included electrical, SCADA/instrumentation, wet well, valves, piping, pumps, site, and building. A 2015 structural evaluation found the station to be "functional but… increasingly showing signs of its age." (Parametrix 2015). The primary concern identified that timber piles support the concrete floor and pumps. At the time of the evaluation, it was estimated that the station would be able to support up to another 5 years of service.

Additional field investigations and technical analyses were conducted under this master plan project. Record drawings, historical station assessment reports, and interviews with staff were also used to document the condition of pump station system components. During the field investigations, the outfalls of the stations (force main outfall pipes) were visually evaluated, and thickness measurements were taken in a single location on each of the steel outfall pipes.

General information about the PIR PS is summarized in Table 3-3; the table includes tested pump flows from the field investigation.

Table 3-3. PIR Pump Station Summary

Specification	Pump 1	Pump 2
Rated Flow	Not Indicated	7,500 gpm
Rated Head	Not Indicated	31 feet
Tested Flow [a]	8,075 gpm	5,968 gpm
Tested Head [a]	27.4 feet	21.9 feet
Horsepower	100	75
RPM	880	880
Voltage	440 (480 volts nominal)	400 (480 volts nominal)
Full-Load Amps	126	87
Phase	3	3
Discharge Force Main	24 inches in diameter	24 and 20 inches in diameter

[a] See Section 3.2.3, Pump Station Testing, for testing details.
gpm = gallons per minute

3.2.2 Vanport Pump Station

The Vanport PS pump was rebuilt in 2019 and received a new motor in 2020.The pump and motor are expected to outlast the pump station. Periodic maintenance is performed at the Vanport PS to maintain the current discharge capacity.

In the 2016 condition assessment (Parametrix 2016), the Vanport PS was determined to have an overall weighted score of 2.9/5 indicating poor/inadequate condition. Additional field investigations and technical analyses were conducted under this master plan project. Record drawings for the station are unavailable, but interviews with staff were used to document the condition of pump station system

[3] 5 = excellent, 4 = good, 3 = poor, 2 = inadequate, 1 = failing/failed

components. During the field investigations, the station discharge force main was also visually evaluated and thickness measurements were taken in a single location on the pipe.

General information about the Vanport PS is summarized in Table 3-4.

Table 3-4. Vanport PS Summary

Specification	Pump 1
Rated Flow	Not Indicated
Rated Head	Not Indicated
Tested Flow	3,042 gpm
Tested Head	9.7 feet
Horsepower	15
RPM	1,775
Voltage	230/460 volts
Amps	35.0/17.6
Phase	3
Discharge Force Main	12-inch-diameter

3.2.3 Pump Station Testing

The pumps for both stations were tested in the field to evaluate their performance. Pump testing was performed in August 2021 on both pumps (Pump 1 and Pump 2) at PIR PS and in November 2021 for the pump at the Vanport PS. To measure flow rate, a Flexim Fluxus F608 ultrasonic flowmeter was temporarily installed on the discharge piping approximately 15 to 30 feet downstream of the pump. A pressure transducer was installed in a 1/4-inch tap on the crown of the pipe immediately downstream of the pump discharge to collect pressure data.

The data collected through pump testing was analyzed to establish existing pumping capacity. Results of the pump testing are summarized in Table 3-5.

Table 3-5. Pump Station Performance Test Results

Pump Station	Pump No.	Discharge Rate (gallons per minute)	Discharge Head (feet)	Notes
PIR	1	8,075	27.4	Only a single-duty point could be collected. Partial opening of the siphon breaker did not produce additional stable operating points to develop a full pump curve.
PIR	2	5,968	21.9	Only a single-duty point could be collected. Partial opening of the siphon breaker did not produce additional stable operating points to develop a full pump curve.
Vanport Wetlands	1	3,042	9.7	The station does not operate under siphon and does not contain a discharge isolation valve. As such, only a single operating point could be obtained.

3.2.4 Discharge/Outfall Condition Assessment

The discharge piping at the PIR PS and Vanport PS was visually evaluated, and the following were noted:

- PIR PS discharge pipelines
  - Exterior weathering and corrosion on both discharge pipes
  - Corrosion and wear on the interior of the discharge elbows at the Columbia Slough
- Vanport PS discharge pipeline
  - Exterior weathering and corrosion on the pipe
  - Some erosion at the embankment around the discharge

Thickness measurements were recorded in a location approximately 15 to 30 feet downstream of the pump on all three pipelines. Wall thickness was measured with a probe attachment from a Flexim Fluxus F608 ultrasonic flow meter. Table 3-6 summarizes the results of the wall thickness measurements.

Table 3-6. Discharge Pipe Thickness Summary

Location	Crown (inches)	Springline (inches)	Invert (inches)
PIR Pump 1 Discharge	0.364	0.360	0.112–0.117
PIR Pump 2 Discharge	0.363	0.363	0.372
Vanport Wetlands Pump Discharge	0.237	0.239	0.237

The pipe invert for PIR PS Pump 1 discharge has significant wear. Wall thickness at the pipe invert was approximately one-third of the thickness measured at the pipe springline and crown, which is the assumed initial thickness. The Pump 1 performance test showed velocity is approximately 6 feet per second, compared to about 4.4 feet per second for Pump 2. The higher velocity in the Pump 1 discharge may be a cause of additional wear on the pipe invert.

3.3 Water Quality

Existing conditions and water quality data were reviewed to better understand the impacts of existing conditions on water quality within the PEN1 basin's open channels and waterways.

3.3.1 Land Cover

Land cover type impacts stormwater runoff and water quality. Land cover impacts the rain that falls on it, infiltrates through it, flows across it, and runs off into the natural receiving waters. Impervious surfaces such as roadways, sidewalks, compacted gravel, and rooftops allow little or no stormwater to infiltrate into the ground. Vegetated areas such as forests, grass, and landscaping are pervious surfaces that allow air and water to move through and into underlying layers. All land covers are classified as either pollution-generating (such as roads that have vehicular pollutants or farms or playfields that may have fertilizer or pesticides) or non-pollution generating (such as sidewalks or wetland areas). Impervious surfaces increase rainfall runoff volumes and flow, which can erode streambanks, damage habitat, and cause local flooding. Pollution-generating surfaces damage the chemical quality of the rainfall runoff that reaches the natural waterbodies including groundwater.

Land cover within the PEN1 basin consists of roadway, racetrack, non-pollution generating impervious surface, golf course, wetlands, trees, and other grassy areas. The amount of impervious area within the PEN1 basin is 228 acres. The amount of pervious area within the basin is 692 acres. The amount of pollution-generating surface within the basin is 413 acres. The total PEN1 basin, excluding the open channels and water bodies, is 920 acres. The total PEN1 basin, including the open channels and water bodies, is 980 acres.

3.3.1.1 Roadways

Roadways and parking lots are pollution-generating impervious surfaces and have a high impact on water quality. Parking lots collect and convey stormwater runoff that includes pollutants such as sediment, brake pad dust, oil, and grease. Roadways make up 163 acres of the PEN1 basin.

3.3.1.2 Racetrack

Racetrack is another example of pollution-generating impervious surface that has a high impact on water quality. Racetrack runoff is categorized differently than runoff from roads and parking areas because there is more tire and brake pad wear generated on the racetrack surface. PIR implements daily sweeping to reduce the impact of tire-wear on stormwater runoff. However, polluted runoff is still generated from the racetrack. The racetrack collects and conveys stormwater runoff that includes pollutants such as metals, brake pad dust, oil, and grease. Metals may include lead, zinc, and copper. Racetrack makes up 12 acres of the PEN1 basin.

3.3.1.3 Non-Pollution-Generating Impervious Surface

Non-pollution-generating impervious surfaces include sidewalks, buildings, and other hard surfaces that do not collect pollutants but do increase runoff volume and frequency. Non-pollution-generating impervious surfaces have a medium impact to water quantity and quality and make up 52 acres of the PEN1 basin.

3.3.1.4 Golf Course

A golf course is considered a pollution-generating pervious surface. Golf courses are categorized differently than grass because of different maintenance activities and use of pesticides and fertilizer. Heron Lakes Golf Course implements native grass and bent-grass on the course, as well as low use of fungicide—approximately 80 percent less than average for golf courses. However, pollutant runoff is still generated from the golf course surface. Golf courses collect and convey stormwater runoff that includes pollutants such as sediment, phosphorous, and nitrogen. Golf course makes up 237 acres of the PEN1 basin.

3.3.1.5 Trees, Forest Canopy, and Wetlands

Trees, forest canopy, and wetlands are beneficial to water quality. Wetlands naturally treat stormwater runoff. Canopy cover and shade over open channels and bodies of water decrease water temperatures and improve water quality. Trees, forest canopy, and wetlands make up 236 acres of the PEN1 basin. Grassy areas, separate from the golf course, make up 220 acres.

3.3.2 Water Quality Data

Water quality data was provided by the BES Portland Area Watershed Monitoring and Assessment Program (PAWMAP) (BES 2018). PAWMAP is a coordinated long-term monitoring effort designed to measure the city's current and changing ecological resources. The program began in 2010 and was designed to systematically measure changes in water quality, habitat, and biological communities over time to provide a comprehensive and comparable body of information to identify the condition of, and the greatest threats to, Portland streams.

Data was collected at four points of interest: one location within the PEN1 basin and three locations on the Columbia Slough (two upstream of the basin and one downstream; see Exhibit 3-1). The data was reviewed, compared against water quality standards, and is summarized in Table 3-7 below.

Exhibit 3-1. PAWMAP Water Quality Sampling Stations

Table 3-7. PAWMAP WQ Data Summary

Sampling Location	0337	0329	1217	2377		
Location Description	Slough, U/S PEN1	Slough, Just U/S PIR PS	PEN1, D/S Vanport PS	Slough, D/S PEN1	Columbia Slough Report Card Score [a,b]	
Contaminant	Average	Average	Average	Average		Water Quality Standard [c]
Chlorophyll *a* (mg/m^3)	34.582	28.471	17.300	27.967	N/A	15 mg/m^3 per OAR 340-041-0019(1)(b)(B).
Copper (ug/L)	1.19	1.92	2.84	1.46	N/A	
Dissolved Copper (µg/L)	0.62	0.88	1.44	0.63	7.6	Freshwater criterion for copper is a function of the ion concentration, alkalinity, organic carbon, pH, and temperature and is calculated using the Biotic Ligand Model per OAR 340-041-8033, Endnote N.
Dissolved Oxygen (mg/L)	12.68	12.91	8.17	12.75	4.7	4.0 mg/L (absolute minimum)
E. coli (MPN/100 mL)	92.47	71.24	141.57	91.83	8.0	Single sample may not exceed 406/100 mL
Lead (µg/L)	0.54	1.08	1.28	0.84	N/A	
Dissolved Lead (µg/L)	0.10	0.11	0.11	0.10	N/A	The lead criterion is hardness-dependent per OAR 340-041-8033, Endnote F.
Nitrogen (Ammonia) (mg/L)	0.08	0.08	1.08	0.06	9.7	The ammonia criteria are pH- and temperature-dependent per OAR 340-041-8033, Table 30(a).
Total Nitrogen (mg/L)	2.15	2.16	N/A	1.17	N/A	
pH	7.42	7.63	6.98	7.50	N/A	6.5–8.5
Total Phosphorus (mg/L)	0.12	0.14	0.23	0.13	5.5	0.1 mg/L (target)
Total Suspended Solids (mg/L)	9.53	20.41	18.29	17.67	5.3	
Temperature (°C)	14.30	14.02	9.20	14.88	1.0	Summer Maximum: 12°C (bull trout); 16 °C (salmon/trout)
Turbidity (NTU)	6.03	11.07	25.87	10.56	N/A	Good <6; Poor >22
Zinc (µg/L)	5.05	8.80	12.19	5.59	N/A	
Dissolved Zinc (µg/L)	2.63	3.23	4.77	1.48	N/A	The zinc criterion is hardness-dependent per OAR 340-041-8033, Endnote F.

D/S = downstream; mg/L = milligrams per liter; mg/m^3 = milligrams per cubic meter; MPN/100 mL = most probable number per 100 milliliters; N/A = not applicable; NTU = nephelometric turbidity units; PIR = Portland International Raceway; PS = pump station; U/S = upstream; µmho/cm = micromhos per centimeter; µg/L = microgram per liter

[a] Scores: 0–3 = Poor; 4–6 = Average; 7–10 = Good; [b] Source: BES 2019; [c] Source: EPA n.d.

Based on the information in Table 3-7, pollutant loading is higher in the PEN1 basin for copper, *E. coli*, lead, nitrogen (ammonia), phosphorous, turbidity, and zinc than in the lower Columbia Slough both upstream and downstream of the basin. However, there is only one sampling location within the basin, so it is unknown how pollutant loading changes throughout the basin. Identified improvement projects will aim to improve water quality throughout the PEN1 basin.

Ambient surface water quality data is collected as part of PAWMAP and the BES long-term fixed site monitoring program. (BES 2022) One of the main water quality issues in the Lower Columbia Slough is eutrophication and the resulting excess algal growth. Since 2001, BES sampling has shown the chlorophyll *a* water quality criterion of 15 mg/m^3 was exceeded 67 percent of the time—strong evidence of eutrophication as the Lower Slough regularly exceeded the criterion from March to November. This high level of primary productivity is also reflected in the elevated pH and dissolved oxygen concentrations. As photosynthesis increases across the day, the concentrations of dissolved oxygen and pH also increase.

Elevated nutrient inputs can increase primary productivity. To limit algal growth, the Columbia Slough phosphorus TMDL specifies a maximum instream total phosphorus concentration of 0.155 mg/L. Over the past 20 years, this instream limit was exceeded over half the time (52.3 percent). These exceedances in total phosphorus are observed throughout the year and are not limited to the growing season.

3.3.3 Water Quality Permitting

Most of the properties on Marine Drive have private stormwater systems with outfalls discharging to the Columbia Slough and/or the Columbia River. Several properties have businesses that hold National Pollutant Discharge Elimination System General Industrial Stormwater Discharge Permits issued by DEQ and administered by the City's Industrial Stormwater Program. These businesses are inspected annually by City staff and are required to sample their stormwater discharge and meet certain pollutant benchmarks set by the permit. Corrective actions are required if samples exceed benchmark levels. Several properties have private stormwater facilities such as a sedimentation manhole or an oil water separator, which are routinely inspected by the City's Maintenance and Inspection Program to ensure proper functioning. Additionally, the City conducts street sweeping along the Marine Drive right-of-way six to eight times a year to protect the public stormwater system.

3.4 Habitat

Existing conditions for habitat in the PEN1 basin including habitat resources area, focal species, and observed habitat conditions are described below.

3.4.1 Habitat Resource Areas

The PEN1 basin is divided into seven general resource areas, A through F, that provide varying habitat for wildlife in the region:

A. Heron Lakes Golf Course

B. Force Lake Area

C. PIR

D. Vanport Wetlands

E. PIR Dog Park

F. Northern Industrial area and the Portland Expo Center area

G. Lower Columbia Slough

The areas are described below and illustrated in Figure 14. Each habitat resource area is described below.

A. Heron Lakes Golf Course

Resource area A includes the Heron Lakes Golf Course, which contains two golf courses: the Greenback course and the Great Blue course. Heron Lakes Golf Course is a collection of maintained open grass areas with multiple historical wetland and surface water features. Nearly all the wetland and surface water features are influenced by the complex drainage system managed by PEN1, and most are relics of the once sensitive complex of lakes, channels, marshes, and forested wetlands that historically existed in the area. Within Heron Lakes Golf Course, there are mature trees, pockets of native plants, and shrub hedgerows.

The greens within the golf course consist of native bent-grass. The golf course is actively managed to benefit the golfing community as well as habitat. Management of the golf course is consistent with the City of Portland Parks and Recreation Integrated Pest Management program and has been certified since 2018 through Salmon-Safe.[4] Salmon-Safe is an independent certification organization that assesses land management practices and their possible effects on aquatic ecosystems. A park system is considered salmon-safe when both its impact upon the aquatic ecosystem is assessed and any harmful impacts on water quality and fish habitat are minimized. A Salmon-Safe certification also includes extensive on-site visits by qualified inspectors to ensure that standards are being met.

Heron Lakes Golf Course has also been certified through Audubon International since 1996. The Audubon Cooperative Sanctuary Program for Golf is an education and certification program that helps golf courses protect the environment, preserve the natural heritage of the game of golf, promote environmental sustainability, and gain recognition for their efforts. This is done through development and implementation of a plan that meets the environmental management standards set by the Audubon International organization.

Additionally, the Columbia Slough Watershed Council partners with Portland Parks and Recreation to maintain pollinator vegetation plots within the golf course. The Heron Lakes Golf Course is known to provide habitat for native turtles, bats, and songbirds.

B. Force Lake Area

Resource area B includes the Force Lake area and provides some of the best foraging waterbird habitat within the PEN 1 basin. Force Lake has a few non-native plants growing around its edges such as reed canary grass (*Phalaris arundinacea*) and Himalayan blackberry (*Rubus armeniacus*), but there are also native sedges, rushes, and cattails. Force Lake provides habitat for purple martin *(Progne subis)*, native pollinators, native turtles, and many other migratory and resident birds.

The adjacent large, privately owned forested wetland located west of Force Lake and north of Heron Lakes Golf Course is a significant habitat feature in the basin and is the location of a great blue heron

[4] https://salmonsafe.org/

rookery. This area is managed for water quality and habitat by the BES Natural Areas Revegetation staff via agreements with the property owners.

Much of this area is also designated in the City of Portland Natural Resource Inventory Update, dated June 2012, as Special Habitat Area CS7 – Heron Lakes Wetlands/Force Lakes and Wetlands (City of Portland Planning and Sustainability Commission 2012). Special Habitat Areas are an important part of the City inventory of riparian corridors and wildlife habitat. They contain or support special status fish or wildlife species, sensitive and unique plant populations, wetlands, etc.

C. Portland International Raceway

Resource area C includes the PIR area that provides a technical and recreational high-speed driving course for its clients and serves as a venue for other public and private outdoor events. As such, wildlife habitat within the boundary of PIR is limited. However, on the north side of the raceway and on the south shore of Mud Slough, 20-year-old conifers were observed. This area is beneficial to habitat and may be used by various songbirds. According to the Oregon Native Turtle Working Group, painted turtles have been observed in the pump station forebay. It is unknown if there are resident native turtles within PIR.

D. Vanport Wetlands

Resource area D includes the Vanport Wetlands area and is a 90-acre site with 65 acres of native plant-dominated wetland with a surrounding scrub-shrub or forested buffer. Like the Force Lake area, Vanport Wetlands is designated in the City of Portland Natural Resource Inventory Update, dated June 2012, as Special Habitat Area CS8 – Vanport Wetlands. The wetlands provide many beneficial attributes for over 150 wildlife species. Vanport Wetlands provide important breeding and rearing habitat for species such as the great horned owl and other common species.

Wetland-emergent plants are common throughout the area and there is evidence of wetland-adapted mammals such as beaver (*Castor canadensis*). Waterbirds and raptors frequent this specific area of the PEN1 basin. This area is mostly closed to the public, which benefits the majority of wildlife species using the area. Additionally, within Vanport Wetlands, the Port of Portland provides artificial nesting structures for purple martin, which is a critical sensitive listed species. An artificial nesting gourd array was installed in April of 2019 and is one of three sites actively maintained by the Port for purple martin in Portland.

E. PIR Dog Park

Resource area E includes the fenced dog park south of the Vanport Wetlands and at the north end of PIR. The dog park is open to the public and to off-leash dogs. Unleashed dogs are generally a hazard to native wildlife and their habitats. The south fence of the Vanport Wetlands prevents dog access to the wetlands. This fenceline also provides great waterfowl viewing (looking north) within the wetlands. The dog park is a maintained grass field that does not greatly support native wildlife, nor does it contain their required habitat attributes.

F. Northern Industrial and Expo Center Areas

Resource area F includes the Portland Expo Center, which consists of a convention center and its parking lots. Though not a habitat area, it is located within the PEN 1 basin. There are a few planting strips that have been planted with native vegetation, which may benefit native songbirds. The Northern Industrial

Area consists of privately owned businesses that discharge directly to the Columbia River. Similar to the Expo Center, this is not a habitat resource area being considered for improvement in this plan.

G. Lower Columbia Slough

Resource area G includes the Lower Columbia Slough located along the southern boundary of the PEN 1 watershed. The Lower Slough is tidally influenced and connects to the Willamette River. The Lower Slough provides habitat for Endangered Species Act–listed fish species and native turtles and bird species. There have been numerous habitat improvement projects within the slough. Additional habitat improvement projects are needed to support native wildlife.

3.4.2 Focal Species

As described above, the PEN1 basin has seven distinct resource areas (see Figure 14). Habitat conditions for the PEN1 watershed were evaluated for 11 focal species. Focal species were selected to represent various classes of wildlife including reptiles, mammals, birds, and pollinators that may be found in the basin. In addition, species were selected with habitat requirements that, when met, would benefit additional native wildlife. Final selection of focal species was determined by a team of biologists with knowledge of the PEN 1 basin and through discussions with project partners including the City of Portland and the Port of Portland.

Most of the focal species, except for cinnamon teal and western bumblebee, are identified by the City of Portland as Special Status Species. Special Status Species are officially listed or identified as being of concern by the following federal, state, or other entities because they are rare, declining, or of special interest:

- U.S. Fish and Wildlife Service – Candidate, Listed Threatened or Endangered, Species of Concern
- Oregon Department of Fish and Wildlife – Listed Threatened or Endangered, State Sensitive, State Strategy Species
- Oregon Natural Heritage Information Center – Ranked or Listed
- Oregon Watershed Enhancement Board – Priority Species
- Partners in Flight – Focal Species
- Northwest Power and Conservation Council Willamette Basin Subbasin Plan – Focal Species
- National Audubon Society's Watch List

Focal species and their habitat requirements are shown in Table 3-8. Species observations and existing habitat features for each of the focal species are described Section 3.4.3, Observed Habitat.

Table 3-8. Focal Species and Their Habitat Requirements

Species	Habitat Requirements
Birds	
Bald eagle (*Haliaeetus leucocephalus*)	Found near lakes, reservoirs, rivers, marshes, and sloughs. Birds select dominant trees for nesting within 2 miles of water and use mature trees for perching.
Cinnamon teal (*Spatula cyanoptera)*	Nest in freshwater wetland habitats. Prefer areas with emergent vegetation (large permanent marshes). They use streams, reservoirs, ditches, ponds, and temporary wetlands. Look for vegetation such as spike rush, tufted hairgrass, bull rush, cattails, and sedges (vegetation is food and cover). Nest beneath dead marsh grasses that are less than 2 feet tall (ground nester).
Purple martin (*Progne subis*)	Found in a variety of habitats. Forage in the air over open areas over or near water. Cavity nesters using abandoned woodpecker holes or artificial nesting habitats.
White-breasted nuthatch *(Sitta carolinensis aculeata)*	Prefer deciduous forests and is commonly associated with Oregon white oak, black cottonwood, and Oregon ash; also associated with edge habitat. Large oaks within open areas tend to provide greater opportunity for nesting and foraging. Foraging is almost completely done on tree trunks and thick branches. Larger trees with fissured bark tend to provide suitable foraging opportunities where nuthatches prey upon arthropods, weevils, and earwigs. They are secondary cavity nesters and rely on woodpeckers to excavate cavities for roost and nest sites. Specific habitat features necessary for this nuthatch include deciduous forest/Oregon white oak, edge habitats, and large, mature trees.
Willow flycatcher (*Empidonax traillii)*	Prefer small upland groves, bushes, willow thickets, and brushy fields. This bird is often found near streams or marshes. Forage from perches within tall shrubs or low trees, flying off to catch insects, usually returning to the same perch for multiple rounds. May also hover and glean insects from foliage. Diet consists mostly of insects including winged ants, wasps, bees, flies, moths, caterpillars, and beetles. Nest in deciduous shrubs or trees, often in willow, between 4 and 15 feet above the ground. Specific habitat features necessary for this flycatcher include the presence of willow or other deciduous shrubs and nearby streams or marshy areas.
Yellow-breasted chat (*Icteria virens)*	Found in areas of dense shrub in a variety of habitats. Often found in blackberry thickets. Low thick vegetation. Feed on spiders and insects (glean from foliage) and young soft insects such as caterpillars. Nest in low dense vegetation. Build nests 1 to 8 feet above ground supported by branches or clumped vegetation. May reuse nest sites, but build a new nest each year.
Mammals	
Little brown bat (*Myotis lucifugus*)	Use buildings, caves, trees (aspen, poplar, oak, maple), tree hollows, rocks, rocky outcrops, and wood piles as roost sites. Occur in forests and live along lakes and rivers. Tend to forage along edges of vegetated habitat. Specific habitat features necessary for bats include the presence of water, roost sites (tree cavity, rocky outcrops, wood piles) and edge habitats.
American beaver (*Castor canadensis*)	Require the presence of water such as freshwater ponds, lakes, rivers, streams, marshes, or swamps. Diet consists of bark, leaves, roots, and wetland plants. The types of forest that this species is associated with include mixed conifer, western ponderosa, red alder, oak, maple, and northern hardwood. Commonly found in riparian areas of deciduous and mixed coniferous-deciduous forests that contain abundant food and lodge-building material such as willow, alder, red-osier dogwood, and cottonwood. Specific habitat features necessary for beaver include the presence of water, small-diameter trees (willow, alder, cottonwood), and wetland-associated species.

Species	Habitat Requirements
Fish	
Chinook salmon (*Oncorhynchus tshawytscha)* Note: This species is not found within PEN1 interior but rather in the Columbia River and Columbia Slough, outside the PEN1 levees.	Small freshwater tributaries, and larger rivers. Associated with low-gradient reaches of tributary streams, which provide suitable spawning areas and good juvenile rearing habitat. Need cold, clear, complex, and connected waters. Spawn in small streams with stable gravel substrates. Specific habitat features necessary for salmon include freshwater stream or river, low-gradient waterways with stable gravel substrate (redds), and backwater refugia.
Reptiles	
Western painted turtle (*Chrysemys picta bellii*)	Found in sloughs, ponds, streams, rivers, and oxbow lakes, particularly areas with numerous basking sites and submerged and emergent vegetation. Aquatic vegetation is important for brood habitat and for food. Nests are constructed in a variety of soil and gravel types, typically within 300 feet of their aquatic habitat. Nest sites are sparsely vegetated (solar exposure is critical for incubation). Overwinter in both aquatic and upland habitats. Water depth of at least 5 feet is important.
Invertebrates	
Western bumble bee (*Bombus occidentalis)*	Western bumble bee is a generalist forager that gathers pollen and nectar from a variety of native, heirloom, perennial, blooming, and flowering plants. This invertebrate prefers flowers that are purple, blue, or yellow, with a diversity of corolla tube lengths to support various tongue lengths. Preferred flowers and plants are lacy phacelia, California poppy, lance selfheal, bigleaf lupine, royal penstemon, showy milkweed, nettle-leaf horsemint, coyote mint, Nuttall's sunflower, and Canada goldenrod. Specific habitat elements necessary for the western bumblebee include pollen sources from blue or yellow flowers, with a diversity of corolla tube lengths and places to nest such as rodent burrows and bird nests.

3.4.3 Observed Habitat

Existing habitat conditions observed during the August 31, 2021, site visit are described below.

3.4.3.1 Bald Eagle

Habitat for the bald eagle is present within the PEN1 drainage basin, and this species was detected during the August site visit. Bald eagles have been seen perching within the golf course and PIR property. They are regularly seen along the Columbia Slough south of the PEN1 basin. These eagles are known to winter at the Columbia Boulevard Sewage Treatment Plant, which is adjacent to the south of the basin. Bald eagles typically nest within 1 mile of waterbodies such as lakes, rivers, or sloughs. There are nest sites available within the PEN1 drainage basin, and a historical nest site (2019) was observed. Current nesting status is unknown; a winter survey would determine if bald eagles are actively nesting within the PEN1 drainage basin. Bald eagle is characterized as "4 – of conservation concern but not currently imperiled" by the Oregon Biodiversity Information Center.

3.4.3.2 Cinnamon Teal

Cinnamon teal was not detected within the PEN1 drainage basin during the August site visit, but suitable habitat is present and they have been documented annually within the Vanport Wetlands since 2002. Cinnamon teal may be attracted by open water and short nutritional grasses. This bird dabbles and feeds on seeds, vegetation, zooplankton, and insects. It may also eat snails, beetles, midges, and flies. Vegetation management and the addition of more wetland plants at shorelines could improve nesting habitat for this species.

3.4.3.3 Purple Martin

Habitat for purple martin is present within the PEN1 drainage basin, and this species was detected during the August site visit. Purple martin are known to nest within woodpecker holes along rivers and forest edges and forage within parks, open fields, wet meadows, and beaver ponds. They also nest in snags and birdhouses (such as gourd houses), and may nest in other human-made structures. The purple martin is an exclusive insectivore feeding primarily on spiders, termites, and flying insects such as beetles, flies, crickets, butterflies, and moths. These birds have the potential to provide enhanced natural mosquito control. Purple martin is characterized as a federal “Species of Concern” and as “Sensitive-Critical” by the state.

3.4.3.4 White-Breasted Nuthatch

The white-breasted nuthatch was detected within the PEN1 drainage basin during the August site visit. While there is limited mature oak habitat in the basin, there is mature cottonwood-ash forested habitat. This species is known to occur in the Vanport Wetlands. Mature oak trees within an open area provide nesting and foraging opportunities for this species. White-breasted nuthatches rely on woodpecker cavities or other artificial nest structures for roosting and nesting. White-breasted nuthatch is classified as “Sensitive-Vulnerable” on Oregon’s State Sensitive Species List and is a priority species in the Oregon Conservation Strategy.

3.4.3.5 Willow Flycatcher

The willow flycatcher was detected within the PEN1 drainage basin during the August site visit. This species occupies shrubs and willows near water and feeds on insects by catching them in mid-air or gleaning them from branches and leaves. Regular prey species include beetles, wasps, ants, and flies. They may also eat berries in the fall. Riparian areas within the PEN1 drainage basin provide suitable habitat for this species. Willow flycatcher is classified as “Sensitive-Vulnerable” on Oregon’s State Sensitive Species List and as a priority species in the Oregon Conservation Strategy.

3.4.3.6 Yellow-Breasted Chat

The yellow-breasted chat was not detected within the PEN1 drainage basin during the August site visit, but limited suitable habitat exists. Yellow-breasted chat were observed within shrub-dominated and forested areas within PEN1 in 1997. This species is found in dense shrubbery, fields, forest edges, marshland, and water edges. It may build nests in raspberry, blackberry, dogwood, honeysuckle, or sumac. Yellow-breasted chat is characterized as a federal “Species of Concern” and as “Sensitive-Vulnerable” by the state.

3.4.3.7 Little Brown Bat

The little brown bat was not detected within the PEN1 drainage basin during the August site visit, but suitable habitat is present. This species has been detected in the Vanport Wetlands during an Anabat survey conducted with the U.S. Fish and Wildlife Service in 2003. This species uses buildings, caves, trees, rocky outcrops, and woodpiles for nesting and roosting. It usually occurs within streamside forests, and it forages along forest edges. The presence of water is necessary. Habitat for this species could be improved by providing additional roosting sites including snags, habitat piles, and roosting boxes. The addition of roosting boxes for bats in woodlands or within the woodland fringes has the potential to increase species diversity and provide mosquito control. Little brown bat is characterized as "4 – of conservation concern but not currently imperiled" by the Oregon Biodiversity Information Center.

3.4.3.8 American Beaver

American beaver was not detected within the PEN1 drainage basin during the August site visit, but suitable habitat exists within the basin and evidence of recent beaver presence was observed. Observations included dams, lodges, blocked culverts, and downed small-diameter trees with beaver chew markings. Beaver were also common during a 1997 reporting of the area (BPS 1997). This species requires the presence of water such as freshwater ponds, lakes, streams, or marshes. Careful management is necessary for this species to avoid conflict with other land uses in the basin (such as the golf course and raceway uses). Appropriately sized culverts may be required, and the installation of "beaver deceivers" could help with beaver management to allow for their presence and the continued successful functioning of the drainage conveyance network. American beaver have been identified as a focal species in the Northwest Power and Conservation Council Willamette Basin Subbasin Plan.

3.4.3.9 Chinook Salmon

The Lower Columbia River Chinook salmon (listed threatened) were not detected during the August site visit, and the interior of the basin does not contain suitable habitat; however, habitat does exist within the adjacent Columbia River and Columbia Slough. This species uses small freshwater tributaries and large rivers, and it is associated with low-gradient streams. Chinook salmon need cold, clear, and connected waters, and they benefit from the backwater refugia of the lower Columbia Slough adjacent to the PEN1 basin. The Lower Slough has been designated as Critical Habitat for Chinook salmon (as well as Columbia River coho salmon and steelhead), which are listed in the Endangered Species Act by the National Oceanic and Atmospheric Administration. Juvenile salmon use the Lower Slough during the winter months as they seek food, cover, and off-channel habitat areas away from the Willamette and Columbia Rivers. Young fish from across the entire Columbia River Basin grow and mature in the Lower Slough before going to the ocean.

3.4.3.10 Western Painted Turtle

Western painted turtles were observed during the August site visit. Suitable habitat exists within the PEN1 basin sloughs, ponds, streams, rivers, and oxbow lakes. Western painted turtles were historically present within the basin, and reporting from 1997 indicates that the slough provides suitable habitat (BPS 1997). Basking sites and submerged and emergent vegetation are necessary habitat elements for western painted turtles. Aquatic vegetation is used during brooding and is also an essential food resource. Western painted turtle nests upland (within 300 feet) from waterbodies in sparsely vegetated areas. Golf sand traps have been used as nesting sites.[5] The extent of turtle use in the PEN1 drainage basin is not well understood; surveys would help determine nesting and site use. The western painted

---

[5] Per verbal communication with Jesse Goodling, a representative of Heron Lakes Golf Course, during August 31, 2021, site visit.

turtle is classified as "Sensitive-Critical" on Oregon's State Sensitive Species List and as a priority species in the Oregon Conservation Strategy.

3.4.3.11 Western Bumble Bee

Bumble bees were detected during the August site visit. Experts may need to be consulted to determine if the species observed is western bumble bee. The western bumble bee gathers pollen and nectar from a variety of flowering plants and builds nests within rodent burrows and bird nests. Pollinator plots have been established at multiple locations throughout the PEN1 drainage basin, and these provide habitat for this species.

3.5 Environmental Concerns and Assets Deficiencies

The following concerns and deficiencies were noted during the August 31, 2021, site visit:

- Three culverts that connect Mud Lake to the channel to the north are rusted out and at risk of failure.
- Beaver dams along the end of the channel running along the north end of Heron Lakes Golf Course cause flooding when not managed.
- The Vanport PS has no SCADA system. The Vanport PS needs repair or replacement.
- Survey throughout the District is out of date or missing data which makes analysis and evaluation challenging.
- Force Lake has a low water table in the summer, which results in higher water temperatures, lower dissolved oxygen, and increased algae blooms.
- Water quality of stormwater runoff from PIR is relatively unknown as regular water quality sampling is not conducted.
- Water quality of stormwater runoff from Heron Lakes Golf Course is relatively unknown as regular water quality sampling is not conducted.
- The PIR PS forebay and outlet from the pump station to the Lower Slough have a high amount of visually noticeable sediment and turbidity.
- In the Vanport Wetlands, stakeholders are concerned about the runoff from the parking lot being treated before discharge to the surface water channel. Per discussions with the Expo Center management, stormwater treatment facilities have been provided under past projects. It was not confirmed if these facilities are currently functioning and providing water quality benefits.
- The industrial area on the north side of the basin most likely impacts stormwater runoff. All of the facilities to the north (except for 12220 N Portland Road) either have a 1200-Z Permit, a No Exposure Permit, or are private stormwater facilities that are monitored by the BES Maintenance Inspection Program.
- There is a lack of nesting habitat for purple martin throughout the PEN1.
- There is a lack of suitable waterbird nesting habitat; less managed grass buffer around water features is needed.
- There is a lack of suitable nesting habitat for turtles.

- There is a lack of habitat complexity for Chinook salmon within the slough.
- There is a lack of riparian plantings in many locations throughout the PEN1 basin.

A map of the identified problem areas is included as Figure 6. Comments received from stakeholders are included in Appendix D.

4. STAKEHOLDER COORDINATION

Stakeholder coordination was conducted throughout the development of this DWQMP. This included virtual meetings, email correspondence, an online survey, and the creation of a story map.

Prior to the stakeholder coordination meetings, a survey was developed to gather initial feedback from the stakeholders and to inform the subsequent coordination meetings. The survey also included an interactive webmap to allow location-specific comments to be provided. A printout of the webmap and comments are included as Appendix D. The stakeholder coordination meetings were held to provide an overview of the DWQMP, better understand the priorities of the various stakeholders, review known deficiencies within the PEN1 basin, and discuss potential opportunities for improvement.

Stakeholder coordination meetings were held online in fall 2021 with various PEN1 stakeholders which included:

- City of Portland (BES and Parks and Recreation)
- MCDD
- Port of Portland
- Metro (Expo Center)
- PEN1 Board
- Columbia Slough Watershed Council
- Portland Audubon

Multiple workshops were held throughout the duration of the project to maintain ongoing communication and collaboration with the various stakeholders.

5. SYSTEM METRICS

5.1 Establishing System Metrics

System metrics were developed to evaluate and rank areas in PEN1 for drainage, water quality, and habitat improvement.

5.2 Drainage Infrastructure Metrics

Existing drainage infrastructure conditions within PEN1 were evaluated based on quantitative and qualitative metrics to better understand existing deficiencies and identify areas for improvement. The metrics used and methodology applied to the drainage infrastructure analysis are described below.

5.2.1 Metrics

The metrics for evaluation included a condition and capacity-based needs planning assessment. Pump stations, pipes and culverts, and open channels were evaluated using the following metrics and methodology.

5.2.1.1 Condition

Pump stations were evaluated based on their previous condition assessment (electrical, structural, mechanical, etc.). The condition assessment results were supplemented with recent pipe thickness measurements and pump performance testing. The approximate overall condition-based need for improvement for each pump station was then determined.

Pipelines and culverts were assessed visually where possible. The age and material of the pipes were evaluated to determine the approximate remaining useful life and to develop an overall condition-based need for improvement.

Open channels were evaluated based on the following metrics: erosion, incision, aggradation, and overgrowth of vegetation. Open channels were observed for erosion of the channel banks and the acute erosion at pipe outfalls; a more visibly eroded channel or outfall would have a higher need for improvement. Degradation and incision of channels were also evaluated to see if the channel bed was lower due to incision and downcutting. Aggradation of open channels was investigated to evaluate accumulation of sediment. The last metric used to evaluate the condition of open channels was the amount of vegetation overgrowth, including riparian overhang into the channel. These metrics were used to determine an overall condition-based need for improvement for the open channels.

5.2.1.2 Capacity

Capacity was another metric considered for drainage infrastructure analysis and developing projects for improvement. Capacity analysis included evaluating the flood capacity protection throughout the basin by comparing the critical water surface elevations established by PEN1 to the model results for design storms as detailed below.

Critical water surface elevations were provided by MCDD in the technical memorandum, *Critical Elevation Selection for PEN1 Drainage and Water Quality Master Plan;* the memo is included in Appendix A. A map of the PEN1 basin and its critical water surface elevations is included in Figure 4. The critical water surface elevations comprise data for operational access and structure protection.

Operational access considers the pump stations and other maintenance locations. Structure protection considers the FEMA floodplain standard that finished floors should be one foot above the 100-year storm event water surface elevations. The critical water surface elevations in the PEN1 basin also include protection of other physical assets such as roadways.

The critical water surface elevations were compared to the model results at the design storms to determine if flooding is anticipated under various design storm events. For this analysis, flooding is defined as locations where the modeled water surface elevation exceeds the identified critical water surface elevation at locations identified by MCDD. High water elevations and backwater conditions may be acceptable within the conveyance system where critical water surface elevations have not been identified. This allows for resources to be focused on the area's greatest need and provides the additional benefits of flood attenuation and storage. If flooding is identified from the model, it indicates that the infrastructure downstream of the flooding is unable to provide adequate capacity to maintain water levels below identified critical elevations during that design storm event. The hydrologic and hydraulic model is detailed in Section 6.1, Drainage Infrastructure Capacity Analysis.

The 2-, 10-, 25-, 100-, and 500-year design storm events were included in the model. The 500-year event was added during alternatives analysis to account for recent intense storms due to climate change and to allow for consideration of future climate resiliency. This qualitative approach (flooding vs. no flooding and/or acceptable backwater conditions) was used to identify capacity limitations as part of the analysis.

5.2.2 Analysis and Scoring

Drainage infrastructure was analyzed based on both condition and capacity. Drainage infrastructure capacity was evaluated based on its ability to provide adequate conveyance to maintain the water surface below the critical water surface elevations located throughout the PEN1. This is done for each design storm event. The results from the modeling analysis, along with infrastructure with needed condition improvements, dictated the alternatives analysis and project identification. This was combined with the potential impact of the infrastructure failure and discussions with District staff to prioritize the identified projects. This is presented in more detail in Table 8-1 in Section 8.1, Drainage Projects.

Opportunities to create a multi-benefit project or identify complementary projects that would provide water quality, habitat, and drainage improvements in one project were also considered.

5.3 Water Quality Metrics

Existing water quality conditions within PEN1 were evaluated based on quantitative and qualitative metrics to better understand existing deficiencies and identify areas for improvement. The metrics used and methodology applied for the water quality analysis are described below.

5.3.1 Metrics

The metrics for evaluation included a quantitative and qualitative approach. The quantitative analysis approach accounted for land cover and shade presence.

5.3.1.1 Land Cover

As previously discussed in Section 3, Existing Conditions, land cover type is one element that impacts stormwater runoff and water quality. For this analysis, land cover within the PEN1 basin was split into seven categories: trees, wetland, grass, pollution-generating pervious surface, non-pollution-generating impervious surface, pollution-generating impervious surface, and racetrack. Based on the different pollutants generated from PIR and a typical roadway, pollution-generating impervious surface and racetrack were considered separately. Grass and pollution-generating pervious surfaces were also considered separately because pollutants are generated from the golf course due to fertilization and other ground treatments, but they are not generated from standard grass.

Each land cover category was assigned a score from 0 to 100. The assigned score is based on the amount of runoff generated and the expected pollutants of each land cover type. The scores for each land cover type are included in Table 5-1 below.

Table 5-1. Land Cover Runoff Scores

Land Cover Type	Points	Reasoning
Trees	100	Lowest amount of runoff with no expected pollutants
Wetland	100	Lowest amount of runoff with no expected pollutants
Grass	50	Some runoff with no expected pollutants
Non-pollution-generating impervious surface	30	High runoff with no expected pollutants
Pollution-generating pervious surface	20	Some runoff with expected pollutants
Pollution-generating impervious surface	10	High runoff with expected pollutants
Racetrack	0	High runoff with expected pollutants and visible evidence of tire wear

5.3.1.2 Shade Presence

Shade near waterbodies impacts water quality. Shade along waterbodies reduces water temperature and increases vegetation along the banks while also restoring riparian buffers. Shade presence was analyzed along the waterbodies within the PEN1 basin to determine if canopy was present or not. Southern facing areas were also given priority as they have a greater impact on shade due to the northern latitude of the PEN1 basin.

5.3.1.3 Qualitative Evaluation Criteria

The qualitative approach was used for weighting criteria in the analysis. The weighting criteria included known or potential water quality problem areas, available space for improvements, and opportunity to include a multi-benefit project which could include water quality, habitat, and drainage improvements in one project.

5.3.2 Analysis

The PEN1 basin was separated into 10 subbasins based on the site's topography and drainage patterns. The 10 subbasins are shown in Figure 7. Each subbasin was analyzed for land cover and shade presence. The land cover analysis evaluated the area and associated points for each land cover type to determine an overall land cover score for each subbasin. The shade presence analysis determined the total gap in bank shade, which is the difference between the current quantity of bank shade and the maximum possible bank shade for each subbasin. This was determined by applying buffer widths to the open channels and comparing the buffer against existing tree canopy. If tree canopy was not present, this was considered a canopy gap and opportunity for improvement.

5.3.3 Scoring

The land cover score for each subbasin was ranked from lowest to highest, with lower numbers (higher rank) representing a worse landcover score and more opportunity for improvement. The shade presence score for each subbasin was ranked from largest area of gap in bank shade to the least, with lower numbers (higher rank) representing a larger area of bank shade gap and more opportunity for improvement. The land cover rank and shade presence rank were then averaged to get an overall ranking for each subbasin. This is summarized in Section 6.10, Water Quality Evaluation. The overall ranked basins were then screened using the above qualitative evaluation criteria to determine project focus areas within the PEN1 basin. This is summarized in Section 7.2, Habitat and Water Quality Analysis

5.4 Habitat Metrics

Existing habitat within the PEN1 basin was evaluated for benefits to the focal species discussed in Section 3.4.2, Focal Species. To allow habitat improvements to be combined with water quality projects as detailed within Section 5.3.1.3, Qualitative Evaluation Criteria, habitat uplift opportunities were evaluated within each of the 10 identified subbasins. The process for this evaluation is described below.

5.4.1 Metrics

The metrics for evaluation included a quantitative assessment of the number of focal species that may benefit from potential projects and the relative importance of habitat in each subbasin. A qualitative assessment included land available for habitat improvements and the ability for improvements to be combined with water quality projects. Additionally, a consensus approach was used in evaluating overall priority of each recommended improvement project.

5.4.1.1 Potential for Projects to Benefit Focal Species

Various habitat components are necessary for focal species to fulfill their life history. In each subbasin, the ability to improve to one or more habitat features for each focal species was determined. Habitat features include availability of nesting and rearing habitat, availability of food and cover, and ability to disperse and/or connect to other habitats. Examples include basking structures for painted turtles, emergent vegetation for cinnamon teal, and riparian plantings for multiple species including willow flycatcher and yellow-breasted chat. The total number of focal species in each subbasin that could benefit from potential habitat features was determined. Additionally, the total number of classes (i.e., bird, mammals, fish, reptiles, or invertebrates) of focal species that could benefit from habitat improvements was determined. Different habitat features considered for the focal species are described below.

Nesting Habitat

Nesting habitat varies by species and guild; it is the space needed to raise their young. These may be mature conifers where large birds can build nests, dead or dying trees with holes where cavity nesters are able to take up residence, artificial nesting structures that serve as a surrogate in the absence of natural nesting substrate, low-to-the-ground dense shrubs where nests can be assembled from nearby sticks and grasses, or long grasses and rushes by the side of water features suitable for ground-nesting waterbirds.

Rearing Habitat

Rearing habitat for Endangered Species Act–listed salmonid species, such as Chinook salmon, is essential for survival of this species. Side channels and backwater refugia, such as the Columbia Slough, are often used by juveniles as they make their way to the Pacific Ocean.

Food and Forage Habitat

Foraging habitat includes areas where focal species can look for and find preferred food sources that contain required nutrients for animals to carry out essential life functions.

Cover and Protection from Predators

Cover and protection from predators is essential for an organism to reach the age of reproduction. This can come in the form of dense canopy within a forest or underneath a dense shrub layer. It can be long grasses near a waterbody, which would enable a reptile or amphibian to migrate from one habitat type to another. It may migrate from one site where it grows to another site where it breeds, or from one site where an organism feeds to another where it rests. Cover and protection can be within a cavity of a snag or underneath a rotting tree or log. Cover and protection provide places where potential prey has the ability to rest and recover while not being detected by potential predators.

Dispersal and Connectivity

Following the breeding season, wildlife have the potential to disperse from their place of birth. This can be a short distance of just a few feet or it may be a long distance of many miles. Connectivity between habitat types is essential for safe dispersal (migration) for wildlife to successfully reach adulthood and pass genes onto the next generation. Connectivity can be accomplished through the maintenance of transition areas between habitat types. Habitat types can vary greatly considering elements such as geographic area, land formation, migratory barriers, or predator assemblages. Specifics about species composition and landscape setting must be considered in maintaining viable connections between habitat types to ensure successful dispersal post-birth.

5.4.1.2 Priority Habitat Areas

Natural resource habitat layers were also reviewed in GIS. This information is from analysis, studies, and planning efforts performed by others to identify areas of habitat significance or for focused habitat improvements. The layers considered in this analysis are listed in Table 5-2 below.

Table 5-2. GIS Layers used to Identify Priority Habitat Areas

GIS Layer	Source	Description
Wetlands	City of Portland, Bureau of Planning and Sustainability	National Wetland Inventory (NWI) with revisions made by local governments in the tri-county region. Portland wetlands are updated from the original Metro dataset by City of Portland, Bureau of Planning & Sustainability to refine geometry, remove erroneously mapped wetlands, and add missing wetlands.
Natural Resources Inventory Special Habitat Areas	City of Portland, Bureau of Planning and Sustainability	Specific habitats or landscape features that have been documented to provide especially or uniquely important fish and wildlife habitat values and function. Special Habitat Areas contain or support special status fish or wildlife species, sensitive/unique plant populations, wetlands, native oak, bottomland hardwood forests, riverine islands, river delta, migratory stopover habitat, connectivity corridors, grasslands, and other unique natural features.
Conservation Opportunity Areas	Oregon Department of Fish and Wildlife	Delineated through a spatial modeling analysis, incorporating datasets focusing on Oregon Conservation Strategy components (Strategy Species, Strategy Habitats, and Key Conservation Issues), and expert biologist review. Focusing investments in the prioritized areas can increase the likelihood of long-term success, maximize effectiveness over larger landscapes, improve funding efficiency, and promote cooperative efforts across ownership boundaries.
Strategy Habitats	Oregon Department of Fish and Wildlife	Provides the extent and distribution of the 11 Strategy Habitats within the Oregon Conservation Strategy using best available data. Dataset was derived in 2015 as part of the Oregon Conservation Strategy revision.
Title 13 Habitat	Metro	Depicts the Metro Fish and Wildlife regulatory program defined in Exhibit A to Metro Resolution No. 04-3506A. The layer divides the region's significant habitat into high, moderate, low, or no conservation area. These designations were established by comparing ecological values to competing development and policy values.
Regional Land Information System High Value Habitat	Metro	Depicts High Value Habitat from the Regional Land Information System.

The total number of the above GIS layers found within each subbasin were considered. A higher number of habitat layers indicated a greater likely potential for current or future habitat benefit.

5.4.1.3 Qualitative Evaluation Criteria

In addition to the metrics above, the following were reviewed for each subbasin: existing conditions; land available for improvements or limitations such as areas reserved for golf course and drainage district operations; and the ability to combine with water quality improvements.

Existing Conditions

Existing condition scores were assigned to each subbasin using best professional judgement based on observations during the August 2021 site visit and discussions with project stakeholders. Three scores were possible for existing conditions: (1) poor, (3) fair, and (5) good. Subbasins that received a score of 1 were generally devoid of natural habitat elements necessary for retention and reproduction of focal species (paved impervious surfaces, industrial development). Subbasins that received a score of 3 were generally areas used for human recreation and may have had industrial or commercial influences, but they also had viable wildlife habitats within their margins. Subbasins that received a score of 5 were areas already set aside as wildlife habitat that could be enhanced with a few additional habitat elements or continued maintenance.

Land Available for Improvement

Land availability was also evaluated for each subbasin based on discussions with project stakeholders. Three categories were possible for land availability. "No" was provided where no land or very little land was available for habitat improvements, "some" was provided where there was some land available for habitat improvements but significant limitations existed, and "yes" was provided where there was substantial land available for habitat improvements. Subbasins that received *no* were generally already developed and had significant constraints as a function of their current uses. Examples of constraints included paved surfaces surrounding the Expo Center or the safety implications of focal species in the Internal Raceway subbasin. Subbasins that received *some* were generally open areas with area available for improvement but with significant limitations (e.g., the Heron Lakes Golf Course) or minimal room for improvement (i.e., Vanport Wetlands). Subbasins that received *yes* were areas that had the least amount of constraints based on their current usage.

5.4.2 Analysis and Scoring

Subbasins were evaluated in terms of the quantitative metrics and qualitative criteria detailed above. Attention was provided to those subbasins that (1) benefit the greatest number of focal species and classes, (2) were identified as higher priority areas in analysis performed by others, and (3) had the greatest ability and space to improve the existing habitat. Best professional judgment was used to identify projects and priority was assigned to subbasins that could include project elements with the habitat features described above. Stakeholder priorities were considered, and recommendations were reviewed by the project team for final consensus.

Habitat improvement projects were also grouped so that, for example, a single replanting effort could benefit or be conducted within multiple areas of the PEN1 basin. The results of this analysis were presented to the project team and priorities were identified by consensus. Results from this analysis are included in Section 6.11, Habitat Evaluation, and are included in Appendix E.

6. PERFORM EVALUATION PROCESS

6.1 Drainage Infrastructure Capacity Analysis

PEN1 has an XP-SWMM model which was developed in 2014 to predict the expected hydraulic performance of the drainage infrastructure and identify where portions of the conveyance system may be inadequate or undersized. The 2014 model build and results are documented in a separate report as part of the levee accreditation process (PEN1 2014). The report was reviewed by WEST Consultants (PEN1 2013). This review provided a peer review and recommendations to refine the model's representation of PEN1 drainage systems.

As part of this DWQMP, the model hydrology was reviewed for accuracy and did not require any updates. The hydraulic model was also reviewed and updated. Updates were completed as part of this DWQMP based on available detailed data, and updates are detailed in Section 6.4, Hydraulic Update. The updated XP-SWMM model assisted in identifying deficiencies within the conveyance system and pump station infrastructure.

The capacity analysis based on the updated XP-SWMM hydrologic and hydraulic model identified locations where the drainage system is not anticipated to meet the minimum capacity criteria. The evaluation also focused on identifying the cause of capacity limitations and identifying whether the conveyance pipe or culvert is undersized or if the associated pump station is causing the restriction.

This capacity analysis encompassed the entire drainage basins for the PIR PS and Vanport Wetlands PS systems in the PEN1 XP-SWMM model. The northern industrial area in the PEN1 basin along Marine Drive was not included in the model because this system drains north directly to the Columbia River. The stormwater pipe network was constructed in 1992. Drainage characteristics since that time have not changed appreciably, so the pipe capacities are assumed to be adequate. Project recommendations are focused on deficiencies within the identified critical conveyance network. The critical conveyance network is shown in Attachment A of the technical memorandum, *Defining Critical Conveyance Routes within Internal Drainage Systems in PEN1, PEN2, MCDD, and SDIC*. The memo is included in Appendix A of this plan.

The following system evaluations identified problem areas in the current drainage system and led to recommended project actions to correct system deficiencies.

- Conveyance system capacity evaluation, assuming pump stations are operating with current settings to move water through the conveyance system.
- Pump station capacity evaluation, assuming pump stations are operating with current settings.
- System evaluations to test what-if scenarios related to changed pump station settings and pump station component failures.

Each of the analyses assumed that the conveyance system was free of accumulated debris or other blockages that could restrict the flow of water. Debris accumulation is an ongoing challenge for PEN1 operations and likely reduces the capacity of the drainage system. Further discussion of the effects of debris accumulation are included in Section 7.1.3, Debris and Blockage Considerations.

The evaluations in this section relied on existing land use and associated percent impervious area. A future condition was not evaluated as the land use is not anticipated to significantly change within the planning timeframe of this study. The setback levee currently proposed, as part of the USACE Portland Metro Levee System projects, on the western boundary was not considered as part of this study. The setback levee as currently proposed will impact the north to south drainage way parallel with the railroad embankment on the western property edge of the PEN1 basin, as well as impact the water body in the southwest corner of Heron Lakes Golf Course

For the initial assessment of drainage system capacity of both the conveyance system and the pump stations, multiple storm events were modeled, including the 2-, 10-, 25- and 100-year SCS Type IA 24-hour rainfall events. The updated 2022 model was run for these storm events following calibration, which is discussed in Section 6.6, Model Validation.

6.2 Hydrology Update

The 2014 XP-SWMM model used the RUNOFF method for hydrograph development. There are four primary inputs used for this method:

1. Subcatchment area
2. Percent impervious
3. Slope
4. Width

Model inputs were reviewed, and the values were found to be reasonable. Key observations within PEN1 that were reflected in the model inputs included the limited impervious area relative to the total drainage area and the limited topographic relief across the area resulting in low slope calculations. The width parameter is a function of the total area and overland flow path length. The width was computed for three subcatchments and compared to the model parameters. This served as a check for how the width was previously calculated. The flow path length calculation was also completed to ensure these were reasonable.

Infiltration parameters for the prominent soil type, silt loam, are appropriate and align with the soil type within PEN1 drainage area. The model uses the Green-Ampt method, which requires three input parameters: average capillary suction, initial moisture deficit, and saturated hydraulic conductivity. The Green-Ampt method is well suited to hydrologic modeling as theoretical values can be sourced from literature and no field work is necessary.

Additional infiltration input parameters within the model included depression storage, Manning's n for both pervious and impervious surfaces, and zero detention percentage (applied to only the impervious areas). The range of appropriate values for these parameters is well understood, and the values used within the model are within the range of acceptable values.

Based on review of the input data and the previous review by WEST Consultants, no changes were made to the hydrology to establish the 2022 model update.

6.3 Modeled Storm Events

Storm events simulated include the 2-, 10-, 25-, and 100-year, SCS Type 1A 24-hour storm events. Twenty-four-hour precipitation values (see Table 6-1) were obtained from Appendix C of the City of Portland *2020 Stormwater Management Manual*.

Table 6-1. Design Storm Depth

Storm Event	Depth (inches)
2-year	2.4
10-year	3.4
25-year	3.9
100-year	4.5

The 500-year storm event was also modeled. The 500-year rainfall was extrapolated using a log best fit from the storm event rain depths listed above. The 500-year storm event was modeled using a rainfall depth of 5.62 inches. This was compared to the ODOT TransGIS site 500-year storm event rain depth of 5.21 inches. The 500-year storm event rain depth of 5.62 inches was determined to be reasonable and conservative and was used in this analysis.

The extent of inundation during the 100-year and 500-year storm events was determined using the XP-SWMM model results and GIS lidar topography. Maps were created detailing the extent of inundation, which would occur with the drainage infrastructure properly functioning with existing conditions and are shown in Figure 12-A. The 2-, 10-, and 25-year storm events were not mapped for this scenario because the extent of inundation for these three storm events was minimal. The extent of inundation was also determined for a scenario with the 25-year and 100-year storm events where both pump stations were disabled. See Figure 12-B.

6.4 Hydraulic Update

The 2014 XP-SWMM model included 70 nodes and 74 links to represent the drainage system. The model included main channels and ponds throughout PEN1, areas that drain into the main drainage channels from the Expo Center, and a single node representing the Vanport Wetlands. The Vanport Wetlands, Expo Center drainage, and associated areas are pumped to the main drainage channels via the Vanport PS. At the terminus of the drainage system is the PIR PS, to which all flow is routed.

The hydraulic model was updated with new information to increase the accuracy and confidence in results. Updates were primarily focused on increasing the accuracy of information for areas defined as part of the critical conveyance network, updating pump station settings to reflect tested conditions and adding detail to the Vanport Wetlands infrastructure and pump station.

6.4.1 Conveyance System Hydraulics

Hydraulic updates were integrated into the model conveyance system from various data sources including design drawings, GIS information, field survey, site visits, and direct feedback from MCDD staff. When available, pipe and culvert data from GIS databases provided by PEN1 and the City of Portland were used to update the model hydraulics. The primary source of GIS data was the project webmap. The webmap provided a central location for existing and updated GIS data and other data related to this study. Information regarding reference information for hydraulic modeling data is described below.

6.4.2 Design Drawings

Design drawings provided an accurate source of updated hydraulic model information. The design drawings that were integrated to update the hydraulic model are listed below:

- 2001 Vanport Wetland As-built
- 2003 Vanport Wetland Grading Plan

6.4.3 GIS

GIS databases are a critical resource when developing or updating a hydraulic model. GIS data from the project webmap was used to check all pipe and culvert data and populate missing data or elements that needed to be updated. Most of this information was used to fill in data gaps on pipes or channels or for verification purposes. The project webmap is a composite of all available data sources including PEN1, the City of Portland, and the Port of Portland.

6.4.4 Survey

Following a site visit and a kickoff meeting with PEN1 staff, a list of locations where additional field surveys were needed was developed. These locations consisted of areas of concern where GIS information was unreliable. District staff performed the necessary surveys to provide the data needed for model and webmap integration.

6.4.5 Field Investigations

In addition to field survey work, a site visit was conducted on August 31, 2021. District staff, City of Portland Parks and Recreation, and BES staff walked the study area. The site visit helped the project team become familiar with the drainage system and the general nature of the conveyance patterns. In addition, the site visit provided a fundamental understanding of operations and maintenance procedures, challenges of the system, staff-identified problem areas, and a visual image that aided in the model development.

6.5 Pump Station Settings

Pump station settings and pump curves for the PIR PS and Vanport PS were updated to reflect field -tested pump curves and operational settings at each of the two pump stations. A summary of the updates made to the model to better replicate the nature of the PS is outlined below.

6.5.1 Manufacturer/Existing Model Pump Curve Settings

The existing 2014 model had settings for the pumps integrated into the model. Data to verify that the pump curves used in the model was unavailable, and the team was unable to verify the model pump curves. Based on the uncertain information in the model, field-tested data was collected and used to populate the pump curve model input.

6.5.2 Field Testing

The two pumps at the PIR PS and the single pump at the Vanport PS were tested to inform the model and facilitate a better understanding of the current pumping capacity. The field tests that were completed provided a real measurement of the current pump station capacity. The testing was completed in August 2021 and November 2021. The pump station capacity summary, provided in Table 6-2, lists the current (2021) discharge flow rates.

Table 6-2. Pump Station Capacity Summary

Pump Tested	Current (2021) Discharge Flow Rate (gpm) Based on Test Results
PIR Pump 1	8,075
PIR Pump 2	5,968
Vanport Wetland Pump	3,100

gpm = gallons per minute

6.5.3 Operational Settings

The PIR PS pumps are programmed to turn on and off based on water levels measured by the SCADA system. The PIR PS has several operational modes that include the following:

- Mode 1 (winter): Typical setting for wet-weather months.
- Mode 2 (pre-storm): Lower draw-down elevations to "drain" the conveyance system and increase flood storage in advance of anticipated storm events. Pre-storm settings are also used in late fall to draw debris out of open channels, so it can be removed before it causes a blockage during winter storms.
- Mode 3: Not used.
- Mode 4: Not used.
- Mode 5 (normal): Typical setting for dry-weather months.

The Vanport PS pump is not connected to the SCADA system; however, staff can use manual controls to adjust pump settings in anticipation of weather patterns and to address field conditions.

Table 6-3 lists the ON/OFF settings for the PIR PS pumps and the settings used in the model runs. The ON/OFF elevations, shown in feet, were provided by the District along with conversion factors to convert data to NAVD 88.

Table 6-3. PIR PS and Vanport PS Pump Settings

	Mode 1 (Winter) SCADA		Mode 2 (Pre-storm) SCADA		Model Settings	
Pump Number	OFF	ON	OFF	ON	OFF	ON
PIR PS Pump 1	6	7	5	6	6	7
PIR PS Pump 2	6.25	7.5	5.25	6.5	6.25	7.5
Vanport PS Pump 1	-	-	-	-	5	7

Note: All elevations in NAVD 88.

6.6 Model Validation

The 2022 model was updated because there is no documentation to confirm 2014 XP-SWMM model validation, and the model hydraulics were updated. Validation was performed by comparing SCADA-recorded water surface elevations to the model-simulated water surface elevations at the pump station. The validation process resulted in minor additional modifications to the model as discussed below.

Relevant SCADA data was available only at the PIR PS, so the model results and historical information were compared for model validation. The evaluation of water surface elevations included a review of the peak water surface levels, the timing of the maximum water surface level, the rate of water level increase/decrease, and overall agreement between the model and SCADA data.

6.6.1 Validation Storm Event

Several historical rain events from rain gages at Portland International Airport were reviewed to identify a time period with multiple rainfall spikes separated by no rain periods so that they could be used for model validation. The validation event also needed to occur during a time when reliable water surface elevation data was captured by the SCADA system. After reviewing several historical events, the event from November 21 to November 27, 2016, was selected. This period provided two relatively large rainfall events followed by two discrete dry periods without rain. The dry periods allowed for evaluation of how the pump station responds to drawing down higher water levels following peak storms. This same storm was used to validate models for the other three districts managed by MCDD: PEN2, MCDD, and SDIC.

The validation period rainfall events are shown in Exhibit 6-1. During the second event, the rainfall intensity peaked at 0.26 inches per hour and had a total depth of 3.56 inches. There was a significant dry period of nearly 40 hours prior to the rainfall which allowed for an understanding of the pumping during periods with no rainfall. The total rainfall was similar in volume to a 10-year event, although the storm included intermittent dry periods over several days. A more accurate comparison would be to classify the first peak as an average winter storm followed by a larger 2- or 5-year event.

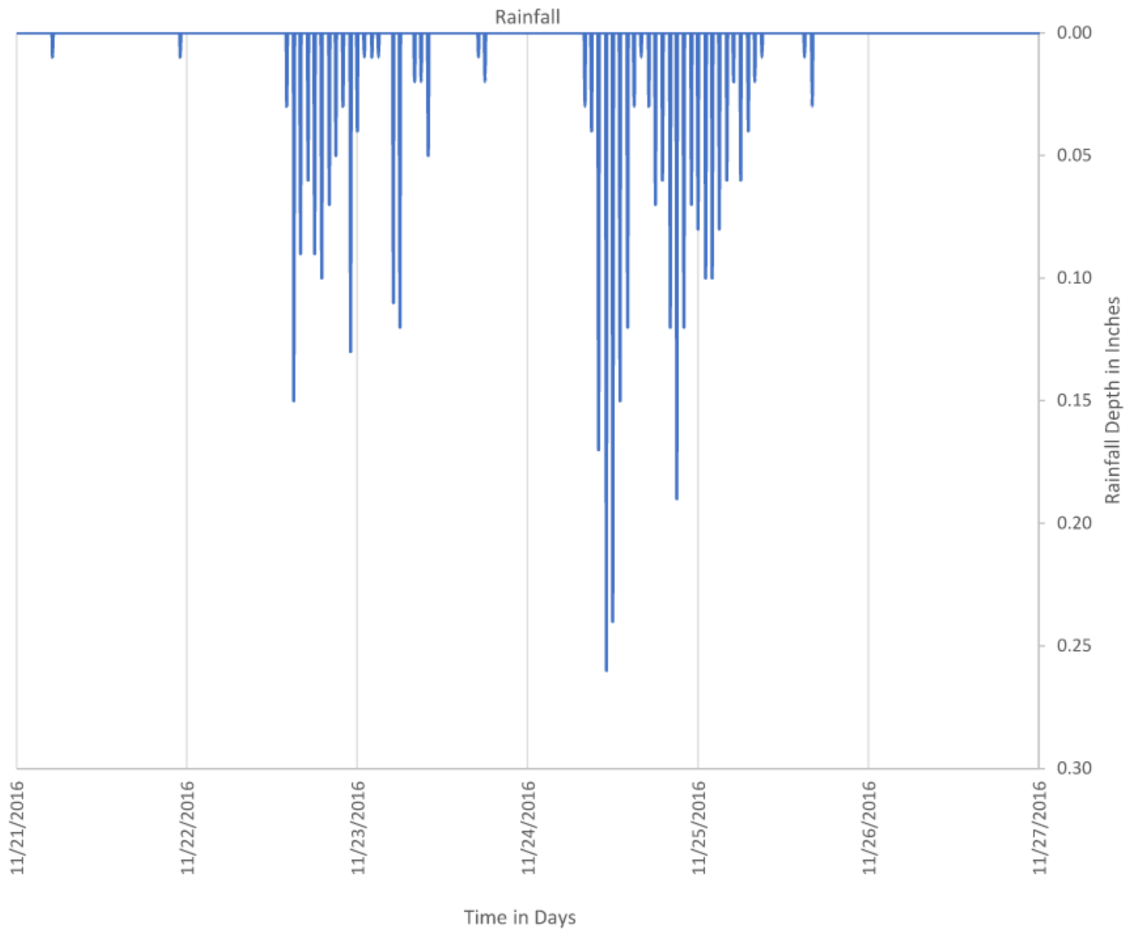


Exhibit 6-1. Validation Rainfall Event – November 21 to 27, 2016

6.6.2 Model Adjustments

The initial settings for the pump station (i.e., the ON/OFF settings) started with the Mode 1 (winter) settings as outlined in Table 6-3. Following initial model runs to compare water surface elevations recorded by the SCADA system with the model output, it was estimated that the Mode 1 settings were likely used during the November 2016 validation storm event. This was based on a review of the start and stop times of the pump station and the upward-sloping angle of the spikes in water surface elevation (referred to in the model as the *rising limb*) and frequency of cycling, as shown below in Exhibit 6-2. Based on the initial model run, a series of sensitivity runs was performed to better match the pump station cycling and the peak represented by the SCADA water surface elevation.

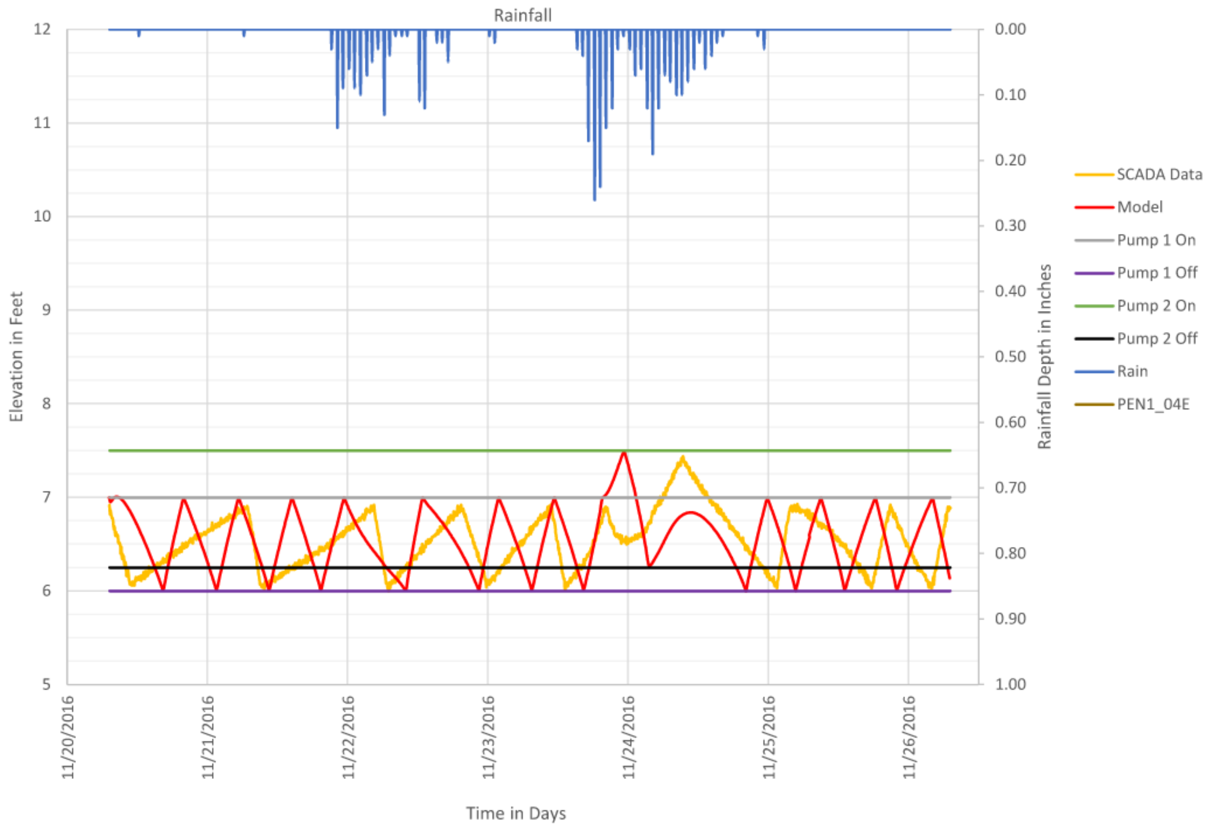


Exhibit 6-2. Initial Validation Model Run with Pump Settings in Mode 1 for the PIR PS (November 20–26, 2016)

Sensitivity model runs were performed to better match the rising and falling limb, the cycling frequency of the pumping, and the peak timing of the SCADA data. The parameters were modified to determine the sensitivity of the model to changes in order to make appropriate modifications and validate the model. Not all of the changes were made permanently. A summary of the hydrologic and hydraulic parameters modified are listed below:

- Adjusted subbasin widths to double the base model.
- Adjusted input by added constant flow to mimic ground water.
- Adjusted impervious area zero detention percent from 90 to 0.
- Adjusted pervious area depression storage from 0.2 to 0.3 inches.
- Adjusted pervious area Manning's n from 0.02 to 0.35.
- Reduced impervious percentage by 50 percent for all subcatchments.
- Adjusted initial water depth for all nodes from 1.0 foot to 0.5 feet.
- Adjusted initial water depth for only node D-15 (which represents the Vanport Wetland) to 5 feet. This change results in the wetland overtopping the control weir.

- Added an orifice from the Vanport Wetlands to the Vanport PS.
- Adjusted initial water depth of node D-15 to 5.1 feet.

Each of these adjustments was completed independently to review the results and how the model, and therefore the conveyance system, responded to each adjustment. Based on the adjustments listed above and the model's response, a combination of the above model updates resulted in the calibrated model shown in Exhibit 6-3.

Exhibit 6-3 shows the peak water surface elevations at the pump station increased from the original model, and it displays a shape similar to the SCADA data during the peak rainfall. The modeled water surface elevation follows the complex curve prior to the peak flow which indicates a well-calibrated model. The repeating rising limb and frequency of cycling, prior to and following the peak, does not closely match the SCADA.

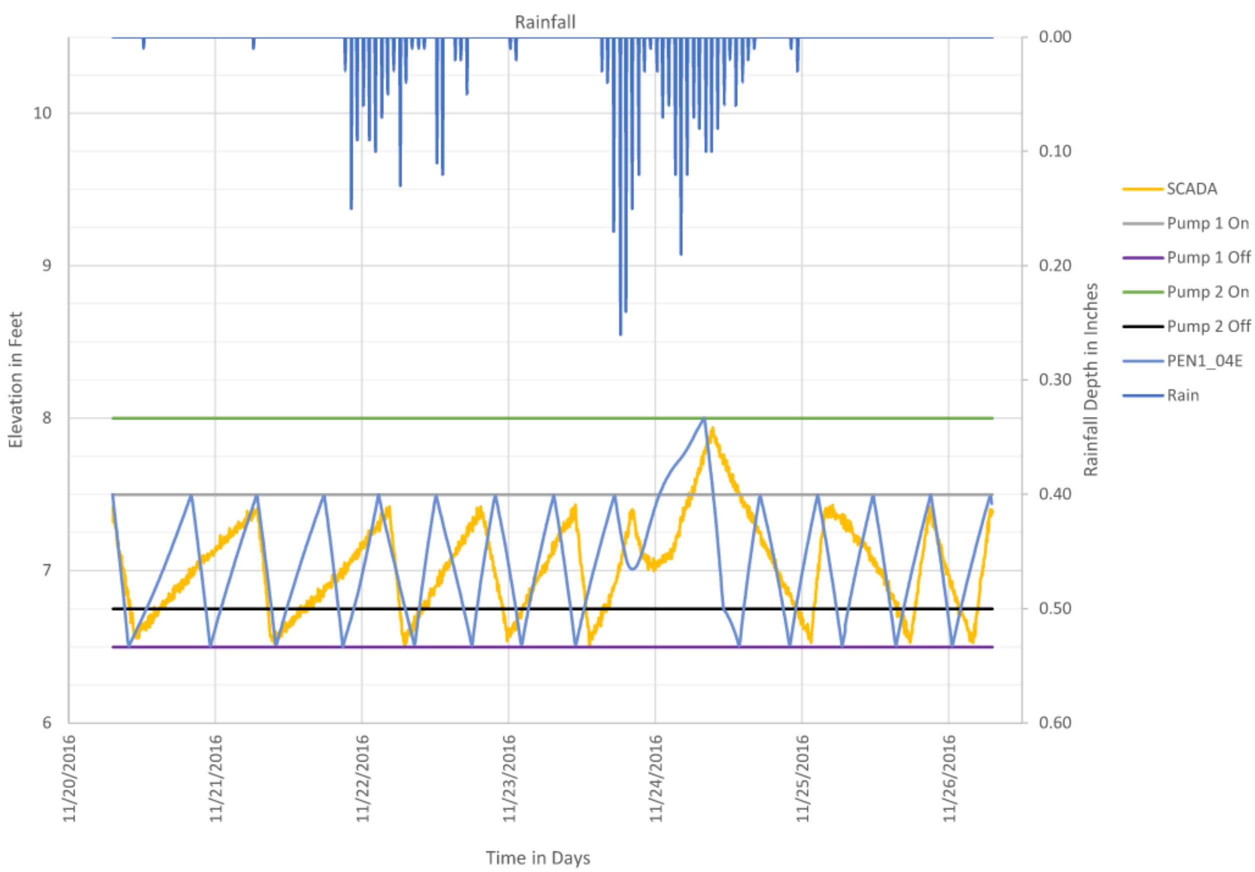


Exhibit 6-3. PIR Pump Station Validation Model Run – Winter Settings (November 20–26, 2016)

6.7 Validation Discussion

The model adjustments, described in Section 6.6.2, Model Adjustments, informed model modifications that resulted in a conveyance system configuration that more closely represents the characteristics and response of the PEN1 drainage infrastructure. Exhibit 6-3 shows the resulting validation comparison at PIR PS. The final, permanent changes made to calibrate the model are listed below:

- Added an orifice from the Vanport Wetlands to the Vanport PS.
- Adjusted initial water depth of node D-15 (Vanport Wetlands) to 5.1 feet.
- Adjusted initial water depth for all nodes from 1.0 foot to 0.5 feet.

Exhibit 6-3 shows the modeled system was cycling the pump on and off much more frequently than the SCADA data showed, and the timing of the peak water surface elevation was not aligned. The primary goal of the calibration process was to more closely match the model response to the peak rainfall and the timing of the pump station cycling. As outlined in Section 6.6.2, many different model changes were evaluated to increase the agreement between the SCADA data and model output. The timing and frequency of pump cycling was not improved, but the response to the peak rainfall was improved.

As shown in Exhibit 6-3, the XP-SWMM model provides a good approximation of the range of water levels that are seen at the pump station during large storm events. However, the model is not able to perfectly replicate more frequent pumping cycles that are likely the result of dynamic, not easily modeled conditions such as debris blockages throughout PEN1. These conditions and associated considerations are described below.

6.7.1 Model Validation and Results Considerations

Hydrologic and hydraulic modeling is a predictive tool used to approximate real-world conditions. There are elements of the conveyance system that can change based on physical conditions and current operational needs. When modeling this system, a fixed set of assumptions were included for all scenarios. In reality, the system may be more dynamic. Therefore, the model results may not perfectly predict the real-world conditions. Some of the conditions that may impact the PEN1 drainage basin have been evaluated at other locations within the four drainage districts and include the following:

- Beaver dams. Beaver dams can be frequent and numerous along open channels that are common throughout the project study area. Beaver dams contribute to fish and wildlife habitat by ponding water and creating habitat conditions for focal species. Beaver dams also create backwater effects and slow the movement of water through the conveyance system. This can result in pump stations receiving a slow trickle of water during an event or dry period and can cause the pumps to cycle on and off more frequently. This also delays pumping the volume of water out of the system before the next rain event follows.
- Debris jams. Debris jams impact the storm drainage system in a similar way as beaver dams but can result in focused ponding and backups in the conveyance system to a much greater extent. If there is significant debris available in the system or if debris builds up over an extended period of time, the blockage can become severe, which can cause localized flooding and pump station cycling.
- Pump station settings. The SCADA system is used to monitor water surface elevation and trigger the pump station's on/off settings. Pump settings have default on/off elevations during certain times of the year. However, there are instances where MCDD staff will manually change the

settings based on anticipated storm events or to address a specific, localized condition. Additionally, the Vanport Wetlands PS is not connected to the SCADA system, so its operation and potential changes to its pumping capacity or malfunction are not monitored.

- Temporary pumps. Additional pumping needs are addressed with temporary pump stations that are mobilized when needed. These can significantly change the system's response to a rainfall event.
- Groundwater. Groundwater influence on the conveyance system and pump station could vary significantly, seasonally. There could be strong input from the Columbia River and slough in the spring when water levels are high, while at other times there could be a strong exfiltration when water levels in the Columbia River and slough are low. The slough and Columbia River are tidally influenced, and as such, water surface elevations vary which may also introduce a daily variation in groundwater.

6.8 Conveyance System Capacity Evaluation

The typical mechanism for analysis of a conveyance system is to run multiple design events through the model to identify where the system has deficiencies. The typical method calculates the rate of water moved through the system and estimates the current capacity of the pipes, culverts, and channels. To assess capacity and flooding, the water surface elevations simulated in the model are compared to the elevation of structure rims or adjacent roadways. Most commonly, this approach assumes that conveyance capacity is driven by gravity and the slope of the conveyance infrastructure. However, flow in the PEN1 conveyance system is driven by pump stations and not gravity. Therefore, the rate at which water moves through the system is often a function of the pump station capacity and operations and not the culvert and channel slope, which is the case in a solely gravity-driven system.

6.8.1 Model Analysis

Because the pump stations drive the movement of water through PEN1 conveyance system, a primary single design event was selected to evaluate the capacity of the conveyance system. This evaluation was based on the 10-year event with the existing land use. Locations that are under-capacity for the 10-year event are assumed to be under-capacity for larger storms. Flooding was defined as the modeled water surface elevation exceeding critical water surface elevations as described in Section 5.2.1.2, Capacity. All locations modeled (except for the Expo Center ditch) are shown to have capacity for the 10-year event, although some are shown to be under-capacity for larger storm events. For model-predicted water surface elevations at each critical water surface location during multiple design storm events, refer to Appendix F.

A flooding problem identified by the model does not necessarily reflect a pipe that is undersized. Instead, the cause of the flooding could be a result of limited downstream pumping capacity and associated backwater, excessive upstream pumping capacity, a low point in the system, or a downstream structure causing backwater effects.

The 2-, 25-, 100-, and 500-year design storm events were also included in the model analysis, and water surface elevations were provided at each storm event.

6.9 Pump Station Capacity Evaluation

The pump station capacity evaluation included use of the updated 2022 XP-SWMM model to perform a critical water surface elevation comparison. This exercise included simulating a series of rainfall events to compare the resulting water levels to critical elevations across the PEN1 basin. This evaluation informed the current pump station capacity.

6.9.1 Model Evaluation

The critical elevations were the primary mechanism to assess pump station capacities as outlined in Section 5.2, Drainage Infrastructure Metrics. For this analysis, each of the design storms was routed through the XP-SWMM model, and the peak water surface elevations upstream of each pump station were compared to the critical elevations. If the water surface elevation exceeded the critical elevation during a 10-year event but remained below the critical elevation during a 2-year event, the pump station was considered to have a 2-year storm capacity. The analysis included running the hydraulic model and conducting the capacity evaluation for the 2-, 10-, 25-, and 100-year design storms for the existing land use scenarios.

6.10 Water Quality Evaluation

The 10 subbasins were evaluated for existing water quality conditions based on land cover and bank shade presence. Land cover categories included trees, wetland, pollution-generating pervious surfaces such as golf course, non-pollution generating impervious surfaces such as sidewalk, and pollution-generating impervious surfaces such as roadway and racetrack at PIR. Each subbasin was scored based on the amount of each land cover type and its associated points. The land cover in the PEN1 basin is illustrated in Figure 8. Each subbasin was also scored for bank shade presence and was ranked based on lack of canopy coverage along the waterways within the basin. The canopy gaps are illustrated in Figure 9.

The results of this evaluation and existing water quality score for each subbasin are included in Table 6-4 below. A rank of 1 indicates the most opportunity for improvement. A rank of 8 indicates the subbasin is in good existing condition based on its land cover type and bank shade presence. The areas that drain directly to the Columbia River, Subbasin 1 – North Industrial and Subbasin 2 – NE Industrial, were not analyzed for bank shade gaps or given an overall existing water quality conditions rank. These areas do not have open channels and are not actively managed by MCDD; therefore, they were not analyzed for existing canopy gaps. Additionally, stormwater discharge from the private businesses in these subbasins is regulated and must comply with DEQ’s Industrial Stormwater Discharge Permit or the City of Portland BES Maintenance and Inspection Program. As there is minimal opportunity for water quality improvements in these subbasins, they were excluded from the water quality analysis.

Table 6-4. Water Quality Existing Condition Score

Subbasin Number	Subbasin Name	Size (acres)	Land Cover Score	Bank Shade Gap (acres)	Overall Existing WQ Conditions Rank[a]
1	North Industrial – N/A	81.2	23		
2	NE Industrial – N/A	23.0	23		
3	Vanport Wetlands	162.4	63	2.8	8
4	Force Lake Area	69.0	53	4.7	7
5	North Golf Course	120.4	57	6.5	6
6	West Golf Course	98.6	30	15.0	2
7	Central Golf Course	127.5	28	16.7	1
8	External Raceway	120.3	53	16.9	3
9	Internal Raceway	83.2	36	6.4	4
10	Southern Slough	91.5	59	8.7	5
PEN 1 Average Composite Score			45	9.8	

N/A = not applicable;
= More opportunity for improvement based on existing conditions;
= Some opportunity for improvement based on existing conditions;
= Less opportunity for improvement based on existing conditions

[a] lower rank indicates more opportunity/need for improvement and a higher rank represents less opportunity/need for improvement.

6.11 Habitat Evaluation

The project team ranked existing habitat conditions in each of the 10 subbasins according to the metrics detailed in Section 5.4.1, Metrics. The subbasins were quantitatively scored for existing conditions based on observations made during the August 2021 site visit. The total number of focal species that may benefit from potential projects was also considered as detailed in Section 5.4.1.1, Potential for Projects to Benefit Focal Species. The presence of wetlands, and information from the project webmap (including the City of Portland Natural Resource Inventory Special Habitat Areas, Oregon Department of Fish and Wildlife [ODFW] Conservation Opportunity Areas, ODFW Strategy Habitats, ODFW Crucial Habitat Assessment, StreamNet Fish Distribution, Oregon Fish Passage Barriers, and High Value Habitat) were evaluated to determine if past analysis has identified areas in each subbasin as important for existing habitat or having high potential for future habitat improvement. The total number of the above GIS layers found within each subbasin were considered as detailed in Section 5.4.1.2, Priority Habitat Areas. A summary of this evaluation is shown in Table 6-5 below and is further detailed in Appendix E.

Weighting criteria for ranking included known priorities within the PEN1 drainage basin, best professional judgment of the project biologists, and known project constraints within the basin. The secondary, qualitative analysis for habitat is described in Section 5.4.1.3, Qualitative Evaluation Criteria.

Table 6-5. Ranking of Existing Habitat Conditions within the PEN1 Basin

Basin Number	Basin Name	Existing Conditions	Existing Condition Score	Number of Focal Species [a]	Number of Habitat Layers [a]
1	North Industrial	Paved impervious surfaces, industrial development	1	1	4
2	NE Industrial	Paved impervious surfaces, industrial development	1	1	4
3	Vanport Wetlands	Wildlife area, mostly closed to public use	5	4	6
4	Force Lake Area	Mixed use, wildlife habitat and recreation	3	9	6
5	North Golf Course	Active golf course, wildlife habitat present	3	8	6
6	West Golf Course	Active golf course, wildlife habitat present	3	3	4
7	Central Golf Course	Active golf course, wildlife habitat present	3	4	5
8	External Raceway	High speed raceway, riparian plantings present	1	6	5
9	Internal Raceway	High speed raceway, lacks wildlife habitat	1	3	5
10	Southern Slough	Habitat present, in poor condition	3	8 [b]	5

Existing Condition Score (1 = poor, 3 = fair, 5 = good)

[a] See Appendix E for list of focal species included and habitat layers

b Chinook salmon is included in this subbasin

7. ALTERNATIVES ANALYSIS

7.1 Drainage Alternatives and Risk Assessment

The capacity analysis for this DWQMP included identification of capacity-related problem areas of the drainage system. The analysis evaluated both conveyance and pump station capacity, with a particular focus on the critical conveyance network and pump stations.

7.1.1 Conveyance Capacity Results

With current pump station conditions and settings, the conveyance system analysis showed conveyance-related capacity concerns in the following locations:

- The Expo Center ditch adjacent to the Vanport Wetlands exceeds its bank elevation during the 10-year event by 0.03 feet (and during the 100-year by 1.13 feet). It is suspected this is due the Vanport PS capacity. This was confirmed with supplemental hydraulic modeling which indicated that the exceedance could be eliminated during the 100-year storm by adding a pump, upsizing an upstream culvert, and regrading sections of upstream channel.
- The northwest Heron Lakes Golf Course culvert exceeded critical water surface elevation for the 100-year event by 0.17 feet.

7.1.2 Pump Station Capacity Results

Table 7-1 identifies the capacity of each pump station in the PEN1 basin, based on whether the pump station is able to maintain water surface levels below the critical elevations for the rainfall events modeled.

Table 7-1. Pump Station Capacity

Facility	Event Capacity with Existing Development
PIR PS	25-year [a]
Vanport PS	2-year

[a] This is based on criteria detailed within Section 6.9.1, Model Evaluation, if the restriction noted at node A-12 is addressed/removed under Drainage Project 3 (DR#3) the station has 100-year capacity.

The pump station capacities listed in Table 7-1 are based on a best-case scenario. The modeling analysis assumed an idealized condition where all conveyance systems are flowing free without debris blockages at culverts or pump station intakes. Blockages in the conveyance system or at the pump stations will reduce the capacity below what is simulated through this model evaluation.

The PIR PS has adequate capacity for the 25-year event. One location does not meet the critical elevation as the water level during the 100-year event exceeds the critical water surface elevations; this location has been identified for improvements detailed under proposed project DR #3.

The Vanport Wetland PS is under capacity as it only has capacity for the 2-year event. Supplemental hydraulic modeling indicated that the exceedance could be eliminated during the 100-year storm by adding a pump of similar capacity to the existing. This is detailed under proposed project DR #2.

The modeling results are included as Appendix F.

7.1.3 Debris and Blockage Considerations

Debris accumulation and other blockages can restrict the flow of water through the system and reduce the capacity reported through this analysis. Two methods for reducing blockages include improving infrastructure (larger culverts or bridges) and ongoing operation and maintenance (physically removing blockages). In some cases, the operation and maintenance of the system is the most cost-effective method for minimizing blockages, while in other cases where blockages are chronic, new or improved infrastructure may be a better long-term solution.

Examples of debris accumulation or system blockages include the following:

- Culvert debris blockages can occur with and without proper inlet protection.
- Beaver dams can and are often built in locations that reduce flows particularly during lower flow conditions.
- Open channel debris blockages can result from larger debris starting a chain reaction of debris gathering.
- Debris build-up on structures of all kinds.
- Debris build-up on the intake structures of the pump stations.

The impacts resulting from blockages are mostly negative to varying degrees. The beaver dam blockages can have a significant impact on pump station cycling, which causes additional wear and increased deterioration of the pumping components. Regular clearing of the drainage system may be needed to maintain clear conveyance systems, and during larger events, staff may be required to work through the night to maintain blockage-free conveyance systems. Working to clear debris during the night has inherent risks, is a safety concern, is hard on the body, reduces productivity during the day, and is generally not an ideal standard for maintaining a clear conveyance system.

PEN1 should consider opportunities to improve debris removal systems, both at the pump stations and culverts throughout PEN1. PEN1 may consider installing passive debris barriers at culverts in the critical conveyance network and at other key problem areas that would allow debris to collect without impeding the flow of water and allow the safe removal of debris from the drainage system according to staff availability (see Photograph 7-1).

Photograph 7-1. Example of passive debris barrier at large culvert

7.2 Habitat and Water Quality Analysis

The results of the habitat and water quality alternatives analyses are described below. Both the habitat and water quality alternatives analyses were completed by comparing the overall existing conditions rank for the subbasin and applying a secondary, qualitative analysis.

7.2.1 Water Quality Analysis

The secondary, qualitative analysis for water quality consisted of the presence of known or potential subbasin concerns, available space for improvement, and opportunity to implement multi-benefit projects to improve water quality, habitat, and drainage within the basin. The results of the water quality alternatives analysis are included in Table 7-2 below.

Table 7-2. Water Quality Weighting Criteria

Basin Number	Basin Name		Overall Existing WQ Conditions Rank	Known or Potential Concern	Space Available for Improvements	Combine with Habitat
7	Central Golf Course	(red)	1	x	x	x
6	West Golf Course	(red)	2	x	x	x
8	External Raceway	(yellow)	3	x	x	x
9	Internal Raceway	(red)	4	x		
10	Southern Slough	(blue)	5	x	x	x
5	North Golf Course	(yellow)	6		x	x
4	Force Lake Area	(yellow)	7	x	x	x
3	Vanport Wetlands	(blue)	8		x	
1	North Industrial		N/A			
2	NE Industrial		N/A			

(red) = Low existing condition score, more potential opportunity for improvement; (yellow) = Mid existing condition score, some potential opportunity for improvement; (blue) = High existing condition score, less potential opportunity for improvement

N/A = not applicable, there is minimal opportunity for water quality improvements in these subbasins and as such they were excluded from the water quality analysis. see Section 6.10, Water Quality Evaluation, for additional information.

The higher ranked subbasins—(1) Central Golf Course, (2) West Golf Course, (3) External Raceway, and (4) Internal Raceway—are ranked higher because of high quantities of pollution-generating surfaces (roadway, racetrack, golf course) and canopy gaps that could be addressed within the subbasins. The lower ranked subbasins have lower amounts of pollution-generating surfaces with higher amounts of trees and wetlands, as well as less canopy gaps along waterways. However, all of the subbasins were still considered for improvements if there were known concerns and available space for improvements.

7.2.2 Habitat Analysis

The secondary, qualitative analysis for habitat included evaluating existing conditions, the benefit of project uplift to focal species, project priorities of the team, potential site limitations for projects, and the ability to combine projects for additional uplift, as well as providing the best professional judgement of the project team. Habitat uplift projects were considered for the Southern Slough, External Raceway, Golf Course areas, and Force Lake areas. These areas already provide some important habitat features for the focal species. Habitat enhancements will improve habitat for focal species. Habitat improvement projects are not recommended for the Internal Raceway and industrial areas (Subbasins 1 and 2) because these areas are not providing habitat and the current use of these areas is not compatible with wildlife habitat uplift projects. The results of the habitat alternatives analysis are included in Table 7-3 below and in Appendix E.

Table 7-3. Scoring for Habitat Project Selection

Basin Number	Basin Name	Existing Condition Score	Number of Focal Species [a]	Number of Habitat Layers [a]	Space Available for Improvements	Combine with Water Quality	Habitat Projects Considered
1	North Industrial	1	1	4	No		No
2	NE Industrial	1	1	4	No		No
3	Vanport Wetlands	5	4	6	Some [c]	Yes	Yes
4	Force Lake Area	3	9	6	Yes	Yes	Yes
5	North Golf Course	3	8	6	Yes	Yes	Yes
6	West Golf Course	3	3	4	Some	Yes	Yes
7	Central Golf Course	3	4	5	Some	Yes	Yes
8	External Raceway	1	6	5	Some	Yes	Yes
9	Internal Raceway	1	3	5	No		No
10	Southern Slough	3	8[b]	5	Yes	Yes	Yes

a See Appendix E for list of focal species included and habitat layers.

b Chinook salmon is included in this subbasin.

C Some available space for improvements due to higher existing conditions score.

The overall scores of each subbasin's water quality conditions and habitat conditions were then compared to identify habitat and water quality improvement opportunities within the PEN1 basin.

Many alternatives were identified and discussed during the analyses for habitat and water quality improvements in the PEN1 basin. Improvements to vegetation, especially along waterways, were identified as a high priority throughout Subbasins 4 through 10. A site-specific planting palette, correlated to focal species, was developed for projects where planting appears feasible. A list of proposed plants and the associated focal species thought to benefit by them is included in Table 7-4. A planting palette organized by plant type or structure is included in Table 7-5 below.

Table 7-4. PEN1 Focal Species and Proposed Planting Palette

Benefitted Focal Species	Plants
Bald Eagle	**Ponderosa pine**, **western hemlock**, **Pacific yew**
Little brown bat	**Cascara**, **Scouler's willow**, **serviceberry**
American beaver	**quaking aspen**, black cottonwood
Chinook salmon	slough sedge, **common cattail**
Cinnamon teal	soft rush, **Pacific rush**, **dagger-leaf rush**, **tufted hairgrass**, **deer fern**, water parsley, **Pacific waterleaf**, common spikerush
Purple martin	**western red cedar**, **Pacific madrone**
Western painted turtle	common duckweed, northern water plantain
White-breasted nuthatch	**Oregon white oak**, **Oregon ash**, **grand fir**, **big leaf maple**
Willow flycatcher	**native willow shrub species**, **vine maple**, **red twig dogwood**, **black twinberry**, **Pacific ninebark**, **red elderberry**, **Douglas spirea**, **salal**
Yellow-breasted chat	**red-flowering currant**, **snow brush**, **serviceberry**, **coyote brush**, snowberry, Oregon grape, Pacific madrone, native roses
Western bumblebee	California poppy, lance selfheal, **large-leaved lupine**, **Cascade penstemon**, showy milkweed, nettle-leaf horsemint, **Canada goldenrod**, **yellow monkey flower**, grass widow, **globe gilia**

Note: Plants in **bold** text are also included in the Portland Plant List.

Table 7-5. PEN1 Basin Planting Palette

Planting Type	Plantings
Large trees > 15 feet tall fully grown	Ponderosa pine, Pacific willow, Scouler's willow, black cottonwood, quaking aspen, western red cedar, Oregon white oak, grand fir, big leaf maple
Small trees < 15 feet tall fully grown	native willow shrub species, cascara, serviceberry, hawthorn, choke cherry, red twig dogwood, black twinberry, vine maple, Pacific ninebark, red elderberry, red flowering currant, Pacific willow
Understory shrubs < 5 feet tall fully grown	snowbrush, Douglas spirea, salal, kinnikinnick (only in highly landscaped areas), snowberry, coyote brush, Oregon grape
Flowers	California poppy, large-leaved lupine, yellow monkey flower, Cascade penstemon, grasswidow, globe gilia
Pond habitat	slough sedge, common cattail, Pacific rush, dagger-leaf rush, tufted hair grass, deer fern, Pacific water leaf, common duck weed, northern water plantain, soft rush, water parsley, common spike rush

Basinwide vegetation enhancement projects (see projects HWQ #1 through #3 in Section 8.2, Habitat and Water Quality Projects) were identified to enhance habitat for the project focal species and increase shade along the waterways. The basinwide projects were included as recommendations to allow the project implementation team to determine where to focus efforts as future improvement projects are considered. This will also allow project implementation teams to identify where it is feasible to incorporate basinwide project elements into other projects proposed in this plan.

Subbasin-specific habitat and water quality improvement projects (see projects HWQ #4 and #5 in Section 8.2, Habitat and Water Quality Projects) were also identified during the analysis. Two projects were identified in Subbasin 10: habitat improvements along the Lower Slough and habitat and water quality improvements within the PIR PS forebay.

The project analysis identified multi-benefit projects. For example, every drainage-related project will include elements to enhance habitat and water quality including vegetation enhancements within each project footprint. This includes drainage projects in Subbasins 3 – Vanport Wetlands, 4 – Force Lake Area, 5 – North Golf Course, and 10 – Southern Slough.

8. PROJECT SELECTION

PEN 1 DWQMP projects include programmatic solutions and capital projects. The drainage capital projects are listed in Section 8.1 below; numbers indicate priority based on risk of failure and stakeholder input. The habitat and water quality capital projects are listed in Section 8.2, Habitat and Water Quality Projects; numbers indicate priority based on overall need and stakeholder input. Project fact sheets and detailed cost opinions were developed for each project and are included in Appendices G and H, respectively. A location map of the proposed projects is included as Figure 10. Some of the proposed projects included below may be impacted by the upcoming USACE Portland Metro Levee System projects; the proposed projects will need to be coordinated with USACE and may need to be modified as design proceeds.

Inflation costs for the projects were derived from construction cost index (CCI) numbers for the Seattle area from *Engineering News-Record*. The CCI increased by 7 percent in 2020 to 2021. Other annual increases from 2010 to 2020 range from 2 to 7 percent. The known CCI numbers from 1978 to 2021 were used to calculate annual inflation cost increases and develop a linear trendline to determine anticipated inflation increases for 2025, 2030, 2035, and 2040. CCI information is included in Appendix H.

8.1 Drainage Projects

Drainage projects were prioritized based on both the likelihood of a drainage element failure based on condition or capacity and the impact on the functionality of the upstream collection system. The impact was determined by the location within the critical conveyance network and, in the cases of DR#3, DR#4, and DR#5, the availability of an emergency overland drainage path. As another example, DR#1 – PIR PS Replacement is the highest priority as it conveys drainage for the entire PEN1 basin and there is no overland flow path in the event of a failure. Table 8-1 summarizes the condition, capacity, and consequence of the elements considered when prioritizing each drainage project.

Table 8-1. Drainage Project Prioritization Summary

DR Project Number	Description	Likelihood		Impact	Notes
		Condition	Capacity		
1	PIR PS Replacement	Poor	Adequate	High	Sole drainage discharge from PEN1 basin; reaching the end of useful life; no alternate gravity flow path
2	Vanport PS Replacement	Poor	Inadequate	Moderate-High	Reaching the end of useful life; upstream conveyance included in project is under-capacity; no alternate gravity flow path; drains small upstream subbasin
3	Golf Course Culvert Channel Daylighting	Poor	Inadequate	Low	Noted poor condition; under-capacity; alternate overland flow path
4	Force Ave Channel Daylighting	Moderate [a]	Adequate	Moderate	Unknown condition but includes aging pipe; alternate overland flow path would cause significant upstream flooding
5	Mud Lake Discharge Culvert Replacement	Poor	Adequate	Low	Poor condition; alternate overland flow path

[a] Minimal condition information available. Conduit filled with sediment but otherwise has no known condition deficiencies.

8.1.1 DR #1: PIR PS Replacement

The PIR PS mechanical equipment and discharge piping is aging. The station lacks the ability to monitor flow, has no backup power, and has limited access for operation and maintenance vehicles. There are also previously identified structural deficiencies, which result in limited anticipated future service life. The goal of this project is to replace the station and discharge piping. The new station will increase resiliency via added pump redundancy, include a backup power generator, and provide better maintenance access. Based on previous conditions assessments and the evaluation provided in the current work, the following are recommended:

- **Short-Term Action** – Section 3.2.1, PIR Pump Station, noted significant degradation of the northern-most discharge pipe invert near the station. Additional investigations, such as CCTV inspection of the pipe and additional thickness measurements, are recommended to determine the extent of degradation and if short-term repairs or additional monitoring is needed.
- Replace the PIR PS.
    - Three pumps should be provided for redundancy. Two pumps should be capable of providing the pump station design capacity.
    - Pumps should be provided with variable frequency drives.
    - New station to include an automatic trash rack.
- Locate the new station as close to the center of the forebay approach as possible.
    - This may require partial re-alignment of the discharge pipes; see additional recommendations for pipes below.
- Conduct hydraulic modeling and improve station inlet conditions
    - Based on hydraulic modeling conducted at a similar MCDD flood management pump station (separate project), the configuration of the upstream forebay approach into the pump station can negatively impact pump performance and increase the potential for swirl, eddies, and vortices. As such, replacement of the PIR PS should include hydraulic modeling of the upstream channel, design elements to improve station inlet conditions, and recommendations for forebay channel improvements. The forebay improvements may be made as part of a separate habitat improvement project (HWQ #4) and should therefore be evaluated as part of PIR replacement such that a future improvement project is compatible with the new station.
- Replace the two existing discharge pipelines and add a third pipeline.
    - The pump station discharge in the Columbia Slough will require a new outfall with energy dissipator to mitigate disturbance to the slough sediments.
- Improve drainage.
    - Use new HDPE discharge piping.
- Improve habitat.
    - Plant from the planting palette in Table 7-4.
    - Grade the shoreline; see the planting palette in Table 7-5 for plant choices.

- Consider joint implementation of PIR PS Replacement project with PIR PS Forebay Improvement project (HWQ #4).

The overall cost for the PIR PS Replacement project ranges from $8,820,000 to $18,900,000 with a permanent generator and from $8,330,000 to $17,840,000 with a portable generator hookup. A detailed cost opinion is included in Appendix H.

8.1.2 DR #2: Vanport PS Replacement

The Vanport PS is aging; previous evaluations have identified the station to be in poor/inadequate condition. The station has only one pump and lacks redundancy if the pump should fail, and the station has no backup power. The goal of this project is to replace the station with a new one that has two pumps and a backup power generator to increase resiliency. The new station and added resiliency will ensure flooding concerns at the eastern end of N. Expo Road are alleviated. Based on previous conditions assessments and the evaluation provided in the current work, the following are recommended:

- Replace the Vanport Wetland PS.
    - Install two canned, axial flow submersible pumps. Pumps should be sized such that all flow can be conveyed with a single pump.
    - Pumps should be provided with variable frequency drives.
    - Include an automatic trash rack in the new station.
- Locate the new pump station approximately 125 feet to the north of the existing pump station. This move will provide better maintenance access from the service road.
    - Restore the channel/habitat at the original pump station location.
- Improve drainage.
    - Install new HDPE discharge piping through an existing downstream culvert.
- Improve habitat.
    - Plant from the planting palette in Table 7-4.
    - Grade the shoreline; see the planting palette in Table 7-5 for plant choices.

The overall cost for the Vanport PS Replacement project ranges from $2,230,000 to $4,770,000 with a permanent generator and from $2,040,000 to $4,360,000 with a portable generator hookup. A detailed cost opinion is included in Appendix H.

8.1.3 DR #3: Golf Course Culvert Channel Daylighting

The culvert in the northwest corner of Heron Lakes Golf Course is undersized, in poor condition, and exceeded the critical water surface elevation by 0.17 feet during the 100-year storm event. Flooding at this location impacts the ability of PEN1 staff to maintain the culvert inlet to keep it free from debris, and it impacts golf course play. The goals of this project are to reduce flood risk at the northwest portion of Heron Lakes Golf Course, provide habitat for project focal species, and increase connectivity for aquatic species. Based on the evaluation provided in the current work, the following are recommended:

- Replace the existing culvert.

   - Use a 10-foot-wide metal box culvert. The crossing structure will provide access for larger maintenance equipment.
- Review the irrigation mainline crossing at the proposed culvert channel and ensure irrigation routing will remain intact. Address utility relocation as needed.
- Improve habitat.
   - Plant to enhance shoreline emergent vegetation; see the planting palette in Table 7-4 for plant choices. Selected plantings shall be low lying as to not obscure line of sight for daily golfers.
   - Grade the shoreline to enhance shoreline emergent vegetation; see planting palette in Table 7-5 for plant choices.

The overall cost for the Golf Course Culvert Channel Daylighting project ranges from $230,000 to $490,000. A detailed cost opinion is included in Appendix H.

8.1.4 DR #4: Force Ave Channel Daylighting

The culvert along Force Avenue in the west buffer of the Vanport Wetlands mitigation site has sediment buildup that limits flow capacity, and it lacks enhanced habitat. The goals of this project are to reduce flood risk along N Force Avenue, provide habitat for project focal species, and increase connectivity for aquatic species. Based on the evaluation provided in the current work, the following are recommended:

- Remove the existing sediment-filled 36-inch-diameter culvert.
- Grade the channel to match the cross section of the adjacent stream reaches.
- Improve habitat.
   - Note that this area contains an established planted buffer to the Vanport Wetlands mitigation site.
   - Plant to enhance the riparian forest; see the planting palette in Table 7-5 for plant choices.
   - Grade the shoreline to enhance the riparian forest; see the planting palette in Table 7-5 for plant choices.
- Replace trees impacted during construction.
- Provide long-term maintenance access along the new channel reach and at the Vanport Wetlands embankments.
- Consider trenchless cured-in-place pipe if it is determined that the impact of channel daylighting and its associated construction footprint is too large.

The overall cost for the Force Avenue Channel Daylighting project ranges from $950,000 to $2,020,000. A detailed cost opinion is included in Appendix H.

8.1.5 DR #5: Mud Lake Discharge Culvert Replacement

Three culverts that discharge from Mud Lake are sediment-laden and collapsed. The goals of this project are to replace aging structures, mitigate flooding issues, enhance habitat for native species, and increase connectivity for aquatic species. Based on the evaluation provided in the current work, the following are recommended:

- Replace the existing middle culvert with a box culvert.
  - Install a 10-foot-wide metal box culvert to provide golf cart access.
  - Install a crossing to provide golf cart access and maintenance equipment access.
- Remove the upstream northern-most and downstream southern-most culverts.
  - Excavate and regrade the channel to match the cross section of the adjacent reaches.
- Install a weir structure to control the level of the lake.
- Review the irrigation mainline crossing at the proposed culvert channel and ensure irrigation routing will remain intact. Address utility relocation as needed.
- Improve habitat.
  - Plant to enhance low shrub riparian habitat; see the planting palette in Table 7-5 for plant choices. Selected plantings shall be low lying as to not obscure line of sight for daily golfers.
  - Grade the channel for emergent shoreline vegetation; see planting palette in Table 7-5 for plant choices

The overall cost for the Mud Lake Discharge Culvert Replacement project ranges from $450,000 to $950,000. A detailed cost opinion is included in Appendix H.

8.1.6 Programmatic Drainage Recommendations

In addition to the capital projects, nine programmatic drainage recommendations were identified during the development of this plan. These are the operational actions recommended for implementation by the District to track the condition of the conveyance system, perform preventative maintenance on pump stations, prepare for emergencies, and plan for future replacements before systems reach failure conditions.

Many of the recommendations are for ongoing programs that the District should implement immediately. This includes closed-circuit television inspections, pump station testing and monitoring, and pump station maintenance. Other programs, such as the debris barrier program and portable generator acquisition program, may take more time to implement. Two of the recommendations are for one-time studies that may identify additional capital needs or will inform District decisions in the future.

Table 8-2 summarizes the programs and studies that are recommended for the District. Detailed program descriptions are included in Appendix I. The program cost estimates include both the total cost of the program, as well as the annual cost for a long-term program. For programs that can be shared between drainage districts, the assumption is that PEN1 would incur 20 percent of the program costs.

Table 8-2. Recommended Programs and Studies for the District

Program/Study	Timeline

Ongoing Programs	
CCTV Inspection and Condition Assessment Program	5 years
Pump Station Testing and Monitoring	Annually
Districtwide Debris Barrier Program	10 years
Ongoing Periodic Pump Rebuilds	10 years
Sediment Management Plan [a]	Annually
Beaver Management Program [b]	Annually
One-Time Studies	
Flow Control Requirements Evaluation	One-time study
Mapping, Access, and Easement Needs Study	One-time study
Pump Station Structural Evaluation and Resiliency Study	One-time study – shared throughout the basin

[a] WEST 2016
[b] BES 2020

8.2 Habitat and Water Quality Projects

Habitat and water quality projects were prioritized based on presence of known or potential subbasin concerns, existing conditions, the benefit of project uplift to focal species, project priorities of the team, potential site limitations for projects, and the ability to combine projects for additional uplift.

8.2.1 HWQ #1: Plantings

Healthy riparian buffers in the PEN1 basin are currently lacking in some areas such as where there are gaps in streambank shade—a critical component for habitat and water quality. The goal of this project is to implement plantings throughout PEN1 to increase shading along waterways and improve habitat for the project focal species. Plantings are proposed to improve several habitat types: riparian, shrub-riparian, shoreline emergent, and pollinator plots. This is a basinwide project and may be implemented as multiple projects as determined by the project implementation team, property owner, and associated stakeholders. Plantings are considered in the following subbasins: 4 – Force Lake, 5 – North Golf Course, 6 – West Golf Course, 7 – Central Golf Course, 8 – External Raceway, 9 – Internal Raceway, and 10 – Southern Slough. Plantings are considered for the entire PEN1 basin (excluding Subbasins 1 through 3) and are shown in the associated figure with the fact sheets for the HWQ #1 and HWQ #2 projects in Appendix G. Specific planting locations will be determined on a project-by-project basis. Some areas identified may already be planted as part of other projects such as Portland Parks and Recreation projects with the Columbia Slough Watershed Council. Based on the evaluation provided in this plan, the following are recommended:

- Plant large trees, small trees, understory shrubs, and flowers throughout the PEN1 basin; plant where feasible throughout Heron Lakes Golf Course and PIR.
- Prepare a detailed planting plan including topography, site features, and proposed location and size of plantings for each planting location. Final detailed planting plans shall be reviewed and approved by the City, property owner, and associated stakeholders.

The overall cost for the Plantings project ranges from $650,000 to $1,390,000. A project fact sheet is included in Appendix G, and a detailed cost opinion, with the anticipated cost per acre, is included in

Appendix H. Planting plans and implementation that can be completed and managed by the BES Revegetation Team could reduce the cost per acre by approximately 50 percent.

8.2.2 HWQ #2: Shoreline Grading

Fresh emergent wetlands are among the most productive wildlife habitats in Oregon. They provide food, cover, and water for many species of birds, mammals, reptiles, and amphibians. Many species rely on emergent wetlands for their entire life cycle. Existing emergent herbaceous habitat in the PEN1 basin is scarce. The goals of this project are to implement shoreline grading and planting throughout the basin to promote more complex, emergent vegetation and improve habitat for project focal species such as cinnamon teal and western painted turtle. This project could be implemented in collaboration with HWQ #1 – Plantings and HWQ #3 – PEN1 Habitat Improvements. This is a basinwide project and may be implemented as multiple projects as determined by the project implementation team. Based on feedback from Portland Parks and Recreation, shoreline grading may be feasible in the following subbasins: 4 – Force Lake, 5 – North Golf Course, and 7 – Central Golf Course. Based on the evaluation provided in the current work, the following are recommended:

- Grade waterway shorelines, where feasible, throughout the Heron Lakes Golf Course to create emergent herbaceous habitat. The waterway shoreline grading plan must be approved by the property owner: Portland Parks and Recreation.
- Create emergent habitat during shoreline grading through stepped, partially submerged areas.
- Implement herbaceous wetland plantings to increase habitat complexity.
- Prepare a detailed planting plan including topography, site features, and proposed location and size of plantings for each planting location. The planting plan must be approved by the property owner and associated stakeholders.

The overall cost for the Shoreline Grading project ranges from $1,530,000 to $3,270,000 per acre. A project fact sheet is included in Appendix G, and a detailed cost opinion, with the anticipated cost per acre, is included in Appendix H. Shoreline grading projects that can be completed and managed by the BES Revegetation Team could reduce the cost per acre by approximately 50 percent.

8.2.3 HWQ #3: PEN1 Habitat Improvements

Habitat is lacking in the PEN1 basin for several native species including purple martin, western painted turtle, little brown bat, yellow-breasted chat, and western bumble bee. The goal of this project is to increase and/or enhance habitat for specific project focal species. This is a basinwide project and may be implemented as multiple projects as determined by the project implementation team. Habitat improvements are considered in the following subbasins: 3 – Vanport Wetlands, 4 – Force Lake, 5 – North Golf Course, 6 – West Golf Course, and 7 – Central Golf Course. The exact siting of all habitat improvements will be coordinated with the associated stakeholders and property owner prior to implementation. Based on the evaluation provided in the current work, the following are recommended:

- Install nesting gourds for purple martin.
- Install basking structures for native turtles.

- Install roosting structures for bats (little brown bat).[6]
- Install habitat piles for general habitat (nesting structure for pollinators, cover for songbirds).
- Implement actions to minimize disruption to daily golf operations.

The figure in the associated fact sheet represents potential locations for habitat improvements; see Appendix G. Additional locations may be determined as the project proceeds. The overall cost for the PEN1 Habitat Improvements project ranges from $17,000 to $36,000. A detailed cost opinion is included in Appendix H.

8.2.4 HWQ #4: PIR PS Forebay Improvements

The forebay of the PIR PS has noticeably high turbidity and sediment with limited shading. The goals of this project are to implement retrofits, decrease sediment loading, improve water quality, increase shading and buffering, and provide emergent herbaceous habitat within the PIR PS forebay prior to discharging to the Columbia Slough. Based on the evaluation provided in the current work, the following are recommended:

- Retrofit the existing forebay.
  - Lengthen (meander) the flow path, eliminate flow short-circuiting, and create a more uniform cross-sectional velocity to promote sediment settling.
  - Grade the north side of the forebay with a lower profile to allow for localized ponding during high flow events.
  - Implement plantings to enhance emergent and ponded habitat, increase the riparian buffer, and increase shading along the forebay.
- Evaluate the influent culverts to determine if channelization is technically feasible and can be included as part of this project.
  - In 1996, the levee was stabilized by placing addition material on the landward side and installing the existing northwest culvert that conveys flow from the golf course. Prior to including channelization of this culvert within the project, a structural and geotechnical analysis (of the work that was completed in 1996) should be performed to determine if the culvert can be safely removed and channelized.
- Consider joint implementation of the PIR PS Forebay Improvement project with the PIR PS Replacement project (DR #1) and/or the planting project identified in Subbasin 10 from HWQ #1.

The overall cost for the PIR PS Forebay Improvements project ranges from $2,200,000 to $4,700,000. A project fact sheet is included in Appendix G, and a detailed cost opinion is included in Appendix H.

[6] Siting of bat boxes is critical in order to maximize potential for use and bat health. The Bat Conservation International guidelines are recommended for siting guidance: https://www.batcon.org/about-bats/bat-houses/.

8.2.5 HWQ #5 Lower Slough Habitat Enhancements

The Lower Columbia Slough, the PEN1 basin's receiving waterbody, is lacking in the complex habitat necessary for listed salmonid species known to use the system. The goals of this project are to improve habitat in the Lower Columbia Slough by adding levee-friendly habitat elements along the leveed, slough-side bank adjacent to the basin and provide resting and feeding locations for juvenile salmonids. Based on the evaluation provided in this plan, the following are recommended:

- Install USACE-approved, levee-friendly habitat elements at specific locations within the Lower Slough along the leveed border with the PEN1 basin.
- Grade the channel bank to create benches with plantings, as technically feasible. Benches will be implemented to ensure that all project elements are constructed outside of the levee design prism.
- Vegetate all bank and benched areas with plantings that follow the USACE guidelines (USACE 2019).
- Complete a USACE Section 408 determination as required. USACE may request seepage models to verify that plantings do not create a shortened seepage path to the interior of the PEN1 levee system.

The overall cost for the Lower Slough Habitat Enhancements project ranges from $2,370,000 to $5,070,000. A project fact sheet is included in Appendix G, and a detailed cost opinion is included in Appendix H

8.2.6 Programmatic Habitat/Water Quality Recommendations

In addition to the capital projects, five programmatic habitat/water quality recommendations were identified through development of this plan. These are the operational actions recommended for implementation by the City or PEN1 to track the condition of the basin and plan for future improvements to benefit habitat and water quality in the basin.

One of the recommendations is for an ongoing program that should be implemented immediately. This includes regular water quality sampling, monitoring, and analysis. BES currently conducts regular water quality sampling through the PAWMAP and other long-term fixed site-monitoring programs. This program recommends water quality sampling at multiple locations within the PEN1 basin to better understand the varying pollutant loading within the basin. The other four recommendations are for one-time studies that may identify additional capital needs or inform future decision-making.

Table 8-3 summarizes the detailed program descriptions included in Appendix I. The program cost estimates include both the total cost of the program, as well as the annual cost for a long-term program.

Table 8-3. Recommended Programs and Studies for the PEN1 Basin

Program/Study	Timeline
Ongoing Programs	
Water Quality Monitoring	Annually
One-Time Studies	
Sediment Load Source Evaluation	One-time study

Program/Study	Timeline
Ongoing Programs	
Levee Seed Mix Evaluation	One-time study
Heron Lakes Golf Course Vegetation Management Evaluation	One-time study
Water Quality Sampling and Assessment of Stormwater to Marine Drive Right of Way	One-time study

9. CONCLUSION AND NEXT STEPS

An important next step for the District and the City is to establish a plan for funding projects and increasing revenue to cover increasing program needs. The projects and programs recommended in this plan will require a significant financial investment that exceeds the current revenue projections for the City and the District. In addition to current funding sources, the City and the District have opportunities to seek out new revenue streams. This could include grants tied to emergency response, economic development, or natural resource enhancement.

At the same time, the District is heavily reliant on partner agencies (City of Portland and the Port of Portland) for management of the conveyance infrastructure. Many of the projects proposed in this DWQMP will require joint attention to fund and construct the required upgrades. Resources are limited, and the District is working to establish formal agreements with partner agencies related to conveyance system maintenance and rehabilitation responsibility.

This document was prepared solely for Peninsula Drainage District No. 1 in accordance with professional standards at the time the services were performed and in accordance with the contract between the District and Parametrix dated June 16, 2021. This document is governed by the specific scope of work authorized by the District; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by the District and the City, and unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

10. REFERENCES

BES (City of Portland Bureau of Environmental Services). 2005. Portland Watershed Management Plan.

BES. 2018. Portland Area Watershed Monitoring and Assessment Program.

BES. 2019. Portland Watershed Report Card. https://www.portlandoregon.gov/bes/62109

BES. 2020. Beaver Management Plan. https://www.portlandoregon.gov/bes/article/355000

BES. 2021. 2021 Intergovernmental Agreement Oversight of Columbia Slough Sediment Remedial Action.

BES. 2022. Summary of PAWMAP Findings for the Kenton Outfalls Priority Area Report.

BPS (City of Portland Bureau of Planning and Sustainability). 1997. Natural Resources Management Plan for Peninsula Drainage District No. 1.

BPS. 2019. Historical Context of Racist Planning: A History of how Planning Segregated Portland.

City of Portland. n.d. Portland International Raceway. https://www.portland.gov/parks/portland-international-raceway.

City of Portland Planning and Sustainability Commission. 2012. Natural Resource Inventory Update.https://www.portlandoregon.gov/bps/40539

DEQ. 2005. Record of Decision Remedial Action Approach for Columbia Slough Sediment.

EPA (U.S. Environmental Protection Agency). n.d. Federal Water Quality Standard Requirements. https://www.epa.gov/wqs-tech/federal-water-quality-standards-requirements.

FEMA (Federal Emergency Management Agency). 2010. Flood Insurance Rate Map for City of Portland, Oregon.

MCDD. 2021. Critical elevation selection for PEN1 Drainage and Water Quality Master Plan.

MCDD. 2018. Defining Critical Conveyance Routes within Internal Drainage Systems in PEN1, PEN2, MCDD, and SDIC.

ODOT. 2014. Hydraulics Design Manual. https://www.oregon.gov/odot/GeoEnvironmental/Pages/Hydraulics-Manual.aspx

Parametrix. 2015. PIR Pump Station Structural Evaluation.

Parametrix. 2016. Pump Station Condition Assessment.

Parametrix. 2017. Pump Station Condition Assessment – Amendment 1 to Pump Station Condition Assessment, 9/30/16.

PEN1 (Peninsula Drainage District #1). 2013. Interior Drainage Modeling Review.

PEN1. 2014. Internal Drainage Study Prepared for the FEMA Levee Accreditation Process.

USACE (U.S. Army Corps of Engineers). 1989. Engineer Manual 1110-2-3104, Structural and Architectural Design of Pumping Stations. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-3104.pdf?ver=2013-09-04-070829-700.

USACE. 1995. Engineer Manual 1110-2-3102, General Principles of Pumping Station Design and Layout. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-3102.pdf?ver=2013-09-04-070829-123.

USACE. 1998. Engineer Manual, 1110-2-2902, Conduits, Culverts, and Pipes. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-2902.pdf.

USACE. 1999. Engineer Manual 1110-2-3105, Mechanical and Electrical Design of Pumping Stations. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-3105.pdf.

USACE. 2018. Engineer Manual 1110-2-1413, Hydrologic Analysis of Interior Areas. https://www.publications.usace.army.mil/Portals/76/Users/227/19/2019/EM_1110-2-1413.pdf?ver=2018-09-13-125346-687.

USACE. 2019. Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures. https://www.publications.usace.army.mil/Portals/76/Users/182/86/2486/EP_1110-2-18.pdf?ver=bVt-L-DvQrASeFS6szPNaw%3D%3D.

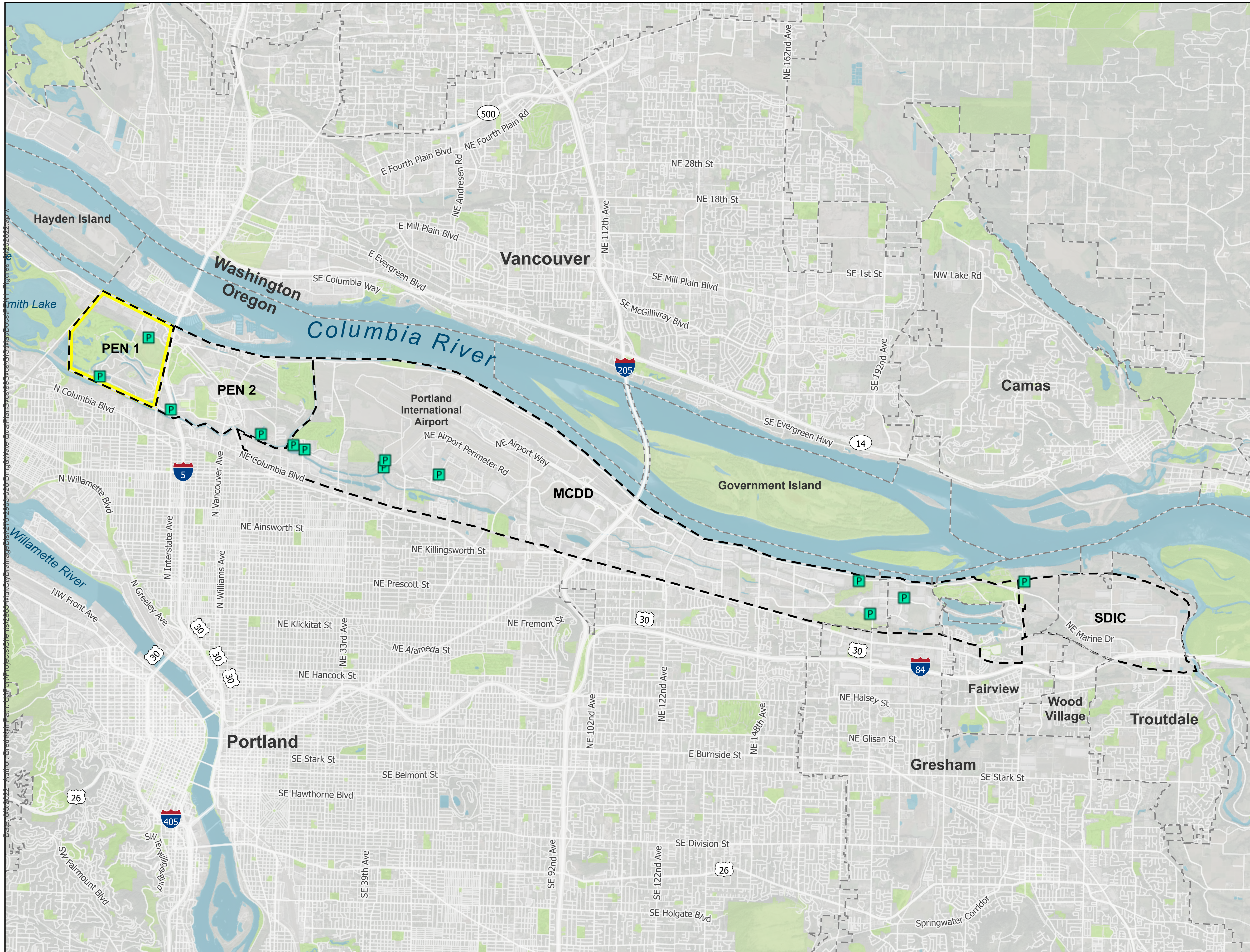
USACE. 2021. Portland Metro Levee System Feasibility Study Integrated Final Report and Environmental Assessment. Portland District. https://www.nwp.usace.army.mil/missions/projects-and-plans/portland-metro-levee-system/USDA NRCS (U.S. Department of Agriculture Natural Resources Conservations Service). n.d. Web Soil Survey. https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm.

USGS (U.S. Geological Survey). 2022. City of Portland HYDRA Rainfall Network. https://or.water.usgs.gov/non-usgs/bes/

WEST Consultants, Inc. 2016. Sediment Management Plan for Multnomah County Drainage District.

Figures

Figure 1
Vicinity Map



page Fig-1

Date: 6/3/2022
Sources: Source: Parametrix, Brown and Caldwell, MCDD, City of Portland, © Mapbox, © OpenStreetMap
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 0.5 1 2 Miles

Figure 2
Drainage Overview Map

- Pump Station
- PEN 1 - District Boundary
- Storm Pipe
- Open Channel
- Waterbody

page Fig-2

Date: 6/6/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Figure 3
Critical Conveyance Network Map

Layer
- Pump Station
- PEN 1 - District Boundary
- Waterbody

Conveyance Criticality Level
- High
- Medium
- Low

Date: 5/27/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Figure 4
Critical Elevations Map

Date: 6/6/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

Figure 5
Pipe Age Map

Layer
- Pump Station
- PEN 1 - District Boundary
- Open Channel
- Waterbody

Pipe Install Date
- Unknown
- 1970s
- 1980s
- 1990s
- 2000s

Date: 6/3/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Figure 6
Problem Areas Map

- Area of Concern [1]
- Modeled Flooding Area [2]
- Pump Station
- PEN 1 - District Boundary
- Storm Pipe
- Open Channel
- Waterbody

1. Areas of concern identified during the August 31, 2021 Site Visit. For additional concerns identified by stakeholders, see Appendix C.
2. See Appendix E, Critical Elevation Selection for PEN1 Drainage and Water Quality Master Plan, for critical locations and elevations in PEN1. See Appendix F, Model Results, for flood elevations during the modeled storm events.

Site visit identified concerns and deficiencies:

1	Three culverts that connect Mud Lake to the channel to the north are rusted out and at risk of failure.
2	Beaver dams along the north end of Heron Lakes Golf Course cause flooding when not managed.
3	The Vanport PS has no SCADA system. The Vanport PS is in need of repair or replacement.
4	Force Lake has a low water table in the summer, which results in higher water temperatures, lower dissolved oxygen, and increased algae blooms.
5	Water quality of stormwater runoff from PIR is relatively unknown as regular water quality sampling is not conducted.
6	Water quality of stormwater runoff from Heron Lakes Golf Course is relatively unknown as water quality sampling is not conducted regularly and was last conducted in the early 2000's.
7	The PIR PS forebay and outlet from the pump station to the Lower Slough have a high amount of visually noticeable sediment and turbidity.
8	In the Vanport Wetlands, stakeholders are concerned about the runoff from the parking lot being treated before discharge to the surface water channel.

Date: 7/8/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Figure 7
PEN1 Subbasins

- PEN 1 - District Boundary
- Drainage Subbasin Boundary
- Open Channel
- Waterbody

page Fig-7

Date: 5/27/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Figure 8
PEN 1 Land Cover

- Trees
- Wetland
- Grass
- PGPS
- NPGIS
- PGIS
- Racetrack
- Waterbody
- PEN 1 - District Boundary
- Drainage Subbasin Boundary

Sub-basin	Land Cover Type	Area	Sub-basin	Land Cover Type	Area
1	Trees	1.13 AC	6	Trees	7.18 AC
	Wetland	N/a		Wetland	N/a
	Grass	8.57 AC		Grass	9.09 AC
	PGPS	N/a		PGPS	63.78 AC
	NPGIS	24.23 AC		NPGIS	0.86 AC
	PGIS	40.00 AC		PGIS	2.59 AC
	Racetrack	N/a		Racetrack	N/a
	Waterbody	7.31 AC		Waterbody	15.13 AC
2	Trees	N/a	7	Trees	8.38 AC
	Wetland	N/a		Wetland	2.87 AC
	Grass	4.13 AC		Grass	0.19 AC
	PGPS	N/a		PGPS	101.31 AC
	NPGIS	5.78 AC		NPGIS	0.03 AC
	PGIS	12.43 AC		PGIS	2.02 AC
	Racetrack	N/a		Racetrack	N/a
	Waterbody	0.69 AC		Waterbody	12.69 AC
3	Trees	13.09 AC	8	Trees	7.51 AC
	Wetland	62.26 AC		Wetland	14.82 AC
	Grass	38.85 AC		Grass	75.18 AC
	PGPS	N/a		PGPS	0.07 AC
	NPGIS	7.99 AC		NPGIS	6.15 AC
	PGIS	38.88 AC		PGIS	9.70 AC
	Racetrack	N/a		Racetrack	5.71 AC
	Waterbody	1.32 AC		Waterbody	1.19 AC
4	Trees	5.87 AC	9	Trees	4.60 AC
	Wetland	22.02 AC		Wetland	6.80 AC
	Grass	4.32 AC		Grass	41.21 AC
	PGPS	15.71 AC		PGPS	N/a
	NPGIS	0.82 AC		NPGIS	0.53 AC
	PGIS	17.75 AC		PGIS	23.40 AC
	Racetrack	N/a		Racetrack	6.64 AC
	Waterbody	2.48 AC		Waterbody	N/a
5	Trees	28.60 AC	10	Trees	8.38 AC
	Wetland	24.69 AC		Wetland	17.39 AC
	Grass	2.50 AC		Grass	35.41 AC
	PGPS	56.35 AC		PGPS	N/a
	NPGIS	0.20 AC		NPGIS	5.59 AC
	PGIS	4.89 AC		PGIS	11.35 AC
	Racetrack	N/a		Racetrack	N/a
	Waterbody	3.13 AC		Waterbody	13.36 AC

Date: 9/21/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Figure 9
PEN1 Shade Analysis

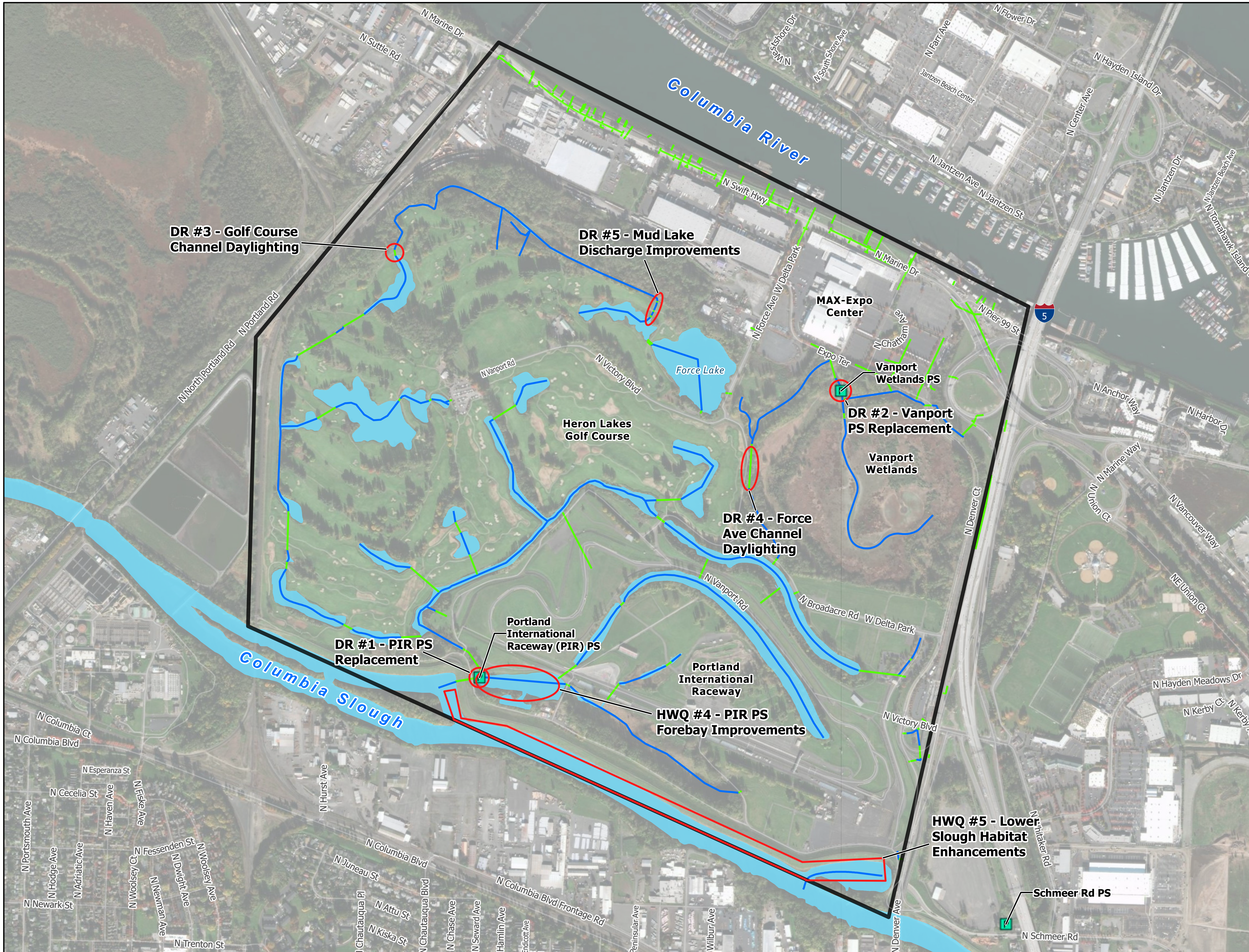
- Canopy Gap - Priority Shade Area
- Canopy Gap - Not Priority Shade Area
- PEN 1 - District Boundary
- Drainage Subbasin Boundary
- Open Channel
- Waterbody

Sub-basin	Category	Area
1	Canopy Gap - Priority Shade Area	N/a
	Canopy Gap - Not Priority Shade Area	N/a
2	Canopy Gap - Priority Shade Area	N/a
	Canopy Gap - Not Priority Shade Area	N/a
3	Canopy Gap - Priority Shade Area	2.74 AC
	Canopy Gap - Not Priority Shade Area	N/a
4	Canopy Gap - Priority Shade Area	2.60 AC
	Canopy Gap - Not Priority Shade Area	2.08 AC
5	Canopy Gap - Priority Shade Area	4.34 AC
	Canopy Gap - Not Priority Shade Area	2.19 AC
6	Canopy Gap - Priority Shade Area	8.63 AC
	Canopy Gap - Not Priority Shade Area	6.38 AC
7	Canopy Gap - Priority Shade Area	6.35 AC
	Canopy Gap - Not Priority Shade Area	10.40 AC
8	Canopy Gap - Priority Shade Area	4.91 AC
	Canopy Gap - Not Priority Shade Area	12.05 AC
9	Canopy Gap - Priority Shade Area	5.00 AC
	Canopy Gap - Not Priority Shade Area	1.31 AC
10	Canopy Gap - Priority Shade Area	1.40 AC
	Canopy Gap - Not Priority Shade Area	7.29 AC

Date: 4/22/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Figure 10
Capital Improvement Locations



- CIP Location
- PEN 1 - District Boundary
- Storm Pipe
- Open Channel
- Waterbody

Basin-Wide Projects:
HWQ #1 - Plantings
HWQ #2 - Shoreline Grading
HWQ #3 - Habitat Improvements

Date: 6/6/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Figure 11
Habitat Existing Conditions

Pump Station
PEN 1 - District Boundary
Storm Pipe
Open Channel

0 250 500 1,000 1,500 Feet

Date: 6/6/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

Figure 12-A
Inundation Map with Pumps Enabled

- 100-yr Floodplain
- 500-yr Floodplain
- Pump Station
- PEN 1 - District Boundary
- Storm Pipe
- Open Channel
- Waterbody

Date: 6/3/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

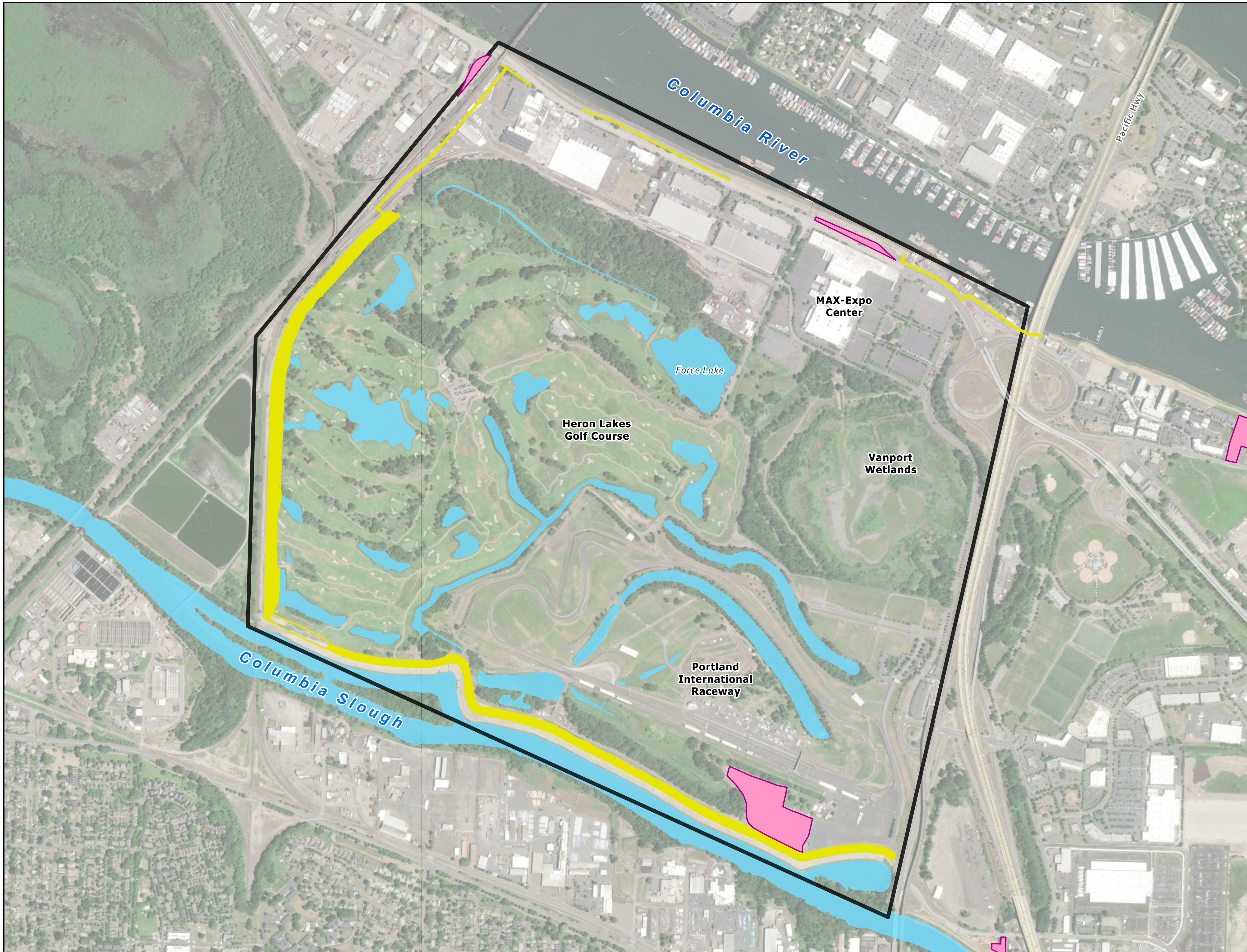
Figure 12-B
Inundation Map with Pumps Disabled

- 25-yr Floodplain
- 100-yr Floodplain
- Pump Station
- PEN 1 - District Boundary
- Storm Pipe
- Open Channel
- Waterbody

Date: 6/3/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Figure 13
USACE Portland Metro Levee System (PMLS) Proposed Future Impacts



- PMLS Impact Area
- PMLS Staging Area
- PEN 1 - District Boundary
- Waterbody

Date: 6/30/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Figure 14
Habitat Resource Areas

Date: 7/12/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

Appendix A

MCDD Technical Memoranda

Critical Elevation Selection for PEN1 Drainage and Water Quality Master Plan

Defining Critical Conveyance Routes within Internal Drainage Systems in PEN1, PEN2, MCDD, and SDIC.

Technical Memorandum

Date: October 14, 2021

From: Mackenna Bell

Subject: Critical elevation selection for PEN1 Drainage and Water Quality Master Plan

Overview

As part of the Peninsula Drainage District #1 (PEN1) Drainage and Water Quality Master Plan (DWQMP), Multnomah County Drainage District #1 (MCDD) identified locations and elevations of critical points within the PEN1 drainage system. These points represent areas within the system that, if the water surface elevation exceeded the elevation provided, would result in building inundation or impacts to the District's ability to maintain the system. These elevations would then be used as flooding thresholds in the ongoing DWQMP hydraulic modeling efforts.

Critical elevation points were categorized into four types: Building, Operational, Pump Station Deck, and Road. Staff from MCDD's Operations Team provided input to identify locations within the PEN1 drainage area that may experience inundation or operational impacts during heavy rainfall.

Building elevations were taken as the finished floor elevation from a 2017 State of Oregon Department of Geology and Mineral Industries (DOGAMI) dataset. Road elevations were extracted from 2010 National Oceanic and Atmospheric Administration (NOAA) LiDAR. Remaining elevations were surveyed using a Topcon GRS-1 in early October 2021.

All elevations presented in this document are in the NAVD88 vertical datum. The attached map shows the locations of these critical elevation points.

General Assumption

To determine an Operational Impact, it was determined that if the water was more than one foot (1') above a working surface, it was not safe to work on that surface. This principal was applied to culverts, maintenance platforms, and pump station decks.

The elevation in which water had inundated a building was calculated by using the finished floor elevation of a building and then subtracting one foot (1').

Critical Elevation Locations

A – **PIR racetrack- Roadway flooding**: The lowest road surface elevation within the racetrack is 10.10'.

B – **N Force Ave- Roadway flooding**: The road east of Force Lake is prone to overland flow. The lowest road surface elevation is 14.12'.

C – **N Expo Rd- Roadway flooding**: The lowest road surface elevation on N Expo Rd is 12.06'.

D – **Vanport Wetlands Pump Station**: The Vanport Wetlands Pump Station floor has an elevation of 13.12', making the operationally impactful water surface elevation (WSE) 14.12'.

E – **Expo Center Ditch**: The pipe maintenance platform at the Expo Center Ditch culvert inlet is 8.37’, making the operationally impactful WSE 9.37’.

F – **Vanport Wetlands Weir**: The Vanport Wetlands weir platform has an elevation of 12.33’, making the operationally impactful WSE 13.33’.

G – **NW Heron Lakes Golf Course Culvert**: The culvert in the NW corner of Heron Lakes Golf Course has a crown elevation of 10.9’, making the operationally impactful WSE 11.9’.

H – **NW of PIR Pump Station Forebay Culvert**: The maintenance platform over the culvert to the NW of the PIR Pump Station Forebay has an elevation of 11.96’, making the operationally impactful WSE 12.96’.

I – **PIR Pump Station Deck**: The PIR Pump Station has an intake deck height of 15.13’, making the operationally impactful WSE 16.13’.

J – **Structures within PIR**: The building within PIR with the lowest finished floor elevation is 11.96’. This makes the critical elevation 10.96’.

K – **NE of PIR Pump Station Forebay Culvert**: The maintenance platform over the culvert to the NE of the PIR Pump station Forebay has an elevation of 12.97’, making the operationally impactful WSE 13.97’.

L – **EcoLube Recovery Structures**: The lowest building at EcoLube Recovery has a finished floor elevation of 15.63’, making the critical elevation 14.63’.

M – **Expo Center Structures**: The building within the Expo Center property with the lowest finished floor elevation is 15.49’. This makes the critical elevation 14.49’.

N – **Graphic Packaging Structures**: The building along Marine Dr. with the lowest finished floor elevation is Graphic Packaging at 30.7’, making the critical elevation 29.7’.

Peninsula Drainage District #1 (PEN1) Drainage System

Legend

PEN1 Critical Elevations

- Building
- Operational
- Pump Station Deck
- Road

0 325 650 1,300 Feet

N

Print Date: 10/11/2021

PEN 1 Flood Protection

p. 503.281.5675
www.mcdd.org

This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

Produced By: mbell

Technical Memorandum

Date: December 28, 2018

From: Andrew Riggs and Josh McNamee

Subject: Defining Critical Conveyance Routes within Internal Drainage Systems in PEN1, PEN2, MCDD, and SDIC.

Overview

Staff at Multnomah County Drainage District #1 (MCDD) identified the need to map all district-maintained infrastructure, and to define the critical conveyance routes for internal drainage systems within MCDD, Peninsula Drainage District #1 (PEN1), Peninsula Drainage District #2 (PEN2), and Sandy Drainage Improvement Company (SDIC). This map product could be used as a filter to determine which infrastructure to include in MCDD's Asset Registry and each district's Capital Improvement Plan (CIP).

In October 2018 select members of the MCDD Operations and Engineering Teams held workshops to define these routes and assign their levels of criticality. Printed paper maps of each District's system were provided to the team, as well as highlighters to mark-up the maps. This effort was broken down into two distinct phases:

Phase 1 – Defining "Our" System:

The team was provided the following context: "Please highlight all pipes and ditches that the District maintains, has historically maintained, or should be maintaining, regardless of ownership."

Phase 2 – Defining Criticality:

The team was provided the following context: "For the pipes and ditches highlighted during Phase 1; please define their importance to the overall system using the following:

Low – A partial or complete blockage of this pipe or ditch would not result in flooding or would result in ponding that doesn't cause issues.

Medium – A partial or complete blockage of this pipe or ditch would result in minor inundation of ancillary buildings or would result in nuisance ponding that would impact roadways or other infrastructure.

MCDD Flood Protection Multnomah County Drainage District #1 1880 NE Elrod Drive Portland, OR 97211 / 503.281.5675 phone / 503.281.0392 fax / www.mcdd.org

> High – A partial or complete blockage of this pipe or ditch would result in the inundation of residences, commercial buildings, or other critical infrastructure, or would cause major traffic routes to be inundated."

Decisions during both phases of this workshop were made collaboratively, and final designations were based on consensus using professional judgement based on experience and anecdotal information. Following the workshop, the maps were digitized using ArcGIS and a final Featureclass titled "CriticalityNetwork" was published.

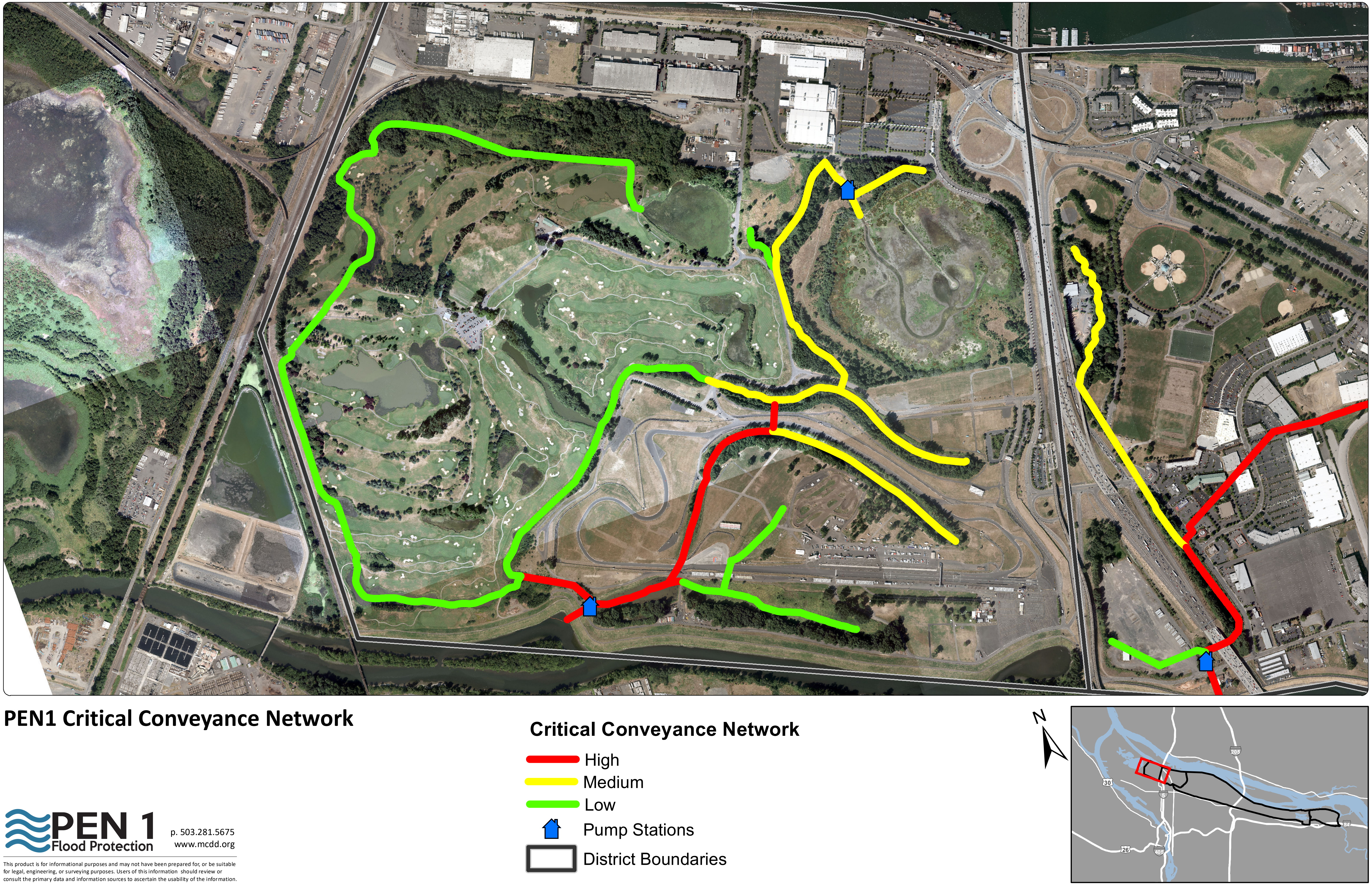
General Assumptions

Each District's internal drainage systems have mixed – and often unclear - ownership and maintenance responsibilities of drainage infrastructure. This effort was not intended to define or establish ownership of any infrastructure, but simply to define where the district does work and what parts of that system are most critical to maintaining conveyance.

There is a pump station at the bottom of each drainage system. During Phase 1, any pipe or ditch that was highlighted resulted in the downstream features being highlighted to connect that feature to the appropriate pump station. Subsequently during Phase 2, all pipes or ditches had to be assigned either a low, medium, or high criticality designation. In the main stem of a conveyance route, no pipe or ditch downstream from a feature could have a lower designation than one higher in the drainage system. Branches off of the main stem of a conveyance route have designations independent from their location in the drainage system.

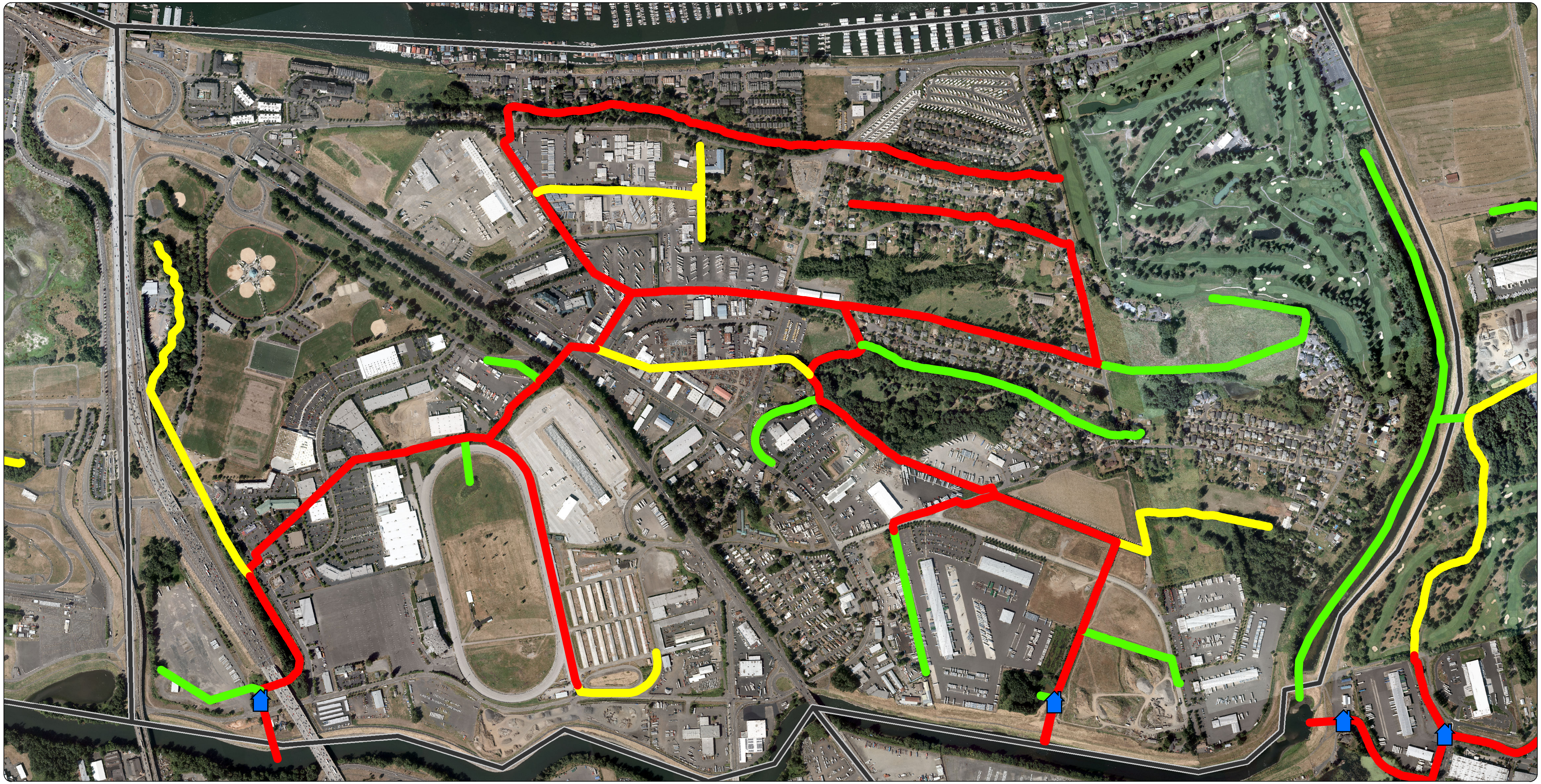
MCDD Flood Protection
Multnomah County Drainage District #1
1880 NE Elrod Drive Portland, OR 97211 / 503.281.5675 phone / 503.281.0392 fax / www.mcdd.org

Produced By: ariggs
Print Date: 1/29/2019
Path: S:\GIS\Projects\Engineering\17-00019 - Pipe Inventory\PipeClassification.mxd



PEN1 Critical Conveyance Network

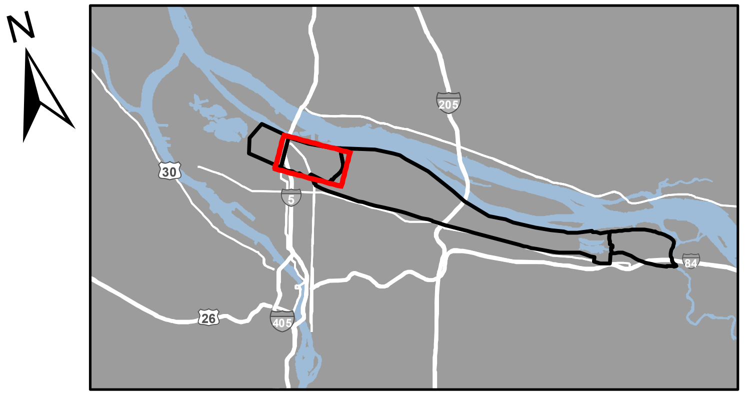
PEN 1 Flood Protection
p. 503.281.5675
www.mcdd.org



PEN2 Critical Conveyance Network

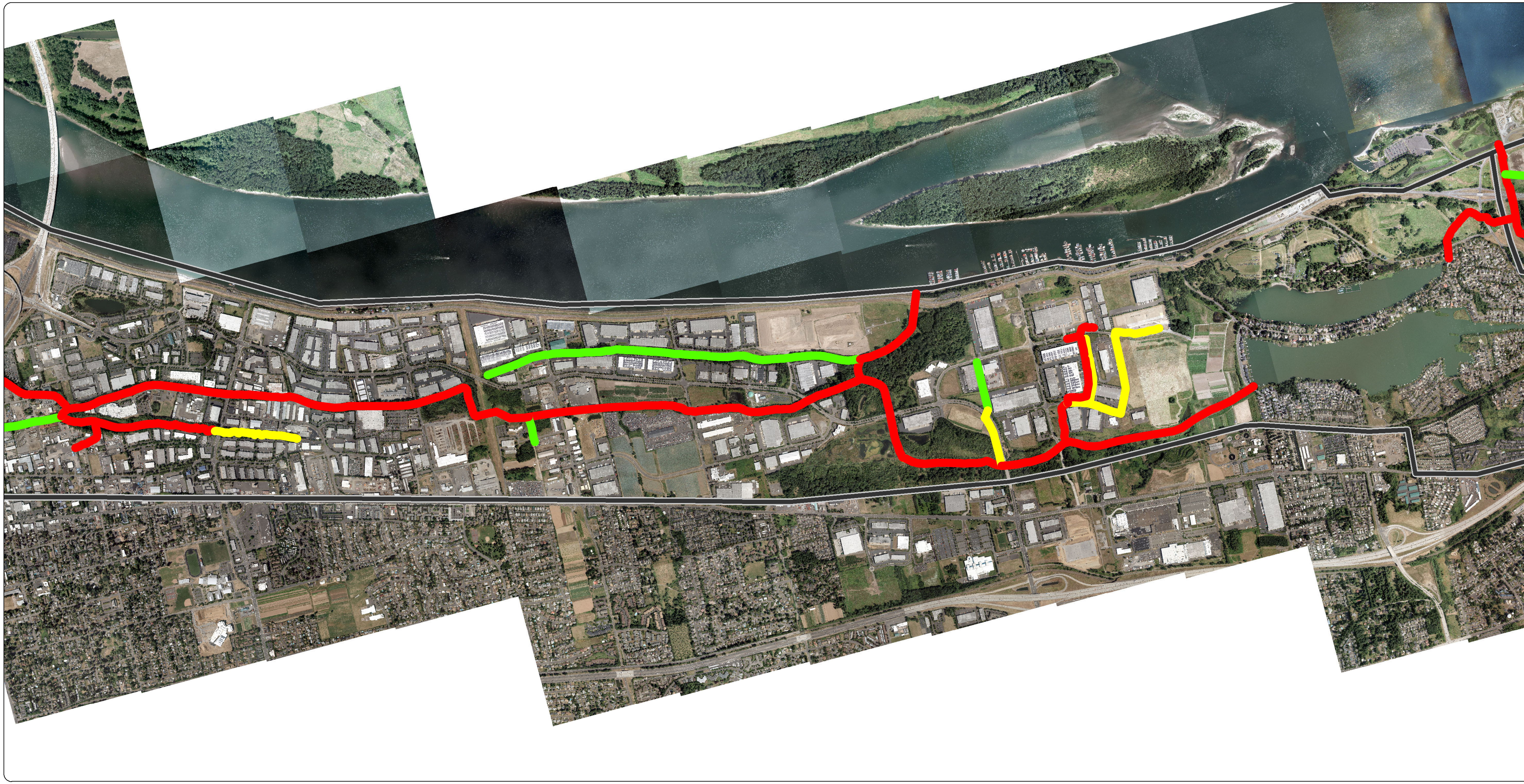
Critical Conveyance Network

- High
- Medium
- Low
- Pump Stations
- District Boundaries



PEN 2
Flood Protection

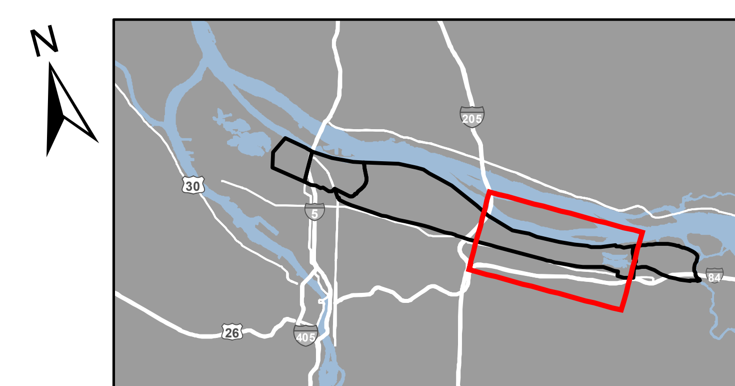
p. 503.281.5675
www.mcdd.org



MCDD (East) Critical Conveyance Network

Critical Conveyance Network

- High
- Medium
- Low
- Pump Stations
- District Boundaries

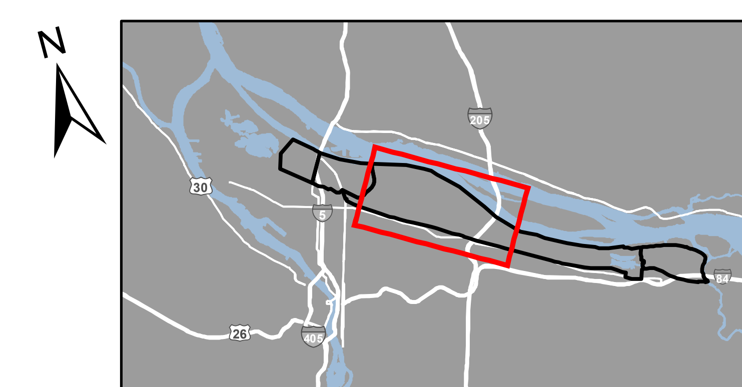


MCDD Flood Protection
p. 503.281.5675
www.mcdd.org

MCDD (West) Critical Conveyance Network

Critical Conveyance Network

- High
- Medium
- Low
- Pump Stations
- District Boundaries



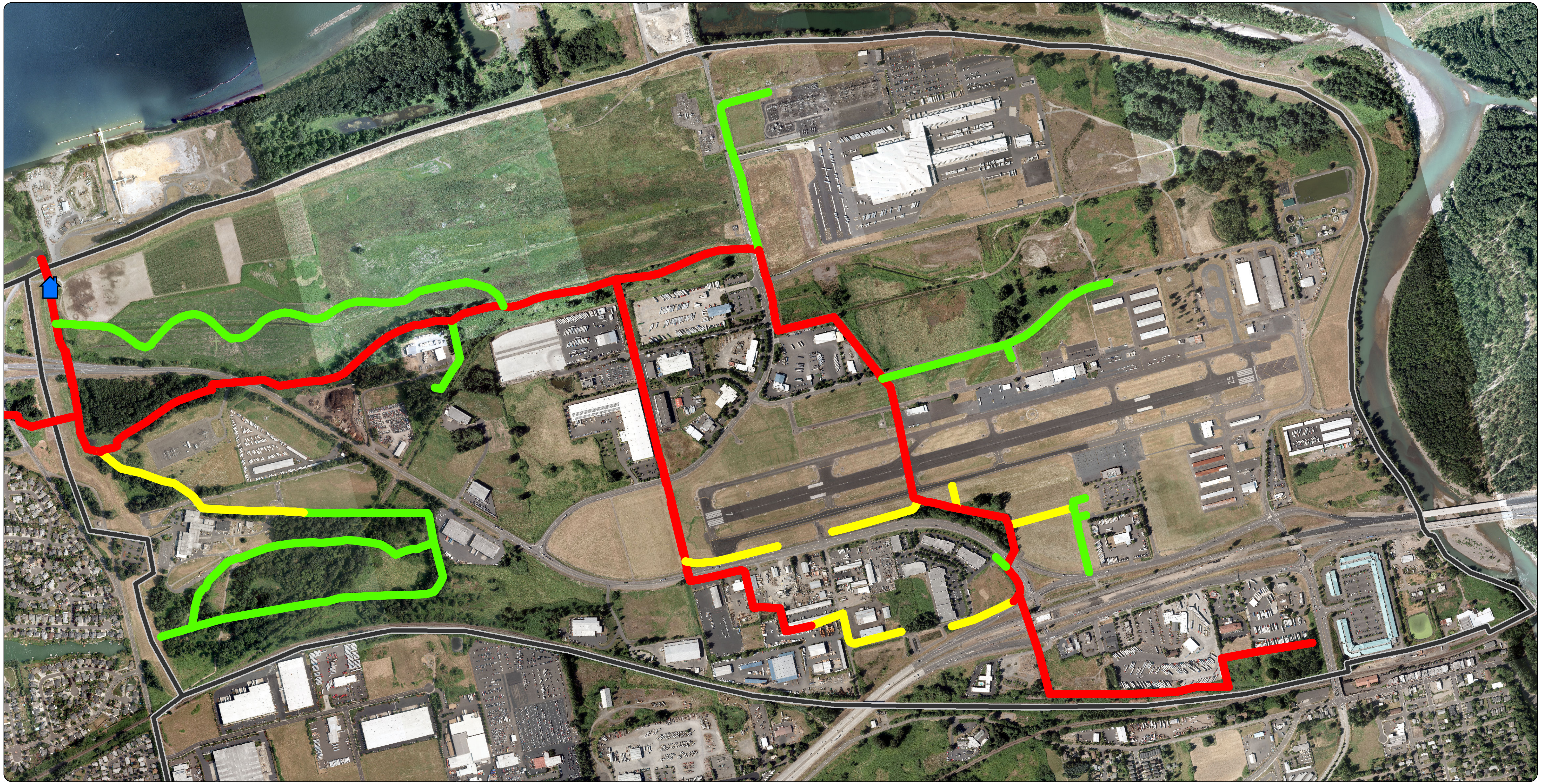
MCDD Flood Protection

p. 503.281.5675
www.mcdd.org

Produced By: ariggs

Print Date: 1/29/2019

Path: S:\GIS\Projects\Engineering\17-00019 - Pipe Inventory\PipeClassification.mxd

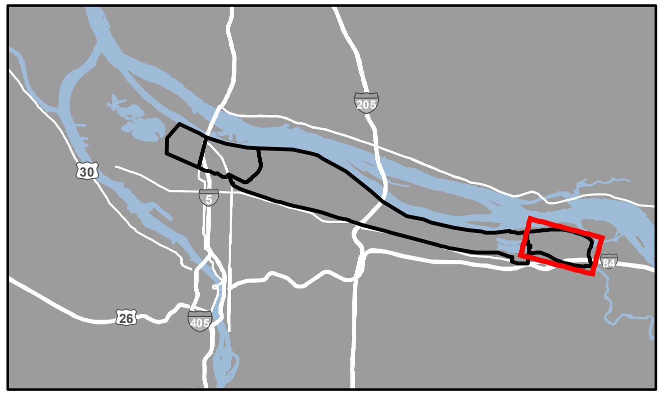


SDIC Critical Conveyance Network

Critical Conveyance Network

- High
- Medium
- Low
- Pump Stations
- District Boundaries

N



SDIC Flood Protection

p. 503.281.5675
www.mcdd.org

Appendix B

FEMA FIRM Panels

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 10. The **horizontal datum** was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, MD 20910-3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242,** or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was provided in digital format by the Metro Data Resource Center, 600 NE Grand Avenue, Portland, OR, 97232-2736. drc@metro.dst.or.us (503) 797-1742

This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables *in the Flood Insurance Study report (which contains authoritative hydraulic data*) may reflect stream channel distances that differ from what is shown on this map.

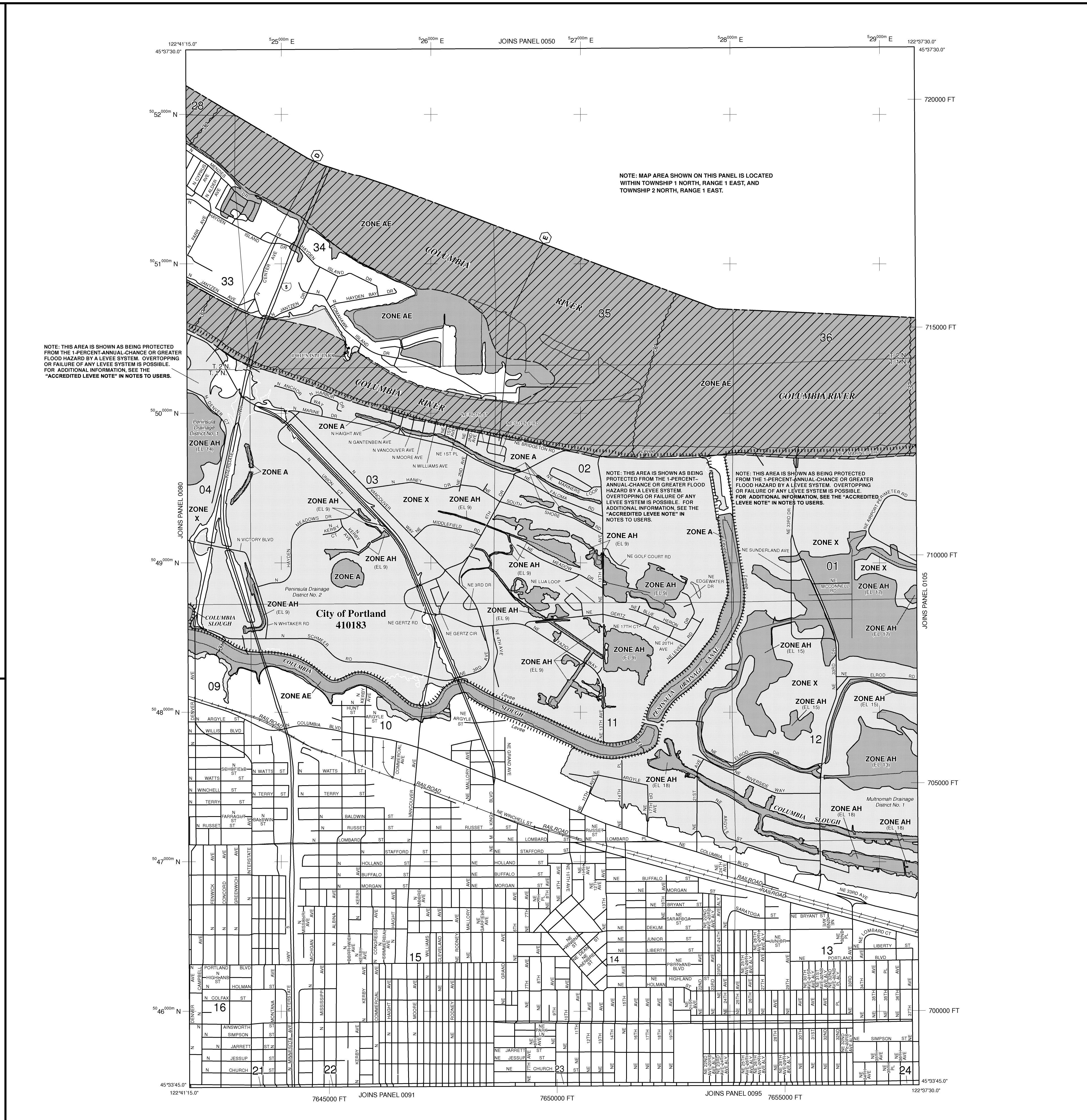
Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map showing the layout of map panels for this jurisdiction.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, *a Flood Insurance Study report*, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/.

Accredited Levee Notes to Users: Check with your local community to obtain more information, such as the estimated level of protection provided (which may exceed the 1-percent-annual-chance level) and Emergency Action Plan, on the levee system(s) shown as providing protection for areas on this panel. To mitigate flood risk in residual risk areas, property owners and residents are encouraged to consider flood insurance and floodproofing or other protective measures. For more information on flood insurance, interested parties should visit the FEMA Website at http://www.fema.gov/business/nfip/index.shtm.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	Floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
~~ 513 ~~~	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

(A)———(A)	Cross section line
(23)- - - - -(23)	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
4275000mN	1000-meter Universal Transverse Mercator grid ticks, zone 10
6000000 FT	5000-foot grid ticks: Oregon State Plane coordinate system, north zone (FIPSZONE 3601), Lambert Conformal Conic
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORY
City Of Portland, Bureau Of Environmental Services, 1221 SW 4th Avenue, Room 230, Portland, Oregon 97204 (Maps available for reference only, not for distribution.)

INITIAL NFIP MAP DATE
January 10, 1975
FLOOD HAZARD BOUNDARY MAP REVISIONS
April 25, 1978
FLOOD INSURANCE RATE MAP EFFECTIVE
October 15, 1980
FLOOD INSURANCE RATE MAP REVISIONS
October 19, 1982 January 3, 1986 November 7, 2001 October 19, 2004
November 26, 2010 -to incorporate previously issued Letters of Map Revision, to reflect updated topographic information, and to add roads and road names.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 1000'
500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0085F

FIRM
FLOOD INSURANCE RATE MAP

CITY OF
PORTLAND, OREGON
MULTNOMAH, CLACKAMAS AND WASHINGTON COUNTIES
PANEL 85 OF 250
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
PORTLAND, CITY OF	410183	0085	F

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER 4101830085F

MAP REVISED NOVEMBER 26, 2010

Federal Emergency Management Agency

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole–foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 10. The **horizontal datum** was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC–3, #9202
1315 East–West Highway
Silver Spring, MD 20910–3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713–3242,** or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was provided in digital format by the Metro Data Resource Center, 600 NE Grand Avenue, Portland, OR, 97232-2736. drc@metro.dst.or.us (503) 797-1742

This map reflects more detailed and up–to–date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables *in the Flood Insurance Study report (which contains authoritative hydraulic data)* may reflect stream channel distances that differ from what is shown on this map.

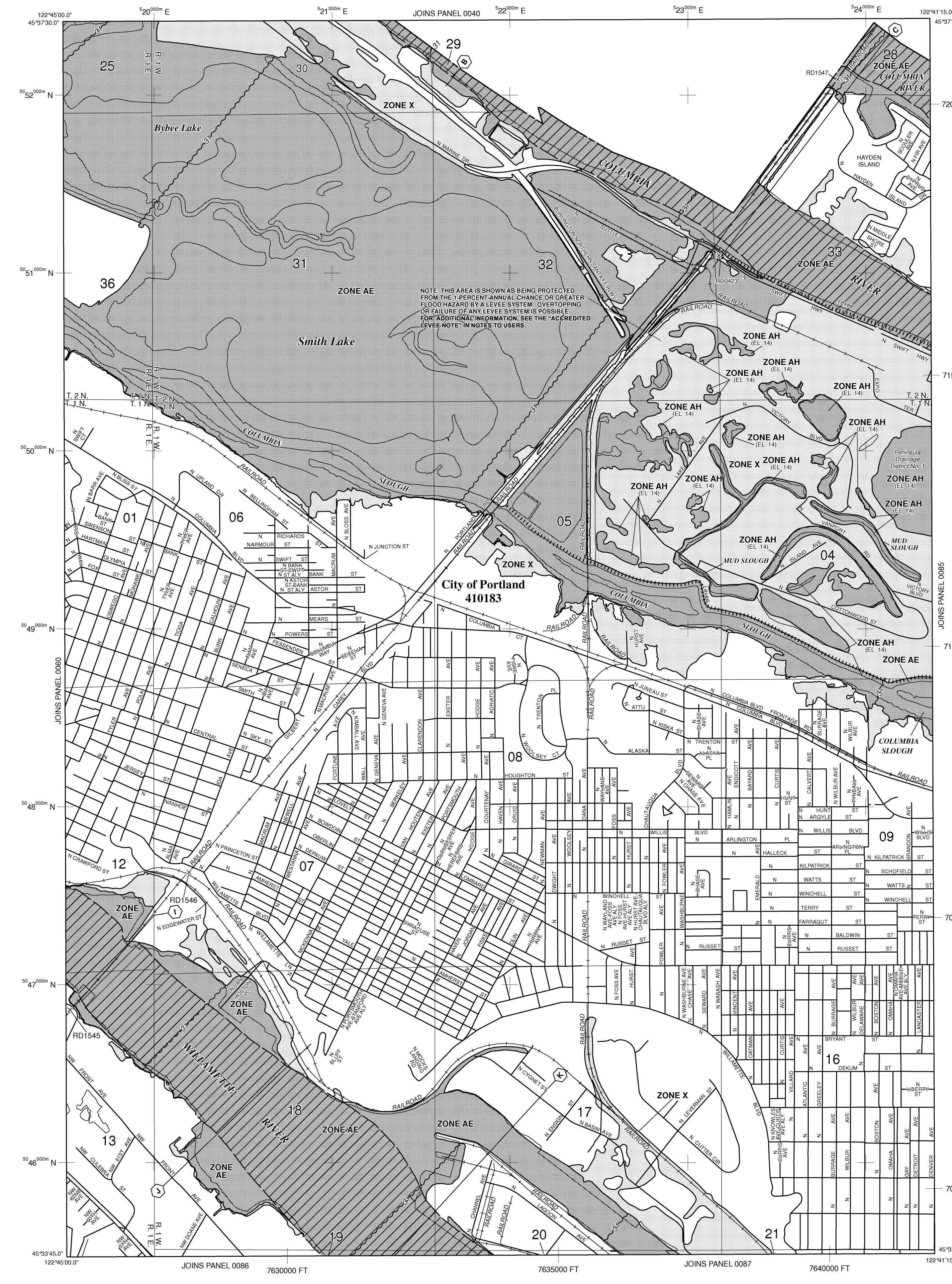
Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de–annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map showing the layout of map panels for this jurisdiction.

Contact the **FEMA Map Service Center** at 1–800–358–9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, *a Flood Insurance Study report*, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1–800–358–9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1–877–FEMA MAP** (1–877–336–2627) or visit the FEMA website at http://www.fema.gov/.

Accredited Levee Notes to Users: Check with your local community to obtain more information, such as the estimated level of protection provided (which may exceed the 1-percent-annual-chance level) and Emergency Action Plan, on the levee system(s) shown as providing protection for areas on this panel. To mitigate flood risk in residual risk areas, property owners and residents are encouraged to consider flood insurance and floodproofing or other protective measures. For more information on flood insurance, interested parties should visit the FEMA Website at http://www.fema.gov/business/nfip/index.shtm.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	Floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
~~ 513 ~~~~	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

(A)———(A)	Cross section line
(23)- - - - -(23)	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
$^{42}75^{000m}$N	1000-meter Universal Transverse Mercator grid ticks, zone 10
6000000 FT	5000-foot grid ticks: Oregon State Plane coordinate system, north zone (FIPSZONE 3601), Lambert Conformal Conic
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
• M1.5	River Mile

MAP REPOSITORY
City Of Portland, Bureau Of Environmental Services, 1221 SW 4th Avenue, Room 230, Portland, Oregon 97204 (Maps available for reference only, not for distribution.)

INITIAL NFIP MAP DATE
January 10, 1975
FLOOD HAZARD BOUNDARY MAP REVISIONS
April 25, 1978
FLOOD INSURANCE RATE MAP EFFECTIVE
October 15, 1980
FLOOD INSURANCE RATE MAP REVISIONS
October 19, 1982 January 3, 1986 November 7, 2001 October 19, 2004
November 26, 2010 –to incorporate previously issued Letters of Map Revision, to reflect updated topographic information, and to add roads and road names.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

N

MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

300 0 300 600 METERS

NFIP

PANEL 0080F

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP

CITY OF

PORTLAND, OREGON

MULTNOMAH, CLACKAMAS AND WASHINGTON COUNTIES

PANEL 80 OF 250

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
PORTLAND, CITY OF	410183	0080	F

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

U.S. DEPARTMENT OF HOMELAND SECURITY

MAP NUMBER 4101830080F

MAP REVISED NOVEMBER 26, 2010

Federal Emergency Management Agency

Appendix C

Site Photographs

Photo 1. Heron Lakes Golf Course

Photo 2. Heron Lakes Golf Course

Photo 3. Heron Lakes Golf Course

Photo 4. Heron Lakes Golf Course

Photo 5. PIR PS and Forebay

Photo 6. PIR Discharge into Columbia Slough

Photo 7. PIR Discharge into Columbia Slough

Photo 8. Mud Slough

Photo 9. Vanport Wetlands

Photo 10. Vanport Wetlands

Photo 11. Vanport Wetlands - Beaver Deceiver Structure

Photo 12. Vanport Wetlands PS

Appendix D

Stakeholder Comments Table and Map

PEN1
Stakeholder Comment Map

- PEN 1 - District Boundary
- Pump Station
- Storm Pipes (COP)
- Natural Channels
- Transition Channels
- Ditches
- Railroad

*Stakeholder Comments

- Area of Excitement/Opportunity
- Area of Overall Interest
- Area of Concern/Deficiency

Comment Type

- Drainage
- Habitat
- Water Quality
- Other

*Reference the tables on the following sheets for Survey Point Comments associated with the Map ID labels on this figure

Date: 10/1/2021
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Areas of Excitement/Opportunity

Point ID	Category	Comment	Commenter
1	Habitat	Install Purple Martin nest box/gourd complex	J Ashcroft
2	Habitat	Plant wetland scrub-shrub habitat with a robust willow component for Willow Flycatcher habitat.	J Ashcfoft
3	Habitat	Install Purple Martin nest box/gourd complex	J Ashcroft
4	Other	Consider a trail along the levee margin around HLGC. Could provide bikers a nice spur or loop ride, or birders more opportunity to view wildlife on the nice habitat features present on HLGC. The path could connect to the Slough trail in the SW corner of HLGC. Maybe other possible connections elsewhere to create a loop?	J Ashcroft
5	Habitat	Grade shoreline to create emergent herbaceous wetland along northern edge of PIR pump station pond. Additional plantings around pond could add shading.	J Ashcroft
6	Habitat	Grade shoreline to create emergent herbaceous wetland	J Ashcroft
7	Habitat	Grade shoreline to create emergent herbaceous wetland	J Ashcroft
8	Habitat	Grade shoreline to create emergent herbaceous wetland	J Ashcroft
9	Habitat	Grade shoreline to create wet scrub-shrub and/or emergent herbaceous wetland	J Ashcroft
10	Habitat	Grade shoreline to create emergent herbaceous wetland habitat. Add riparian shrub plantings where possible.	J Ashcroft
11	Habitat	Potential for herbaceous emergent wetland	J Ashcroft
12	Habitat	Add riparian scrub-shrub habitat with robust willow component	J Ashcroft
13	Habitat	ODFW surveys found little instream habitat, but with the vegetated south bank, there is a lot of potential for improving instream habitat for fish.	Julia Bond
14	Habitat	possibly raise the fairway to allow seasonal flooding from beaver dams	Jesse Goodling
15	Habitat	improve turtle nesting habitat	C. Butler
16	Habitat	Daylighting potential? Any possibility of removing the pipe to connect the channels?	J Bond
18	Habitat	Potential habitat area as the districts move foward.	Nancy Hendrickson

Area of Overall Interest

Point ID	Category	Comment	Commenter
1	Habitat	Provide increased basking habitat (exposed woody debris, etc) for turtles on appropriate HLGC and PIR water features.	J Ashcroft
2	Habitat	Potential opportunity for upland scrub-shrub brush and/or oak-pine habitat	J Ashcroft
3	Habitat	Add tree plantings along southern edge of Broadacre dogpark.	J Ashcroft
4	Habitat	Provide increased basking habitat (exposed woody debris, etc) for turtles on appropriate HLGC and PIR water features.	J Ashcroft
5	Habitat	Provide increased basking habitat (exposed woody debris, etc) for turtles on appropriate HLGC and PIR water features.	J Ashcroft
6	Habitat	Provide increased basking habitat (exposed woody debris, etc) for turtles on appropriate HLGC and PIR water features.	J Ashcroft
7	Habitat	Extend Riparian Buffer	M Brown
8	Habitat	Plant 50-foot buffers on each bank of all drainage ways	MBrown
9	Drainage	storm pipe not shown here	C. Butler
10	Habitat	Riparian tree plantings along this channel -- shadow on the imagery makes it look like there is veg, when there is none next to the channel. Riparian plantings for more habitat and to shade the channel.	J Bond
11	Habitat	Riparian plantings along north bank of the waterbody.	J Bond
12	Water Quality	Importance of riparian shade along open channels where ever possible to keep water temperatures cool.	J Bond
13	Drainage	Remove culvert?	J Bond
14	Habitat	Riparian plantings along waterbodies	J Bond

Area of Concern

Point ID	Category	Comment	Commenter
1	Habitat	Add riparian buffer/tree plantings to fill this gap between PIR and HLGC	J Ashcroft
2	Habitat	What is this area used for? Why is it open field? Could this area be target for comprehensive habitat restoration/enhancement?	J Ashcroft
3	Habitat	Additional tree plantings (trees being lost due to bank erosion, from nutria?)	J Ashcroft
4	Water Quality	Improve Stormwater Treatment to Receiving Waters	MBrown
5	Drainage	storm pipe not shown here	C. Butler
6	Water Quality	improve stormwater treatment	C. Butler
7	Water Quality	improve stormwater treatment	C. Butler
8	Drainage	aging weir	C. Butler
9	Drainage	aging pump station needs replaced	C. Butler
10	Water Quality	<Null>	<Null>
11	Drainage	Really long pipe, older, questionable condition. Flow limited. Cannot visually see the outlet as it is submerged AT A MINIMUM this needs to be inspected..	Josh McNamee
12	Drainage	The sediment level within the forebay is high and impacts the performance of the pumps. Also likely impacts the water quality. Potentially recommend dredging?	Josh McNamee
13	Drainage	Weir gate is generally ok. But there is a sluice gate that is difficult to operate and can often leak. Issues with the weir gate. it has some difficulty lowering as the sediment in front of the weir gate does not allow the weir to lower.	Josh McNamee
14	Drainage	Lots of sediment in this ditch segment. Potentially recommend dredging?	Josh McNamee
15	Drainage	Very flat so water ponding during storms; groundwater issues in winter- appears to come up through asphalt? under pressure/spring? needs confirming. unknown exact location	Josh McNamee
16	Drainage	pipe does not convey water. flows at 5% capacity. not critical for drainage.	Josh McNamee
17	Drainage	Most pipes within golf course are undersized. Maybe condition assessment?	Josh McNamee

Appendix E

Habitat Analysis Results

		Potential Project Benfitting Focal Species																		Priority Habitat Areas							Qualitative Screening		
	Class	Birds							Mam.			Fish		Rep.		Inv.													
SubBasin Number	SubBasin Name / Species	Bald Eagle	Cinnamon Teal	Purple Martin	White-breasted Nuthatch	Willow Flycatcher	Yellow-breasted Chat	Bird Subtotal	Little brown bat	American beaver	Mammal Subtotal	Chinook Salmon	Fish Subtotal	Western Painted Turtle	Reptile Subtotal	Western Bumblebee	Invertibrates Subtotal	**Total Number of Focal Species Classes**	**Focal Species Total**	City of Portland Wetlands	Natural Resources Inventory Special Habitat Areas	ODFW Conservation Opportunity Areas	ODFW Strategy Habitats	Regional Land Information System High Value Habitat	Title 13 Habitat	**Total Sources Prioritizing Habitat**	Existing Condition	Land Available for Improvement	Combine with Water Quality
1	North Industrial - N/A															✓	1	1	1		✓		✓	✓	✓	4	1	No	No
2	NE Industrial - N/A															✓	1	1	1		✓		✓	✓	✓	4	1	No	No
3	Vanport Wetlands	✓	✓	✓				3						✓	1			2	4	✓	✓	✓	✓	✓	✓	6	5	Some	Yes
4	Force Lake Area	✓	✓	✓	✓	✓	✓	6	✓	✓	2			✓	1			3	9	✓	✓	✓	✓	✓	✓	6	3	Yes	Yes
5	North Golf Course	✓	✓	✓	✓	✓		5	✓	✓	2			✓	1			3	8	✓	✓	✓	✓	✓	✓	6	3	Yes	Yes
6	West Golf Course	✓	✓					2						✓	1			2	3			✓	✓	✓	✓	4	3	Some	Yes
7	Central Golf Course		✓			✓		2						✓	1	✓	1	3	4	✓		✓	✓	✓	✓	5	3	Some	Yes
8	External Raceway				✓	✓	✓	3	✓		1			✓	1	✓	1	4	6	✓		✓	✓	✓	✓	5	1	Some	Yes
9	Internal Raceway				✓	✓		2								✓	1	2	3	✓		✓	✓	✓	✓	5	1	No	No
10	Southern Slough	✓				✓	✓	3	✓	✓	2	✓	1	✓	1	✓	1	5	8	✓		✓	✓	✓	✓	5	3	Yes	Yes

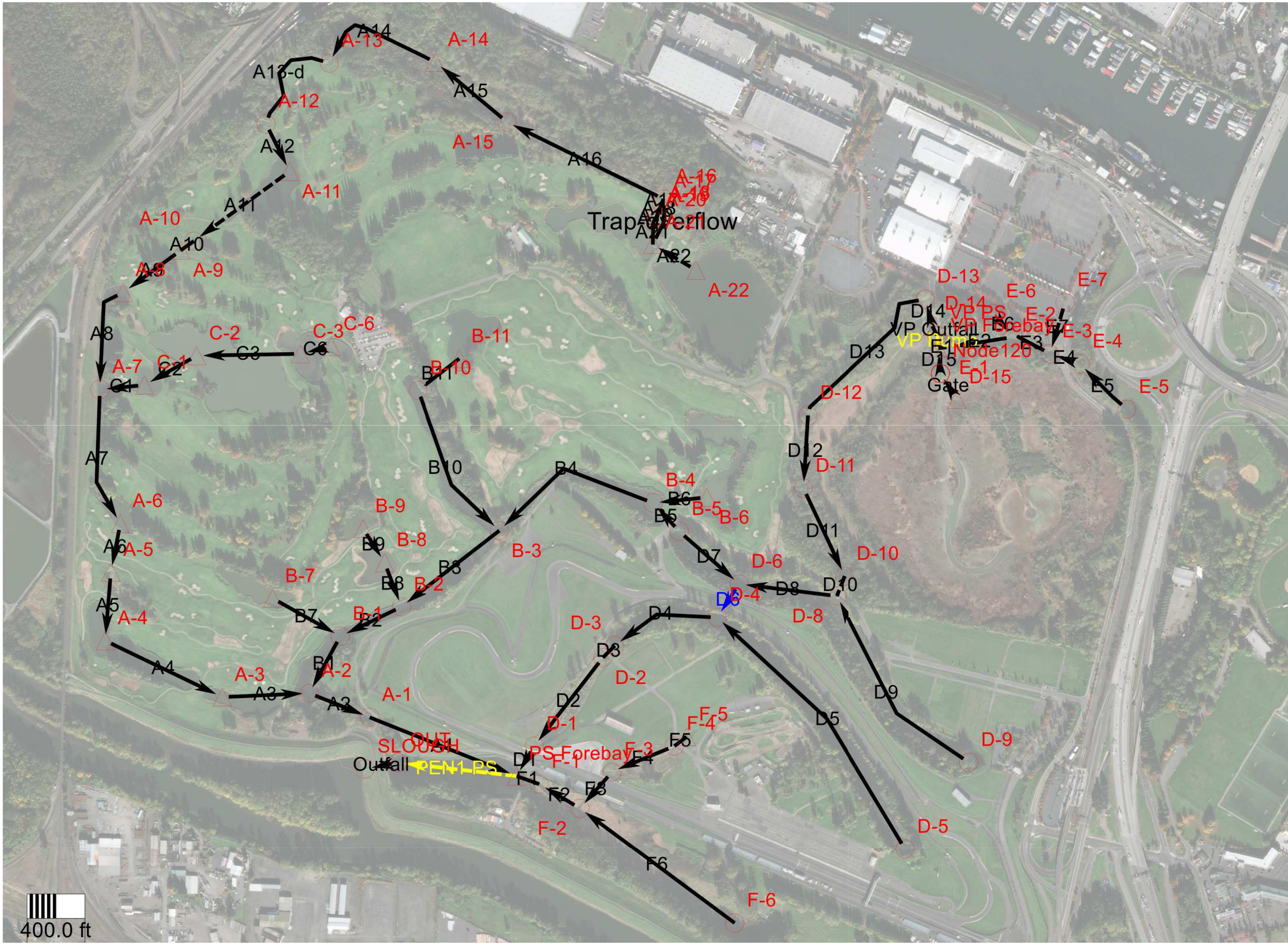
SubBasin Number	SubBasin Name	Existing Conditions	Potential Habitat Project elements
1	North Industrial Area - N/A	Paved impervious surfaces, industrial development	1. Flower and shrub plantings to benefit pollinators
2	NE Industrial - N/A	Paved impervious surfaces, industrial development	1. Flower and shrub plantings to benefit pollinators
3	Vanport Wetlands	Wildlife habitat area, closed to public use. Variety of wetland features, with a mix of city water infrastructure (pump station). Beaver deceivers installed, historic dams detected. Tree frogs, great horned owl detected. This area also includes impervious surfaces (parking lot) and freeway on/off ramps. Purple martin were detected perched on snags during the site visit. The Vanport BES property could also benefit from a nest box program including martin nesting structures already in use on-site. Culverts in this area may prevent fish passage.	1. Install basking structures during upgrades to pump station 2. Consider elevation of water for turtles. 3. Daylighting potential? Any possibility of removing the pipe to connect the channels? 4. Improve turtle nesting habitat 5. Wetland plantings to benefit cinnamon teal nesting. 6. Install nest boxes on poles similar to those within Vanport wetlands; maintain snags on site
4	Force Lake Area	This area is split into roughly three different use types: industrial development, wildlife habitat area, and recreation. Industrial development includes oil refining businesses; wildlife area includes diverse wetland habitats; recreation includes a golf course. Habitat/pollinator patches detected; lupine. Raptor perches. Force Lake is a water body on the north side of Heron Lakes Golf Club, to the west of Vanport Wetlands. This lake is roughly 3-feet deep. It is a former superfund site. Since 1961, Harbor Oil Inc. has recycled used oil on-site, just north of Force Lake. A 1979 fire caused used oil and waste paint to flow into nearby wetlands. Following site investigations, this site was removed from the National Priorities List in 2014. Historic flooding of fields east of N. Force Ave. has been alleviated by the installation of culverts that allow standing water to flow from east to west, under N. Force Ave., and into Force Lake. Many waterbirds were seen within Force Lake during the August 31st site visit, including scaup, pelican, grebe, and wood duck. Culverts in this area may prevent fish passage.	1. Install Purple martin nest box/ gourd complex 2. Provide increased basking habitat (exposed woody debris, etc.) for turtles on appropriate HLGC and PIR water features. 3. Plant wetland scrub-shrub habitat with a robust willow component for Willow Flycatcher habitat. 4. Force Lake is a high use area for wildlife. Concerned about water quality here. Purple martins observed. Suggest nesting boxes here. North side plantings for wildlife? Basking structure for turtles? Turtle friendly culverts? 5. Natural Beaver Dam - Beaver Activity. Look for ways to manage such that beaver stays on site (beaver is a focal species) 6. Controlling nutria to benefit beaver; install beaver deceivers 7. Plant wetland associated plants/grasses for waterbird nesting/cover habitat.
5	North Golf Course	This area contains both wildlife habitat and recreation. Wildlife habitat includes riparian forests; recreation includes a golf course. Multiple wetland features (excavated ponds). Heron rookery detected. Enhancing transitions between habitat types may increase breeding opportunities for reptiles on the landscape. For example, greater transitions between open water, emergent wetland, and upland habitat, would be beneficial for a variety of wildlife species inhabiting the area. Transition areas are used for both foraging and cover. There were a number of nest boxes detected throughout Heron Lakes property. It is assumed that these were previously used to provide nesting substrate for cavity nesting waterbirds and songbirds. There is no known nest box maintenance or survey program currently conducted within PEN1. It is recommended that all current nest boxes be checked, cleaned, and maintained, previous to the 2022 spring nesting season. Additionally, the introduction of a nest box program, within the golf course and/or throughout the drainage district, has the potential to increase the diversity of species found within, by providing nesting areas for cavity nesting birds.	1. Install purple martin nest box/ gourd complex 2. Grade shoreline to create emergent herbaceous wetlands (multiple locations) 3. Install basking structures in ponded and sloughs 4. Install riparian plantings where possible 5. Increase connectivity by allowing flooding from beaver dams (raise elevation of fairway) 6. possibly raise the fairway to allow seasonal flooding from beaver dams. 7. Grade shoreline to create emergent herbaceous wetland habitat. Add riparian shrub plantings where possible. 8. Provide increased basking habitat (exposed woody debris, etc.) for turtles on appropriate HLGC and PIR water features. 9. Potential for herbaceous emergent wetland. 10. Grade shoreline to create emergent herbaceous wetland. 11. Future Setback Levee w/ Floodwall. Turtles observed within water features here. Connectivity to this area should be maintained. Improve basking structures and vegetation. 12. Undersized 12-in Culvert. If larger culverts are installed, they should be turtle friendly to allow passage. 13. Heron rookery should be protected through planned projects. Nest boxes here should be maintained. 14. beaver dams, backing up water onto golf course. Suggest installation of "beaver deceiver" or other control measures to hopefully allow beaver to co-exist on-site. 15. Raptor perch here needs cross limb. Also suggest developing nest box program. 16. Pollinator plots throughout site - maintain and enhance 17. Nutria removal to benefit beaver populations
6	West Golf Course	This area contains recreation opportunities (golf course), railroad corridor, and pedestrian paths. Multiple wetland features (excavated ponds). Pollinator patch detected. Historic bald eagle nesting area. Fish habitat structures within slough to the south. Culverts in this area may prevent fish passage.	1. Grade shoreline to create emergent herbaceous wetland (multiple locations) 2. Install basking logs within ponds. 3. Provide increased basking habitat (exposed woody debris, etc.) for turtles on appropriate HLGC and PIR water features. 4. Install purple martin nest box/gourd complex. 5. Trail improvement projects should include native vegetation and connectivity for focal species.
7	Central Golf Course	This area contains recreation opportunities (golf course), and multiple wetland features (excavated ponds). Blackberry berm onsite could be viable chat habitat. Culverts in this area may prevent fish passage.	1. Install riparian scrub-shrub habitat with robust willow component. 2. Allow connectivity by removing pipe along west side of Vanport Wetlands/Golf Course. 3. Install pollinator plots where allowed. Expand current pollinator plots with recommended mix. 4. Grade shoreline to create wet scrub-shrub and/or emergent herbaceous wetland 5. Add riparian scrub-shrub habitat with robust willow component. 6. Additional tree plantings

SubBasin Number	SubBasin Name	Existing Conditions	Potential Habitat Project elements
8	External Raceway	Commercial/industrial land use, with riparian corridor.	1. Grade shorelines to create emergent herbaceous wetland along northern edge of PIR pump station pond. Add additional plantings around pond. 2. Potential opportunity for upland scrub-shrub brush and/or oak-pine habitat. 3. Add riparian buffer/tree plantings to fill this gap between PIR and HLGC. 4. Riparian plantings along waterbodies. 5. Riparian plantings along north bank of the waterbody. 6. Add tree plantings along southern edge of Broadacre dog park. 7. BES revegetation project. Use as reference for other restoration projects. Consider focal species requirements. 8. Potential to enhance for oak habitat. 9. Opportunity for Meandering or Shading, Braided system /channel for emerging habitat and opportunity for shading in this part of the slough. Planting along other side of the slough. bench or terrace the area. low vegetation. Improve WQ here, shading to decrease temperature. Include specifics for the focal species.
9	Internal Raceway	Commercial/industrial land use, with riparian corridor.	1. Plant 50-foot buffers on each bank of all drainage ways. 2. Riparian plantings here to improve habitat for focal species.
10	Southern Slough	Riparian shrubland, pedestrian path, commercial development. Culverts in this area may prevent fish passage.	1. Install plantings on south bank. 2. Plantings west and south of pump (below berm) to add complexity to system. 3. Potential habitat area as the districts move forward. 4. Provide increased basking habitat (exposed woody debris, etc.) for turtles on appropriate HLGC and PIR water features. 5. Riparian tree plantings along this channel -- shadow on the imagery makes it look like there is veg, when there is none next to the channel. Riparian plantings for more habitat and to shade the channel. 6. Extend Riparian Buffer. 7. ODFW surveys found little instream habitat, but with the vegetated south bank, there is a lot of potential for improving instream habitat for fish. 8. Opportunity to reduce sediment and turbidity that is occurring in the slough near the outfall. Include habitat projects for chinook salmon. Include low bench habitat and native vegetation. 9. Plant beaver friendly vegetation along banks for the slough

Appendix F

Modeling Results

Model Node	District Reference Points and Critical Elevations					Model Results				
	Location	Elevation	Basis/Justification		Map ID	2 Year Event	10 Year Event	25 Year Event	100 Year Event	500 Year Event
F-5	PIR racetrack	10.1	Physical	Roadway flooding elevation	A	8.84	9.30	9.48	9.86	10.17
A-22	N Force Ave	14.12	Physical	Roadway flooding elevation	B	11.57	11.67	11.74	12.11	12.37
E-3	N Expo Rd	12.06	Physical	Roadway flooding elevation	C	8.43	9.40	9.68	10.50	10.97
VP Forebay	Vanport Wetlands Pump Station	14.12	Operational	1' lower than pump station floor	D	8.39	9.38	9.66	10.49	10.93
E-1	Expo Center Ditch	9.37	Operational	1' above culvert crown	E	8.40	9.40	9.68	10.50	10.97
Node120	Vanport Wetland Weir	13.33	Operational	1' above the weir platform	F	8.39	9.38	9.66	10.49	10.93
A-12	NW Heron Lakes Golf Course Culvert	11.9	Operational	1' above culvert crown	G	10.64	11.05	11.52	12.07	12.35
A-1	NW of PIR Pump Station Forebay Culvert	12.96	Operational	1'above culvert crown	H	8.46	8.84	9.07	9.65	10.07
PS Forebay	PIR Pump Station Deck	16.13	Operational	1' above PS deck	I	7.50	8.47	8.82	9.53	9.99
F-5	Structures within PIR North Paddock	10.96	Physical	1' below finished floor	J	8.84	9.30	9.48	9.86	10.17
F-1	NE of PIR Pump Station Forebay Culvert	13.97	Operational	1' above culvert crown	K	8.38	8.74	8.82	9.60	10.06
A-22	EcoLube Recovery Structures	14.63	Physical	1' below finished floor	L	11.57	11.74	11.83	12.11	12.37
E-7	Expo Center Structures	14.49	Physical	1' below finished floor	M	13.51	13.62	13.66	13.74	13.82
	Graphic Packaging Structures	29.7	Physical	1' below finished floor	N	Outside model Extents				
C-6	Heron Lakes Golf Course Club House	16.16	Physical	1' below finished floor	O	9.26	9.83	10.08	10.70	11.09
A-21	Heron Lakes Golf Couse Maintenance Building	14.76	Physical	1' below finished floor	P	11.53	11.81	11.85	12.20	12.38
F-6	Structures within PIR South Paddock	13.33	Physical	1' below finished floor	Q	10.19	10.48	10.58	10.73	10.82
F-6	PIR South Paddock Parking Lot	13.04	Physical	Roadway flooding elevation	R	10.19	10.48	10.58	10.73	10.82



Scale 1 : 10000.00

Appendix G

Project Fact Sheets

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

700 NE MULTNOMAH, SUITE 1000 | PORTLAND, OR 97232 | P 503.233.2400, 360.694.5020

DR #1 Portland International Raceway Pump Station Replacement

Identified Problem and Project Goals

The PIR PS mechanical equipment and discharge piping is aging, and recent structural observations have indicated that the pump station structure is reaching the end of its useful life. High amounts of turbidity have also been observed within the forebay and at the discharge. This project will replace the station, discharge piping, and decrease turbidity in the forebay (when paired with HWQ #4) and at the discharge via the use of an energy dissipater. The project will increase resiliency via a new structure, an additional redundant pump, automatic influent screens, new backup generator, and improved maintenance access.

Project Description

Construct a new approximately 30 MGD (46.4 cfs) firm capacity wet-pit confined-inlet pump station to discharge PEN1 Basin flow into the Columbia Slough. New pump station will be located next to the existing pump station, allowing the new pump station to be more centrally located within the forebay and have a more evenly distributed flow distribution at the station and individual pump inlets. This will also allow the existing pump station to remain in service during construction. The new station will include regrading the bank to provide better access for operations and maintenance vehicles. The pump station will be provided with three mixed-flow vertical turbine pumps (approx. 125 hp), VFDs, flow meters, automatic influent trash rack, emergency generator, control systems, and SCADA communications. Pumps will be sized to allow the pump station to achieve design flow capacity with one pump out of service. Recommended additional investigations include CCTV inspection of the pipe and additional thickness measurements to determine the extent of degradation and if short-term repairs or additional monitoring is needed.

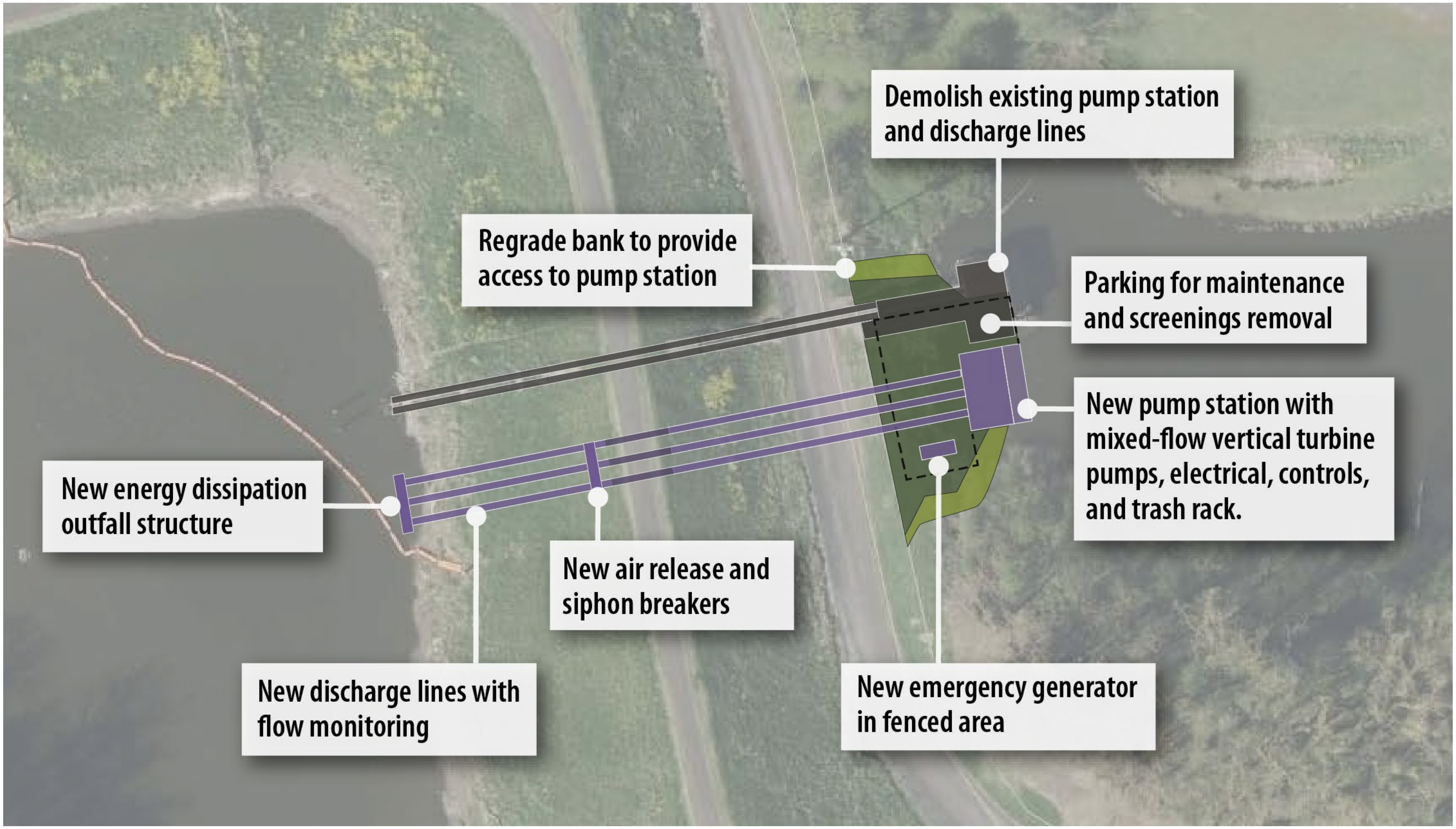
The area to the south of the existing pump station and north of the new pump station will be regraded to provide access to the pump station for screenings removal. The area to the south of the new pump station will be regraded for a permanent generator. Plantings and shoreline grading should be implemented where technically feasible to improve habitat for a variety of project focal species (see master plan for proposed plantings). The desired future condition of the shoreline grading and plantings is to provide habitat for focal species such as the western painted turtle and cinnamon teal. This project should be considered for joint implementation with HWQ#4. See attached figures illustrating the proposed project and station.

Cost

The cost summary below contains the total project cost, including design and construction contingencies, for the pump station, discharge pipes and energy dissipator, and all associated systems. The project has assumed permanent standby power with automatic transfer switch; alternatively, a portable generator hookup with manual transfer switch could be provided resulting in a reduction of approximately $700,000 from the total cost in 2022 dollars (includes reduction of construction cost, design fee, contingencies, etc.).

Item	Total Cost	Low Range (-30%)	High Range (+50%)
PIR PS Replacement	$12,600,000	$8,820,000	$18,900,000

Construction Year	Inflation	Low Estimate	High Estimate
2025	5%	$9,270,000	$19,850,000
2030	14%	$10,060,000	$21,550,000
2035	22%	$10,770,000	$23,060,000
2040	31%	$11,560,000	$24,760,000


Demolish existing pump station and discharge lines
Regrade bank to provide access to pump station
Parking for maintenance and screenings removal
New pump station with mixed-flow vertical turbine pumps, electrical, controls, and trash rack.
New energy dissipation outfall structure
New air release and siphon breakers
New discharge lines with flow monitoring
New emergency generator in fenced area

DR #2 Vanport Pump Station Replacement

Identified Problem and Project Goals

The Vanport Wetlands PS is aging; previous evaluations have identified the station to be in poor/inadequate condition, and the station has only one pump thus limiting redundancy. The goal of this project is to replace the station with a new one that has two pumps, standby power, and automated trash removal to increase resiliency. The new station and added resiliency will also ensure flooding concerns at the eastern end of N. Expo Rd are alleviated under 100-year design storm conditions.

Project Description

Construct a new approximately 4.5 MGD (6.9 cfs) firm capacity submersible pump station to provide drainage for flows downstream of the Vanport Wetlands weir structure, as well as for flows from the southeastern portion of the Expo Center to support localized flood prevention of the Expo Center. The new pump station will be relocated for better maintenance access and to allow the existing pump station to remain in service during construction. The existing forebay channel will be reconfigured, and the station will discharge to the northwest using a new discharge line routed through the existing culvert. The pump station will include axial flow submersible column pumps (approx. 30 to 40 hp), VFDs, automated influent trash rack, emergency generator, control systems, and SCADA communications. Providing two pumps (each 6.9 cfs) alleviates up to 100-year flooding, with only minor flooding occurring up to 500-year storm.

Regrading or other modifications to the upstream Expo Center drainage channel should be considered during design to avoid flooding at the eastern end of N Expo Road during larger storm events. Plantings and shoreline grading should be implemented where technically feasible within the project footprint to improve habitat for a variety of project focal species (see master plan for proposed plantings). The desired future habitat condition for this area is riparian plantings and emergent wetland.

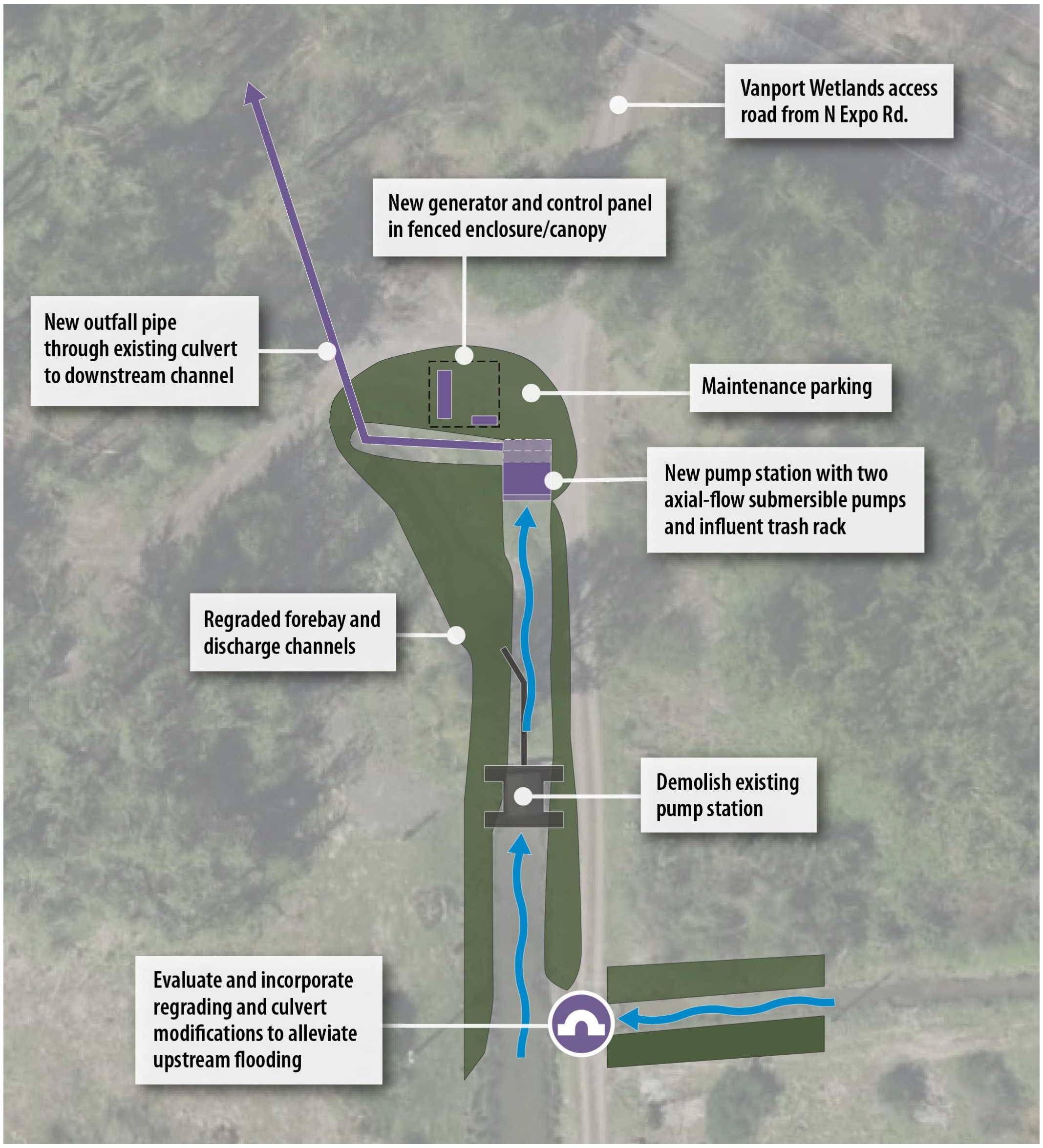
See attached figures illustrating the proposed project and station.

Cost

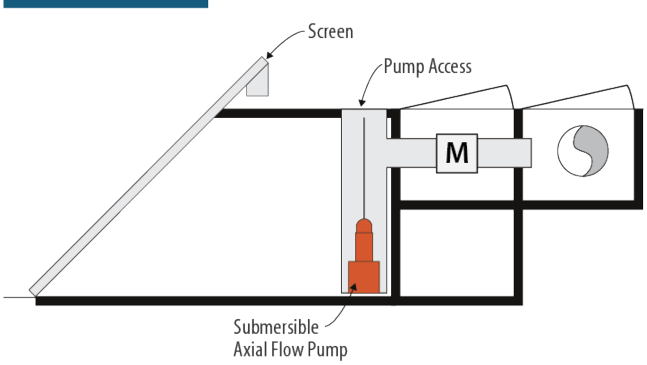
The cost summary below contains the total project cost including design and construction contingencies for the pump station, all associated systems, and the regrading of the forebay and discharge channels. Costs are not included for regrading or reconfiguration of the Expo Center channel. The project has assumed permanent standby power with an automatic transfer switch; alternatively, a portable generator hookup with a manual transfer switch could be provided resulting in a reduction of approximately $275,000 from the total cost in 2022 dollars (includes reduction of construction cost, design fee, contingencies, etc.).

Item	Total Cost	Low Range (-30%)	High Range (+50%)
Vanport PS Replacement	$3,180,000	$2,230,000	$4,770,000

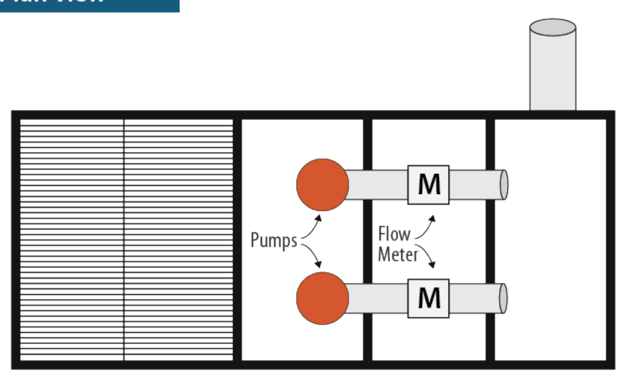
Construction Year	Inflation	Low Estimate	High Estimate
2025	5%	$2,350,000	$5,010,000
2030	14%	$2,550,000	$5,440,000
2035	22%	$2,730,000	$5,820,000
2040	31%	$2,930,000	$6,250,000



Section View



Plan View



DR #3 Golf Course Culvert Channel Daylighting

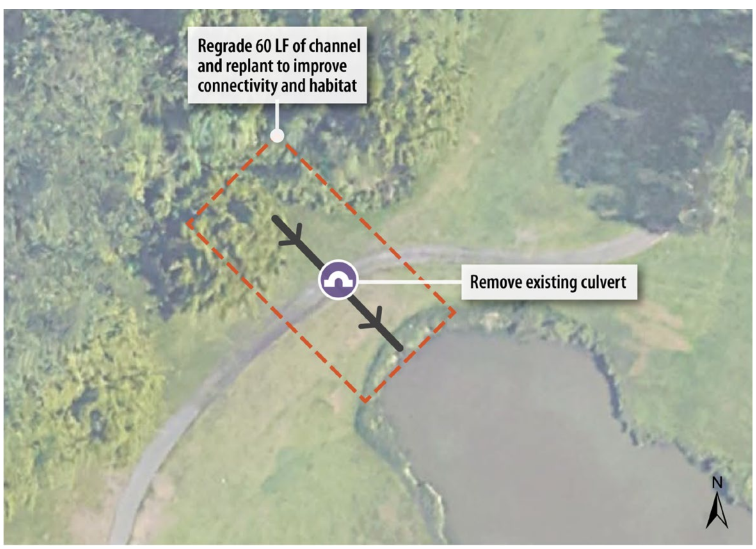
Identified Problem and Project Goals

The culvert in the northwest corner of Heron Lakes Golf Course is undersized and exceeds the critical water surface elevation by 0.17 feet during the modeled 100-year storm event. The goal of this project is to reduce the flood risk in the northwest portion of Heron Lakes Golf Course, provide habitat for project focal species, and increase connectivity for aquatic species.

Project Description

An undersized culvert currently connects a vegetated drainage channel to a pond in the northwest corner of the Heron Lakes Golf Course. This project will remove the existing 24-inch-diameter culvert, excavate and regrade the channel to match the cross section of the upstream reach, and install a larger crossing structure over a limited length of channel to provide golf cart access. The crossing structure will provide access for larger maintenance equipment. The cost estimate assumes a 10-foot-wide box culvert on concrete spread footings to accommodate the channel cross section width. Substituting this with an embedded circular pipe may result in some cost savings depending on the minimum circular culvert size that is required.

This project will implement low-lying plantings and shoreline grading to enhance shade and emergent vegetation while not impacting line of sight for golfers. The desired future habitat condition is shoreline emergent vegetation to benefit focal species (cinnamon teal, American beaver, and western painted turtle).



Prefabricated box culvert, image courtesy of Contech Engineered Solutions, LLC

Cost

The cost summary below contains the total project cost, including design and construction contingencies.

Item	Total Cost	Low Range (-30%)	High Range (+50%)
Golf Course Channel Daylighting	$330,000	$240,000	$500,000

Construction Year	Inflation	Low Estimate	High Estimate
2025	5%	$260,000	$530,000
2030	14%	$280,000	$570,000
2035	22%	$300,000	$610,000
2040	31%	$320,000	$660,000

DR #4 Force Ave Channel Daylighting

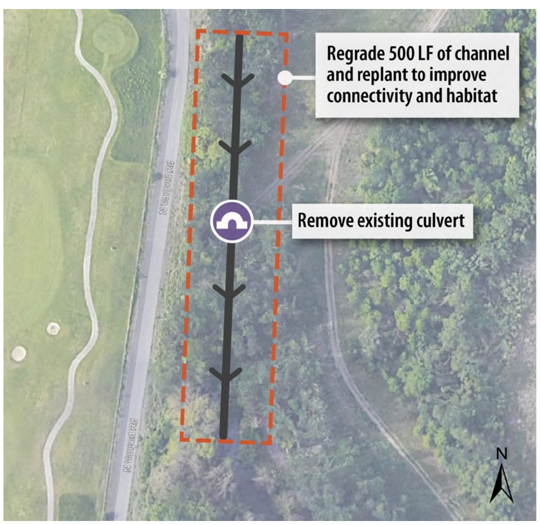
Identified Problem and Project Goals

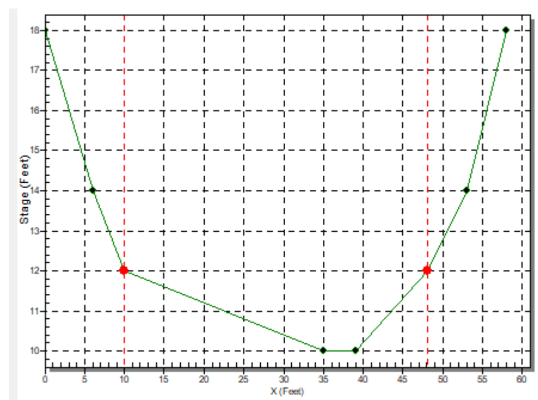
The culvert along Force Ave has sediment build-up that limits flow capacity and lacks enhanced habitat for project focal species. The goal of this project is to reduce flood risk along N Force Ave, provide habitat for project focal species, and increase connectivity for aquatic species.

Project Description

Remove the existing 485-foot long, 36-inch-diameter culvert and excavate and grade a channel to match the cross section of the adjacent stream reaches. This change will increase flow capacity to reduce the likelihood of upstream flooding while improving habitat. Implement plantings and shoreline grading to benefit a variety of species including bald eagle, little brown bat, American beaver, cinnamon teal, purple martin, western painted turtle, white-breasted nuthatch, willow flycatcher, yellow-breasted chat, and western bumble bee. The desired future habitat is riparian forest. Long-term maintenance and access will be included during project design.

Trenchless CIPP may be considered in replacement of the proposed channel as the project proceeds if the impact of channel daylighting is opposed by the property owner and associated stakeholders. Trenchless CIPP is expected to cost more than channel daylighting.





Cross Section of Adjacent Stream Reach

Cost

The cost summary below contains the total project cost, including design and construction contingencies.

Item	Total Cost	Low Range (-30%)	High Range (+50%)
Force Ave Channel Daylighting	$1,350,000	$950,000	$2,030,000

Construction Year	Inflation	Low Estimate	High Estimate
2025	5%	$1,000,000	$2,140,000
2030	14%	$1,090,000	$2,320,000
2035	22%	$1,160,000	$2,480,000
2040	31%	$1,250,000	$2,660,000

DR #5 Mud Lake Discharge Improvements

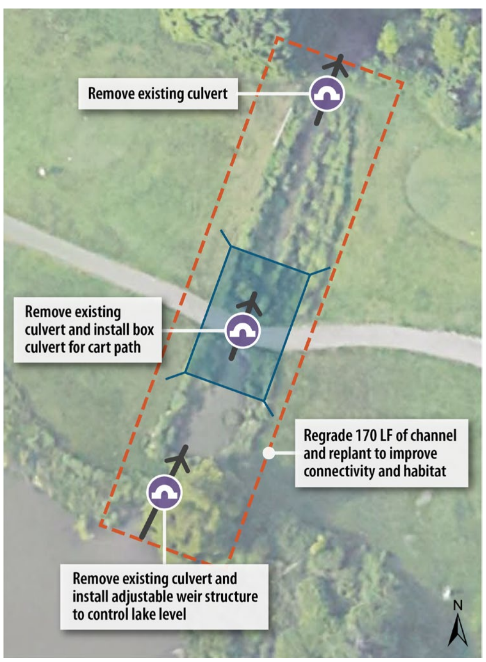
Identified Problem and Project Goals

Three culverts that discharge from Mud Lake are sediment-laden and collapsed. The goals of this project are to replace aging structures, mitigate flooding issues, and enhance habitat for native species.

Project Description

Three small culverts in series drain a lake and discharge to a vegetated drainage channel at the Heron Lakes Golf Course. This project will remove the existing collapsed culverts, excavate and regrade the channel to match the cross section of the adjacent reaches, and install a larger crossing structure to provide golf cart access. The crossing structure will provide access for larger maintenance equipment. A weir structure will be added to control the level of the lake.

The crossing structure should be sized to provide adequate width and loading capacity for the cart path and maintenance vehicles. The cost estimate assumes a 10-foot-wide box culvert on concrete spread foundation. Substituting this with an embedded circular pipe may results in some cost savings depending on the minimum circular culvert size that is required.



Implement low-lying plantings and shoreline grading where technically feasible to improve habitat for a variety of project focal species while maintaining the line of sight for golfers. The desired future habitat condition will include emergent shoreline vegetation and low shrub riparian vegetation to benefit songbirds.

Prefabricated box culvert, image courtesy of Contech Engineered Solutions, LLC

Cost

The cost summary below contains the total project cost including design and construction contingencies.

Item	Total Cost	Low Range (-30%)	High Range (+50%)
Mud Lake Discharge Culvert Replacement	$640,000	$450,000	$970,000

Construction Year	Inflation	Low Estimate	High Estimate
2025	5%	$480,000	$1,000,000
2030	14%	$520,000	$1,090,000
2035	22%	$550,000	$1,160,000
2040	31%	$590,000	$1,250,000

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES
700 NE MULTNOMAH, SUITE 1000 | PORTLAND, OR 97232 | P 503.233.2400, 360.694.5020

HWQ #1 PLANTINGS

Identified Problem and Project Goals

Healthy, vegetated riparian buffers are lacking in areas where there are gaps in streambank shade. The project goal is to provide plantings throughout the PEN1 basin to increase shading along waterways and improve habitat for the project focal species.

Project Description

This project will implement plantings to benefit the project's focal species. The associated figure illustrates areas identified by Portland Parks and Recreation and other local stakeholders as having planting potential within Heron Lakes Golf Course and PIR. Potential planting areas are categorized by the proposed planting type at each location. Plantings will be installed to develop several habitat types: forested riparian, shrub-riparian, and shoreline emergent.

As part of this project, it is important to maintain current land use and operations throughout the PEN1 basin. For example, plantings shown near the Heron Lakes Golf Course clubhouse may not be feasible as it is important to maintain visual access for operational purposes. Another limitation to consider as part of this project is the proximity of the plantings to the levee toe.

A detailed planting plan that includes topography, site features, and proposed location and size of plantings will be prepared for each planting location and must be approved by the property owner and associated stakeholders as part of any future planting implementation.

The table below includes plant options for each planting type and the focal species that benefit from each planting type.

Planting Type	Applicable Plants	Benefit to Focal Species
Tree Plantings > 15 feet fully grown	Ponderosa pine, Scouler's willow, Pacific willow, black cottonwood, quaking aspen, western red cedar, Oregon white oak, grand fir, big leaf maple	bald eagle, little brown bat, American beaver, purple martin, white-breasted nuthatch
Tree Plantings < 15 feet fully grown	cascara, serviceberry, Pacific madrone (specific to exposed, well-drained areas), red twig dogwood, black twinberry, vine maple, Pacific nine bark, red elderberry, red flowering currant, hawthorn, chokecherry, blue elderberry, Oregon crabapple, Pacific willow	bald eagle, little brown bat, purple martin, willow flycatcher, yellow-breasted chat, western bumble bee
Understory Shrubs < 5 feet fully grown	snowbrush, Douglas spirea, salal, kinnikinic (specific to high landscaped areas), snowberry, coyote brush, Oregon grape	willow flycatcher, yellow-breasted chat, western bumble bee
Flowers	California poppy, large leaved lupine, yellow monkey flower, Cascade penstemon, grasswidow, globe gilia, fireweed, phacelia, tanacetafolium	western bumble bee

Cost

The cost summary below includes the cost per acre for each planting type including design and construction contingencies. The total cost reflects all the shaded areas in the associated figure.

Item	Cost[a]/AC	AC	Total Cost	Low Range (-30%)	High Range (+50%)
Trees – Large	$72,900	4.6	$335,000	$230,000	$500,000
Trees – Small	$48,600	4.6	$224,000	$160,000	$340,000
Understory Shrubs – Under 5 feet tall	$36,500	8.0	$292,000	$204,000	$440,000
Flowers	$18,200	4.0	$73,000	$51,000	$110,000
		Subtotal	$924,000	$650,000	$1,400,000

[a] Costs include permitting, design, and construction contingencies. Planting plans and implementation that can be completed and managed by the BES Revegetation team reduce the cost by over 50%.

Planting Year	Inflation	Low Range (-30%)	High Range (-50%)
2025	5%	$690,000	$1,460,000
2030	14%	$750,000	$1,590,000
2035	22%	$800,000	$1,700,000
2040	31%	$860,000	$1,830,000

HWQ #2 Shoreline Grading

Identified Problem and Project Goals

Emergent herbaceous habitat in the PEN1 basin is scarce. The goal of this project is to implement shoreline grading and planting throughout the basin to promote more complex, emergent vegetation and improve habitat for the project focal species.

Project Description

This project will implement shoreline grading along several water features throughout Heron Lakes Golf Course to create emergent herbaceous habitat to benefit the project focal species cinnamon teal and western painted turtle. The associated figure illustrates areas identified by Portland Parks and Recreation and other local stakeholders as having shoreline grading/planting potential within the Heron Lakes Golf Course. As part of this project, it is important to maintain current land use and operations throughout the golf course and minimize any disruption to the daily golf operation. A detailed planting plan that includes topography, site features, and proposed location and size of plantings will be prepared for all grading locations and must be approved by the property owner and associated stakeholders as part of any future grading/planting implementation. The desired future habitat condition is emergent wetland around existing ponds.

The table below includes plant options emergent wetland habitat around existing ponds and the focal species that benefit this planting type.

Planting Type	Applicable Plants	Benefit to Focal Species
Emergent Wetland Habitat	slough sedge, common cattail, Pacific rush, dagger-leaf rush, tufted hair grass, deer fern, Pacific water leaf, common duck weed, northern water plantain, soft rush, water parsley, common spike rush, wapato, tule	cinnamon teal, western painted turtle

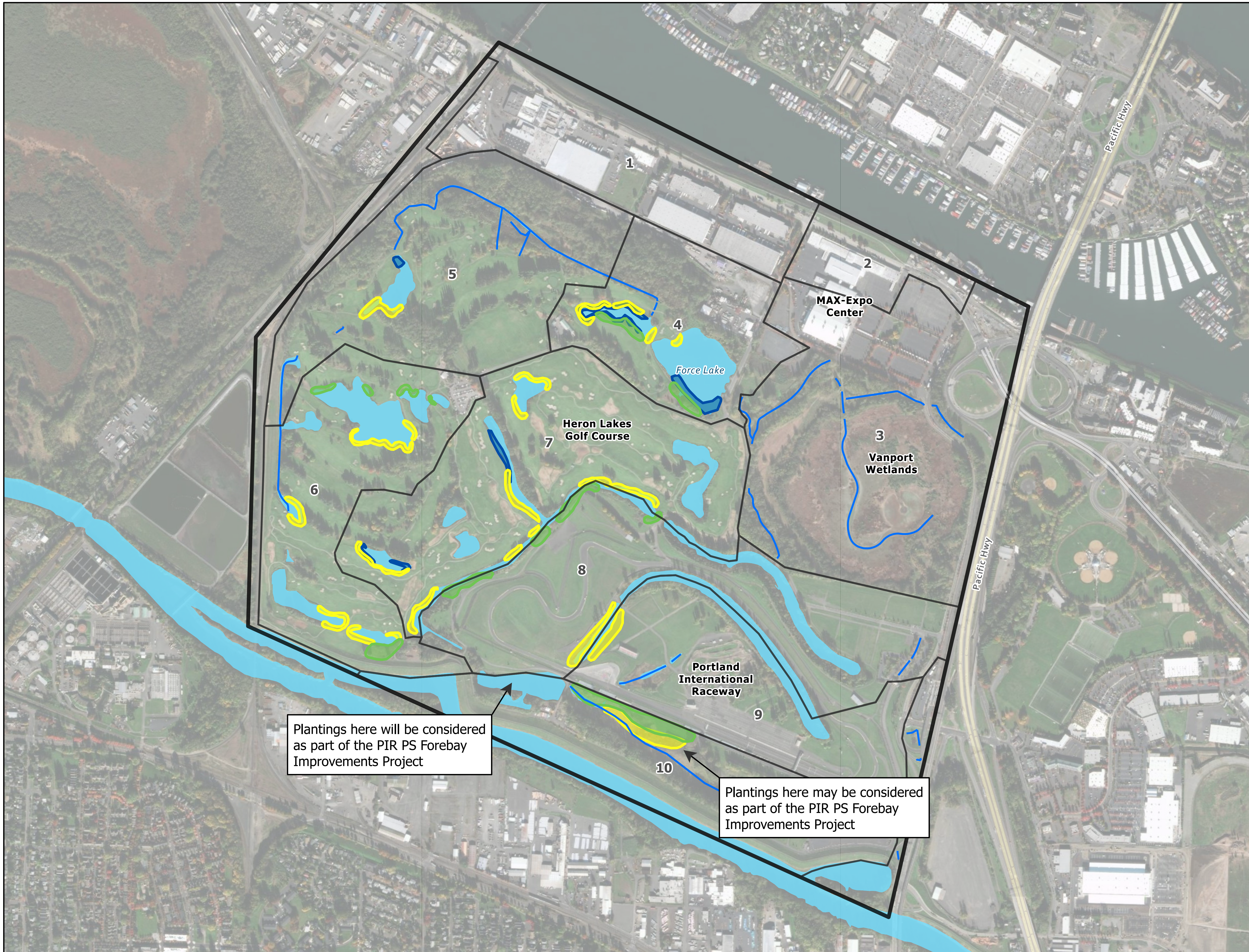
Cost

The cost summary below includes the cost per acre for shoreline grading and plantings including design and construction contingencies. The total cost reflects all the “pond habitat improvement” shaded areas (3 acres total) in the associated figure.

Item	Cost/AC	AC	Total Cost	Low Range (-30%)	High Range (+50%)
Shoreline Grading	$702,000	3.0	$2,110,000	$1,480,000	$3,170,000
Plantings	$24,000	3.0	$72,000	$51,000	$108,000
		Subtotal	**$2,180,000**	**$1,530,000**	**$3,280,000**

Construction Year	Inflation	Low Range	High Range
2025	5%	$1,610,000	$3,450,000
2030	14%	$1,750,000	$3,740,000
2035	22%	$1,870,000	$4,010,000
2040	31%	$2,010,000	$4,300,000

HWQ #1: Plantings Project and HWQ #2: Shoreline Grading Project



- Potential Planting Area - Tree and Understory
- Potential Planting Area - Understory Only
- Potential Planting Area - Pond Habitat Improvement
- Open Channel
- Waterbody
- Drainage Basin Boundary
- PEN 1 - District Boundary

This figure shows all planting potential within Heron Lakes Golf Course and the Portland International Raceway

Note: A detailed planting plan that includes topography, site features, and proposed location and size of plantings is required for design. The planting plan must be approved by the owner prior to implementation.

Drainage Subbasin	Trees	Understory Plantings	Pond Habitat
1	N/a	N/a	N/a
2	N/a	N/a	N/a
3	N/a	N/a	N/a
4	1.61 Acres	1.11 Acres	2.03 Acres
5	N/a	0.83 Acres	0.16 Acres
6	1.75 Acres	2.47 Acres	N/a
7	0.29 Acres	3.36 Acres	0.76 Acres
8	2.19 Acres	1.10 Acres	N/a
9	0.01 Acres	1.00 Acres	N/a
10	3.25 Acres	2.03 Acres	N/a

Date: 3/25/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

700 NE MULTNOMAH, SUITE 1000 | PORTLAND, OR 97232 | P 503.233.2400, 360.694.5020

HWQ #3 PEN1 Habitat Improvements

Identified Problem and Project Goals

Habitat is lacking with the PEN1 basin for several native species including the purple martin, western painted turtle, little brown bat, yellow-breasted chat, and western bumble bee. The goal of this project is to increase and/or enhance habitat for the project focal species.

Project Description

This project will install nesting gourds for purple martin, basking structures for turtles, roosting boxes for bats, and habitat piles for white-breasted nuthatch, yellow-breasted chat, and western bumble bee. The associated figure illustrates the recommended locations for habitat improvements within the PEN1 basin. Exact siting of all habitat improvements will be coordinated with the property owner and associated stakeholders. For habitat improvements placed within Heron Lakes Golf Course, locations will be determined to minimize disruptions to daily golf operations. The desired future habitat condition is nesting and roosting/basking habitat for focal species.




Left to right: purple martin nesting gourd structure, turtle basking log, bat roosting box, habitat pile.

Cost

The cost summary below includes the cost for each structure, including design and construction contingencies. The total cost reflects all the recommended locations identified in the figure.

Item	Cost/Structure	Structures	Total Cost	Low Range (-30%)	High Range (+50%)
Purple martin nesting gourd structure	$2,500	2	$5,000	$3,500	$7,500
Turtle basking logs	$2,500	3	$7,500	$5,300	$11,300
Bat Roosting boxes	$2,100	2	$4,200	$2,900	$6,300
Habitat piles[a]	$2,500	3	$7,500	$5,300	$11,300
		Subtotal	$24,000	$17,000	$36,000

[a]Cost of habitat piles vary based on availability of existing debris on site or nearby

Construction Year	Inflation	Low Range	High Range
2025	5%	$18,000	$38,000
2030	14%	$20,000	$42,000
2035	22%	$21,000	$44,000
2040	31%	$23,000	$48,000

HWQ #3: PEN1 Habitat Improvements Project

- Pump Station
- Waterbody
- Drainage Basin Boundary
- PEN 1 - District Boundary

Habitat Features

- Bat Roosting Box
- Habitat Pile
- Purple Martin Nest Box
- Turtle Basking Log

Date: 9/21/2022
Sources: City of Portland (BES), Maxar
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 250 500 1,000 1,500 Feet

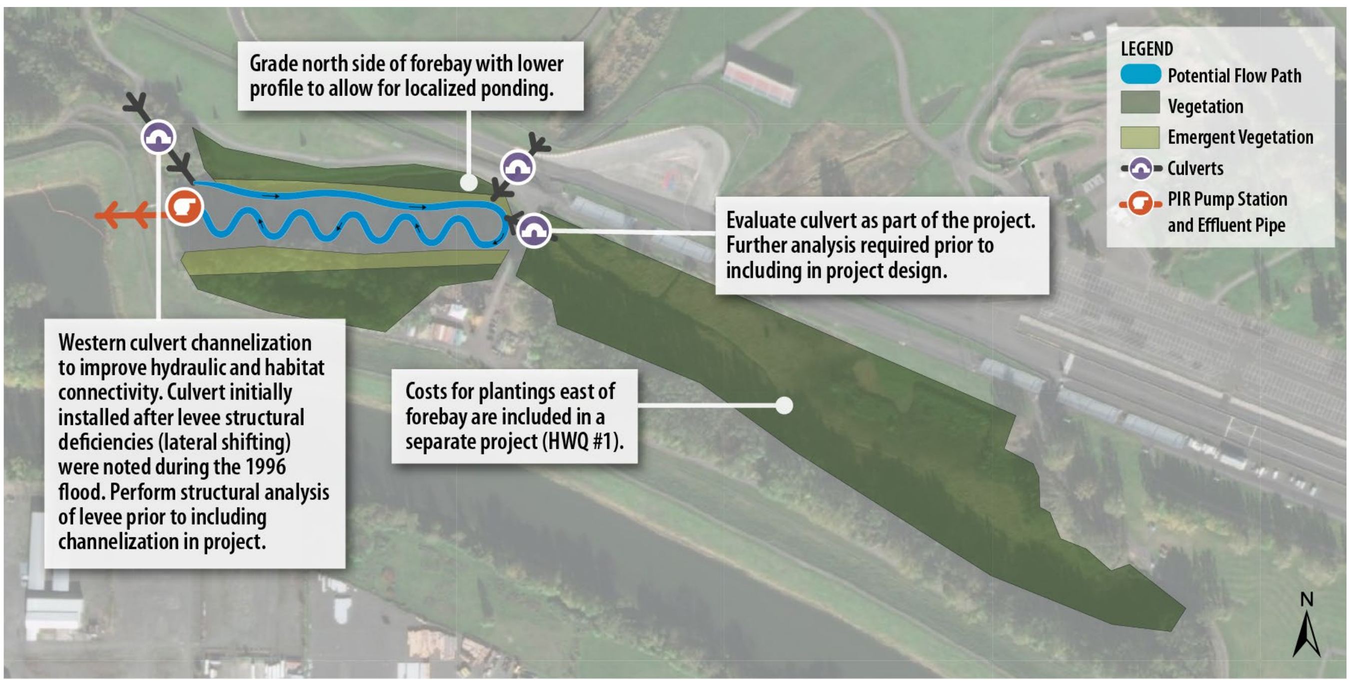
HWQ #4 PIR PS Forebay Improvements

Identified Problem and Project Goals

The forebay of the PIR PS has noticeably high turbidity and sediment with limited shading. The goal of this project is to implement retrofits, including grading and planting, to improve habitat and water quality within the PIR PS Forebay and the Columbia Slough.

Project Description

Retrofit the existing forebay by lengthening and meandering the flow path to allow for additional sediment deposition. Special consideration will need to be provided during design to create and control the velocity profile along each channel to promote settling while reducing short-circuiting. Upland and emergent vegetation plantings should be implemented wherever feasible, as shown in the figure, to provide shade and to act as a buffer from the raceway. The desired future habitat condition of this area is emergent/ponded habitat with a riparian buffer of low shrubs and trees. The culverts identified in the figure below shall be evaluated for removal and channelization feasibility.



Cost

The cost summary below contains the total project cost including design and construction contingencies. The total cost reflects improvements within the existing forebay as shown in the associated figure.

Item	Total Cost	Low Range (-30%)	High Range (+50%)
PIR Forebay WQ Improvements	$3,130,000	$2,200,000	$4,700,000

Construction Year	Inflation	Low Range	High Range
2025	5%	$2,310,000	$4,940,000
2030	14%	$2,510,000	$5,360,000
2035	22%	$2,690,000	$5,740,000
2040	31%	$2,890,000	$6,160,000

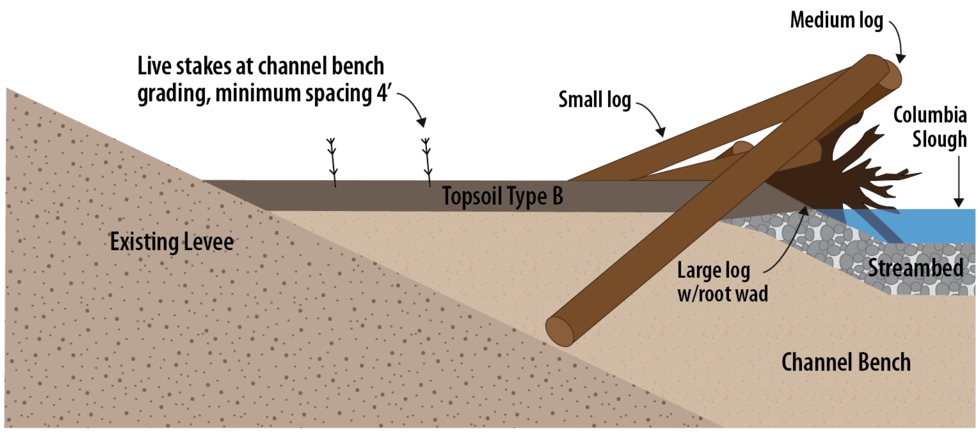
HWQ #5 Lower Slough Habitat Enhancements

Identified Problem and Project Goals

The Lower Columbia Slough lacks the complex habitat necessary for listed salmonid species known to use the system. The goal of this project is to improve habitat in the Lower Columbia Slough by adding levee-friendly habitat elements along the slough side of the levee bank adjacent to the PEN 1 basin and provide resting and feeding locations for juvenile salmonids.

Project Description

This project will install complex woody habitat along the north bank of the lower slough adjacent to the PEN1 basin. Implement channel bank grading as technically feasible at large woody debris structure locations to create benches to anchor large wood placements outside of the levee design profile and to add complexity to the lower slough. Maintenance Access for MCDD Operations staff will be maintained during project construction and after project completion. Vegetate all benched areas with plantings that meet U.S. Army Corps of Engineers requirements. Widths and slopes of the project will also need to meet USACE requirements. A Section 408 determination from USACE may also be required to verify that the large wood does not create a shortened seepage path to the interior of the PEN1 levee system. The desired future habitat condition is to provide complex habitat for juvenile salmonids. Additionally, low benches will provide riparian habitat that will benefit focal species such as the American beaver and songbirds.



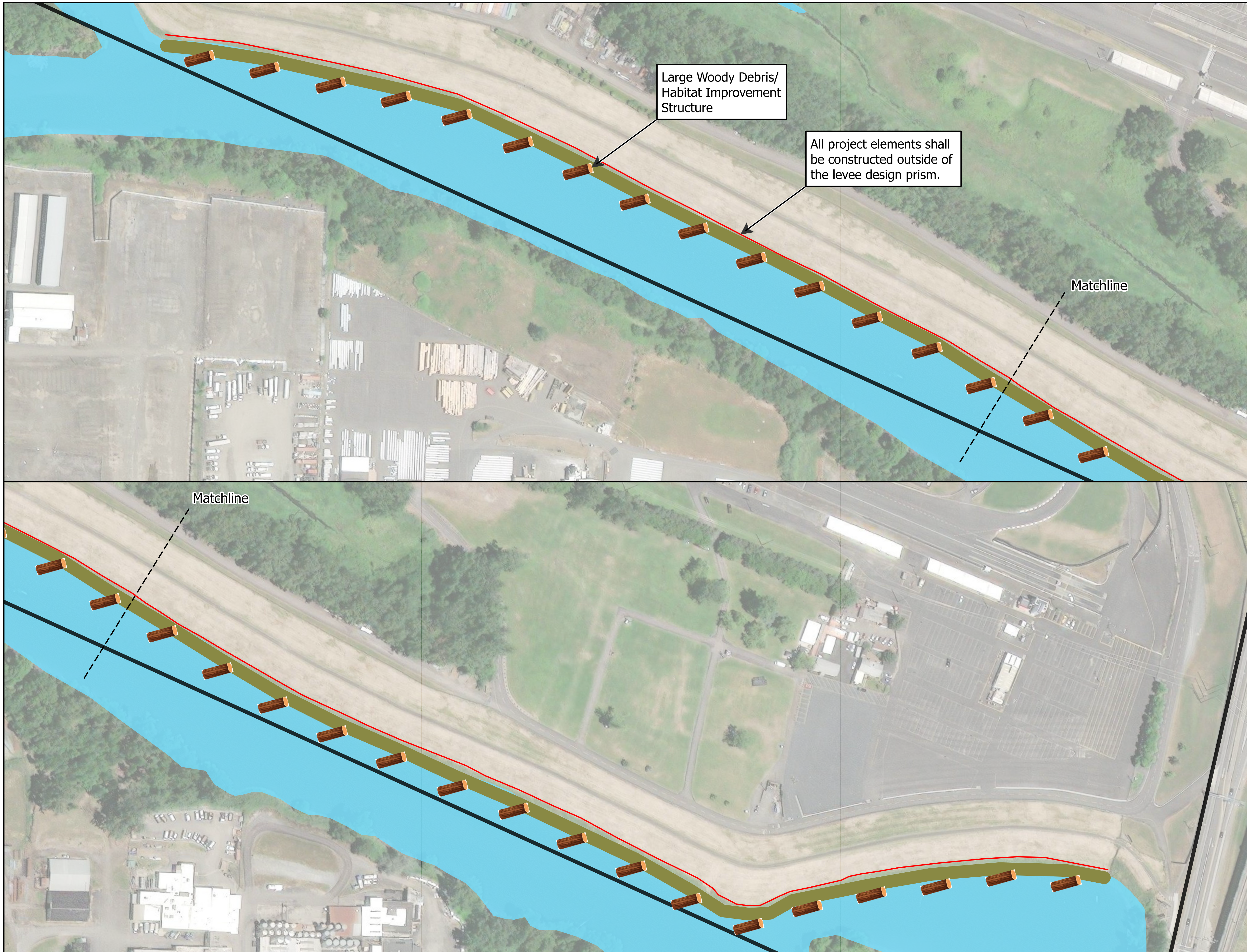
Cost

The cost summary below includes the cost for a large wood structure with channel bench grading at each location including design and construction contingencies. The total cost reflects all the marked locations in the associated figure.

Item	Cost/Location	QTY	Total Cost	Low Range (-30%)	High Range (+50%)
LWD Structure and Channel Bench Grading	$112,700	30	$3,380,000	$2,370,000	$5,070,000

Construction Year	Inflation	Low Range	High Range
2025	5%	$2,490,000	$5,330,000
2030	14%	$2,710,000	$5,780,000
2035	22%	$2,900,000	$6,190,000
2040	31%	$3,110,000	$6,650,000

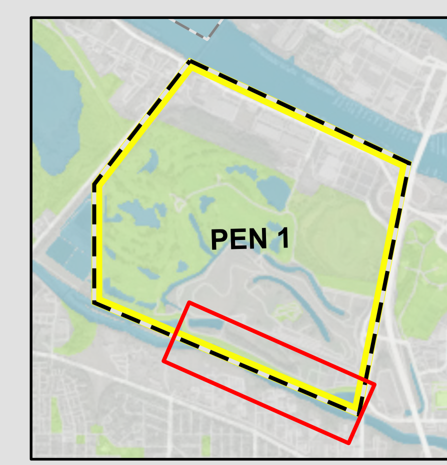
HWQ #5: Lower Slough Habitat Enhancements Project



Habitat Improvement Structure
Approximate Levee Prism
Channel Bench
PEN 1 - District Boundary
Waterbody
Matchline

Note: Habitat improvement structures are shown at 150-foot intervals, final locations will be determined during the design of the project

Project Location



Date: 6/20/2022
Sources: City of Portland (BES), Maxar, Microsoft
PCS: NAD 1983 HARN StatePlane Oregon North FIPS 3601 Feet Intl
Disclaimer: This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes.

0 50 100 200 300 Feet

Levee-Friendly Habitat Examples

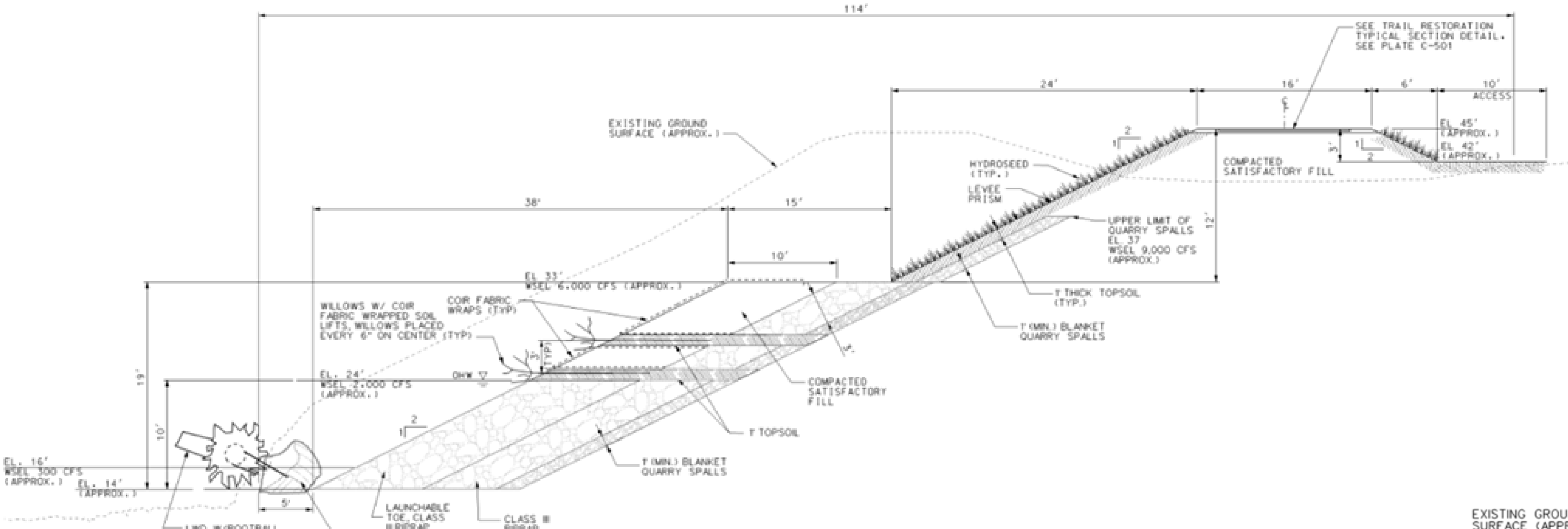
Project design will require review from the Portland District of the US Army Corps of Engineers. Select information on levee-friendly habitat features is attached to this fact sheet. It is not guaranteed that the Portland District of the US Army Corps of Engineers will approve what has been approved by other districts for other projects.

The following example illustrates levee-friendly habitat elements through the use of large woody debris and habitat benches. The example design below may need to be altered for HWQ #5 to meet local regulatory guidelines. For example, to it does not currently appear that metal chains would be an accepted by the Oregon Department of Fish and Wildlife (ODFW) or the Oregon Department of State Lands (DSL) as an acceptable means of securing woody debris.

USACE/ King County Lower Green River Levee Rehab Projects, February 14-2012

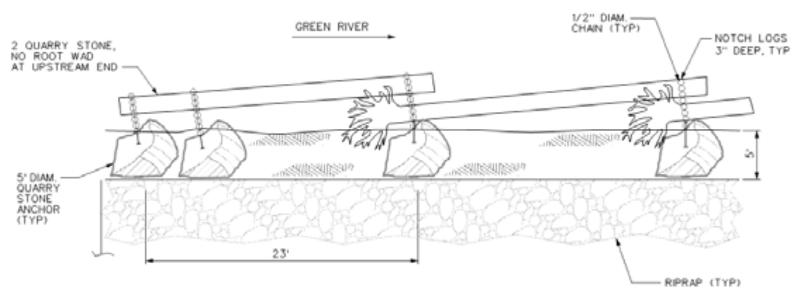
Kent Shops/Narita Levee:
Damaged 2006
Repaired 2007,
$6.6 m (est.),
USACE/King County cost shared
3,600 LF setback FEMA accredited levee, w/bioengineering, habitat benches, riprap scour protection,
130 ea. 5 t boulder anchored LWD facing.

Meyers Golf Levee:
Damaged 2006
Repaired 2007
$2.6 m (est.), USACE/King County cost shared
1,700 LF setback FEMA accredited levee, w/bioengineering, habitat benches, riprap scour protection
60 ea. 5 t boulder anchored LWD facing.

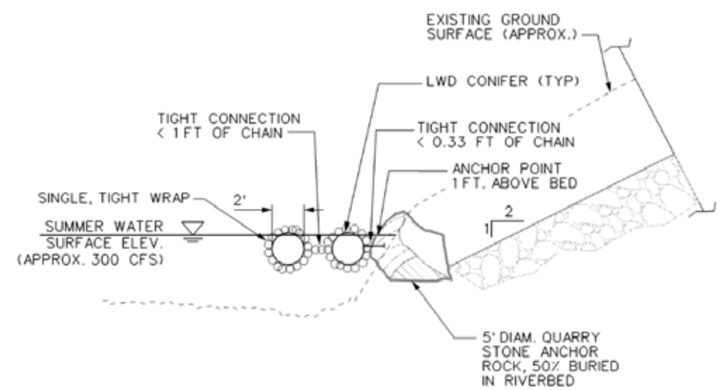


KENT SHOPS - NARITA TYPICA

NOT TO SCALE



UPSTREAM END LOG PLACEMENT (PLAN VIEW)



TYPICAL LOG PLACEMENT (SECTION VIEW)

NOT TO SCALE

Appendix H

Cost Opinions

DR #1 PIR Pump Station Replacement

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	150	3000	$450,000
Structure Installation				
Demo Pump Station, Discharge Pipes, Outfall	LS	250,000	1	$250,000
Construct Pump Station Structure	CY	1,200	400	$480,000
Foundation Piles	EA	15,000	26	$390,000
Pumps (125hp Vertical Mixed Flow)	EA	210,000	3	$630,000
Pump Controls and VFDs	LS	360,000	1	$360,000
Louvers, Fans, and Heating (cooling may be recommended in a portion for VFDs)	LS	30,000	1	$30,000
30" Flow Meter (includes electrical and SCADA connections) and FCA	EA	35,000	3	$105,000
Dewatering and Isolation	EA	500,000	1	$500,000
Bypass Pumping (used during a portion of construction)	EA	250,000	1	$250,000
Generator (600kW) and Automatic Transfer Switch	EA	375,000	1	$375,000
Trash Rack w/ Debris Handling	EA	175,000	3	$525,000
Pipe Unit Cost				
HDPE Pipe w/ Fittings and Supports (30")	LF	900	250	$225,000
Energy Dissipator, pile supported, w/ 140' of 30" Pipe	LS	400,000	1	$400,000
Project Sub-Total				$4,970,000
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$746,000
Mobilization/Demobilization	LS	10%		$497,000
Utility Service and/or Relocation, Coordination Re: Natural Gas Line	LS	5%		$249,000
Erosion Control	LS	2%		$100,000
Overhead and Profit	LS	20%		$994,000
Estimating Contingency	LS	30%		$1,491,000
Market Climate	LS	10%		$497,000
Construction Item Total				$9,544,000
Design, Permitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	5%		$478,000
Engineering,Physical Modeling, Survey, Geotechnical	LS	15%		$1,432,000
Permitting, Enviromental Investigation, and Approvals	LS	7%		$669,000
Construction Administration	LS	5%		$478,000
Project Total			TOTAL	$12,600,000

Low	$8,820,000
High	$18,900,000

Year	Inflation	Low	High
2025	5%	$9,270,000	$19,850,000
2030	14%	$10,060,000	$21,550,000
2035	22%	$10,770,000	$23,060,000
2040	31%	$11,560,000	$24,760,000

DR #1 PIR Pump Station Replacement - With Portable Generator Hookup

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	150	3000	$450,000
Structure Installation				
Demo Pump Station, Discharge Pipes, Outfall	LS	250,000	1	$250,000
Construct Pump Station Structure	CY	1,200	400	$480,000
Foundation Piles	EA	15,000	26	$390,000
Pumps (125hp Vertical Mixed Flow)	EA	280,000	3	$840,000
Pump Controls and VFDs	LS	370,000	1	$370,000
Louvers, Fans, and Heating (cooling may be recommended in a portion for VFDs)	LS	30,000	1	$30,000
30" Flow Meter (includes electrical and SCADA connections) and FCA	EA	35,000	3	$105,000
Dewatering and Isolation	EA	500,000	1	$500,000
Bypass Pumping (used during a portion of construction)	EA	250,000	1	$250,000
Portable Generator Hookup and Manual Transfer Switch	EA	50,000	1	$50,000
Trash Rack w/ Debris Handling	EA	175,000	2	$350,000
Pipe Unit Cost				
HDPE Pipe w/ Fittings and Supports (30")	LF	900	250	$225,000
Energy Dissipater w/ 140' of 30" Pipe	LS	400,000	1	$400,000
Project Sub-Total				$4,690,000
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$704,000
Mobilization/Demobilization	LS	10%		$469,000
Utility Service and/or Relocation, Coordination Re: Natural Gas Line	LS	5%		$235,000
Erosion Control	LS	2%		$94,000
Overhead and Profit	LS	20%		$938,000
Estimating Contingency	LS	30%		$1,407,000
Market Climate	LS	10%		$469,000
Construction Item Total				$9,006,000
Design, Permitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	5%		$451,000
Engineering,Physical Modeling, Survey, Geotechnical	LS	15%		$1,351,000
Permitting	LS	7%		$631,000
Construction Administration	LS	5%		$451,000
Project Total			TOTAL	$11,890,000

Low	$8,330,000
High	$17,840,000

Year	Inflation	Low	High
2025	5%	$8,750,000	$18,740,000
2030	14%	$9,500,000	$20,340,000
2035	22%	$10,170,000	$21,770,000
2040	31%	$10,920,000	$23,380,000

DR #2 Vanport Pump Station Replacement

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	75	1000	$75,000
Structure Installation				
Demo Pump Station, Discharge Pipe, and Discharge Sump	LS	50,000	1	$50,000
Construct Pump Station Structure	CY	1,200	100	$120,000
Foundation Piles (may not be needed at this location)	EA	15,000	8	$120,000
Pumps (30hp Submersible Axial Flow Pumps) with Discharge Column	EA	80,000	2	$160,000
Pump Controls, VFDs, and Canopy	LS	170,000	1	$170,000
12" Flow Meter (includes electrical and SCADA connections) and FCA	EA	8,000	2	$16,000
Dewatering and Isolation	EA	100,000	1	$100,000
Bypass Pumping (used during a portion of construction)	EA	75,000	1	$75,000
Generator (150kW) and Automatic Transfer Switch	EA	125,000	1	$125,000
Trash Rack w/ Debris Handling	EA	150,000	1	$150,000
Pipe Unit Cost				
HDPE Pipe w/ Fittings and Supports (24")	LF	250	200	$50,000
Grout Pipe in Existing 27" Culvert	LS	15,000	1	$15,000
Project Sub-Total				$1,161,000
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$175,000
Mobilization/Demobilization	LS	10%		$117,000
Utility Service and/or Relocation	LS	5%		$59,000
Erosion Control	LS	5%		$59,000
Overhead and Profit	LS	20%		$233,000
Estimating Contingency	LS	30%		$349,000
Market Climate	LS	10%		$117,000
Construction Item Total				$2,270,000
Design, Permitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	10%		$227,000
Engineering, Permitting, Survey, Geotechnical	LS	25%		$568,000
Construction Administration	LS	5%		$114,000
Project Total			TOTAL	$3,180,000

Low	$2,230,000
High	$4,770,000

Year	Inflation	Low	High
2025	5%	$2,350,000	$5,010,000
2030	14%	$2,550,000	$5,440,000
2035	22%	$2,730,000	$5,820,000
2040	31%	$2,930,000	$6,250,000

DR #2 Vanport Pump Station Replacement - With Portable Generator Hookup

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	75	1000	$75,000
Structure Installation				
Demo Pump Station, Discharge Pipe, and Discharge Sump	LS	50,000	1	$50,000
Construct Pump Station Structure	CY	1,200	100	$120,000
Foundation Piles (may not be needed at this location)	EA	15,000	8	$120,000
Pumps (30hp Submersible Axial Flow Pumps) with Discharge Column	EA	80,000	2	$160,000
Pump Controls, VFDs, and Canopy	LS	170,000	1	$170,000
12" Flow Meter (includes electrical and SCADA connections) and FCA	EA	8,000	2	$16,000
Dewatering and Isolation	EA	100,000	1	$100,000
Bypass Pumping (used during a portion of construction)	EA	75,000	1	$75,000
Portable Generator Hookup and Manual Transfer Switch	EA	25,000	1	$25,000
Trash Rack w/ Debris Handling	EA	150,000	1	$150,000
Pipe Unit Cost				
HDPE Pipe w/ Fittings and Supports (24")	LF	250	200	$50,000
Grout Pipe in Existing 27" Culvert	LS	15,000	1	$15,000
Project Sub-Total				$1,061,000
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$160,000
Mobilization/Demobilization	LS	10%		$107,000
Utility Service and/or Relocation	LS	5%		$54,000
Erosion Control	LS	5%		$54,000
Overhead and Profit	LS	20%		$213,000
Estimating Contingency	LS	30%		$319,000
Market Climate	LS	10%		$107,000
Construction Item Total				$2,075,000
Design, Permitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	10%		$208,000
Engineering, Permitting, Survey, Geotechnical	LS	25%		$519,000
Construction Administration	LS	5%		$104,000
Project Total			TOTAL	$2,906,000

Low	$2,040,000
High	$4,360,000

Year	Inflation	Low	High
2025	5%	$2,150,000	$4,580,000
2030	14%	$2,330,000	$4,980,000
2035	22%	$2,490,000	$5,320,000
2040	31%	$2,680,000	$5,720,000

DR #3 Golf Course Culvert Channel Daylighting

DESIGN ASSUMPTIONS

Remove existing culvert and replace with open channel

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	$ 50	110	$5,500
Clearing and Grubbing	LS	$ 25,000	1	$25,000
Channel Grading	SY	$ 50	100	$5,000
Structure Installation				
Box Culvert	LS	$ 50,000	1	$50,000
Structural Backfill	CY	$ 50	60	$3,000
Non-Structural Backfill	CY	$ 30	80	$2,400
Streambed Material	CY	$ 50	10	$500
Path Repair	SF	$ 50	500	$25,000
Plantings	AC	$ 37,000	0.1	$3,700
Project Sub-Total				$120,100
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$18,015
Mobilization/Demobilization	LS	10%		$12,010
Utility Service and/or Relocation, Coordination Re: Natural Gas Line	LS	5%		$6,005
Erosion Control	LS	2%		$2,402
Overhead and Profit	LS	20%		$24,020
Estimating Contingency	LS	30%		$36,030
Market Climate	LS	10%		$12,010
Construction Item Total				$230,592
Design, Premitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	5%		$11,530
Engineering, Permitting, Survey, Geotechnical	LS	30%		$69,178
Construction Administration	LS	5%		$11,530
Project Total			TOTAL	$330,000

Low	$240,000
High	$500,000

Year	Inflation	Low	High
2025	5%	$260,000	$530,000
2030	14%	$280,000	$570,000
2035	22%	$300,000	$610,000
2040	31%	$320,000	$660,000

DR #4 Force Ave Channel Daylighting

DESIGN ASSUMPTIONS

Remove existing culvert and replace with open channel

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	$ 50	5700	$285,000
Clearing and Grubbing	LS	$ 25,000	1	$25,000
Channel Grading	SY	$ 50	3500	$175,000
Structure Installation				
Streambed Material	CY	$ 50	150	$7,500
Plantings	AC	$ 37,000	0.2	$7,400
Project Sub-Total				$499,900
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$74,985
Mobilization/Demobilization	LS	10%		$49,990
Utility Service and/or Relocation, Coordination Re: Natural Gas Line	LS	5%		$24,995
Erosion Control	LS	2%		$9,998
Overhead and Profit	LS	20%		$99,980
Estimating Contingency	LS	30%		$149,970
Market Climate	LS	10%		$49,990
Construction Item Total				$959,808
Design, Premitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	5%		$47,990
Engineering, Permitting, Survey, Geotechnical	LS	30%		$287,942
Construction Administration	LS	5%		$47,990
Project Total			TOTAL	$1,350,000

Low	$950,000
High	$2,030,000

Year	Inflation	Low	High
2025	5%	$1,000,000	$2,140,000
2030	14%	$1,090,000	$2,320,000
2035	22%	$1,160,000	$2,480,000
2040	31%	$1,250,000	$2,660,000

DR #5 Mud Lake Discharge Improvements

DESIGN ASSUMPTIONS

Remove existing culverts and replace with box culvert and open channel

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Earthwork				
General Earthwork/Excavation	CY	$ 50	1000	$50,000
Clearing and Grubbing	LS	$ 25,000	1	$25,000
Channel Grading	SY	$ 50	1000	$50,000
Structure Installation				
Box Culvert	LS	$ 50,000	1	$50,000
Adjustable Weir Structure	LS	$ 20,000	1	$20,000
Structural Backfill	CY	$ 50	60	$3,000
Non-Structural Backfill	CY	$ 30	80	$2,400
Streambed Material	CY	$ 50	50	$2,500
Path Repair	SF	$ 50	500	$25,000
Plantings	AC	$ 37,000	0.2	$7,400
Project Sub-Total				$235,300
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$35,295
Mobilization/Demobilization	LS	10%		$23,530
Utility Service and/or Relocation, Coordination Re: Natural Gas Line	LS	5%		$11,765
Erosion Control	LS	2%		$4,706
Overhead and Profit	LS	20%		$47,060
Estimating Contingency	LS	30%		$70,590
Market Climate	LS	10%		$23,530
Construction Item Total				$451,776
Design, Premitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	5%		$22,589
Engineering, Permitting, Survey, Geotechnical	LS	30%		$135,533
Construction Administration	LS	5%		$22,589
Project Total			TOTAL	$640,000

Low	$450,000
High	$960,000

Year	Inflation	Low	High
2025	5%	$480,000	$1,010,000
2030	14%	$520,000	$1,100,000
2035	22%	$550,000	$1,180,000
2040	31%	$590,000	$1,260,000

HWQ #1 PEN1 Plantings

DESIGN ASSUMPTIONS

Provide plantings throughout PEN1 - This assumes all potential plantings areas to be implemented

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Plantings, including Earthwork				
Trees > 15-ft tall, 6-ft to 10-ft high at planting	AC	$ 30,000	4.6	$138,000
Trees < 15-ft tall, 4-ft to 6-ft high at planting	AC	$ 20,000	4.6	$92,000
Understory Shrubs < 5-ft tall	AC	$ 15,000	8	$120,000
Flowers	AC	$ 7,500	4	$30,000
Project Sub-Total				$380,000
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$57,000
Mobilization/Demobilization	LS	10%		$38,000
Erosion Control	LS	2%		$7,600
Overhead and Profit	LS	20%		$76,000
Estimating Contingency	LS	30%		$114,000
Market Climate	LS	10%		$38,000
Construction Item Total				$710,600
Design, Premitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	5%		$35,530
Engineering, Permitting, Survey, Geotechnical	LS	20%		$142,120
Construction Administration	LS	5%		$35,530
Project Total			TOTAL	$924,000

Low	$650,000
High	$1,390,000

Year	Inflation	Low	High
2025	5%	$690,000	$1,460,000
2030	14%	$750,000	$1,590,000
2035	22%	$800,000	$1,700,000
2040	31%	$860,000	$1,830,000

HWQ #2 PEN1 Shoreline Grading

DESIGN ASSUMPTIONS

Provide shoreline grading and plantings throughout PEN1 - This assumes all potential areas to be implemented

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Earthwork				
Excavation (assuming average excavation depth of 2-ft across available area)	CY	$ 30	9520	$285,600
Fill (asumed all excavated fill is reused)	TN	$ 20	21900	$438,000
Grading	SY	$ 10	14280	$142,800
Plantings, including Earthwork				
Pond Habitat	AC	$ 10,000	3	$30,000
Project Sub-Total				$896,400
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$134,460
Mobilization/Demobilization	LS	10%		$89,640
Erosion Control	LS	2%		$17,928
Overhead and Profit	LS	20%		$179,280
Estimating Contingency	LS	30%		$268,920
Market Climate	LS	10%		$89,640
Construction Item Total				$1,676,268
Design, Premitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	5%		$83,813
Engineering, Permitting, Survey, Geotechnical	LS	20%		$335,254
Construction Administration	LS	5%		$83,813
Project Total			TOTAL	$2,180,000

Low	$1,530,000
High	$3,280,000

Year	Inflation	Low	High
2025	5%	$1,610,000	$3,450,000
2030	14%	$1,750,000	$3,740,000
2035	22%	$1,870,000	$4,010,000
2040	31%	$2,010,000	$4,300,000

HWQ #3 PEN1 Habitat Improvements

DESIGN ASSUMPTIONS

Provide habitat improvements throughout PEN1

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Habitat Improvements				
Purple Martin Nesting Gourd Structure	EA	$ 1,000	2	$2,000
Turtle Basking Logs	EA	$ 1,000	3	$3,000
Bat Roosting Box	EA	$ 850	2	$1,700
Habitat Piles	EA	$ 1,000	3	$3,000
Project Sub-Total				$9,700
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$1,455
Mobilization/Demobilization	LS	10%		$970
Erosion Control	LS	2%		$194
Overhead and Profit	LS	20%		$1,940
Estimating Contingency	LS	30%		$2,910
Market Climate	LS	10%		$970
Construction Item Total				$18,139
Design, Permitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	5%		$907
Engineering, Permitting, Survey, Geotechnical	LS	20%		$3,628
Construction Administration	LS	5%		$907
Project Total			TOTAL	$24,000

Low	$17,000
High	$36,000

Year	Inflation	Low	High
2025	5%	$18,000	$38,000
2030	14%	$20,000	$42,000
2035	22%	$21,000	$44,000
2040	31%	$23,000	$48,000

HWQ #4 PIR PS Forebay Improvements

DESIGN ASSUMPTIONS

Retrofit the existing forebay to improve water quality and habitat

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Earthwork				
Excavation	CY	$ 30	11200	$336,000
Fill	TN	$ 20	25700	$514,000
Grading	SY	$ 10	16800	$168,000
Forebay Retrofits				
Plantings	AC	$ 37,000	2.1	$77,700
Seeding	AC	$ 3,200	0.7	$2,240
Project Sub-Total				$1,097,940
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$164,691
Mobilization/Demobilization	LS	10%		$109,794
Erosion Control	LS	5%		$54,897
Overhead and Profit	LS	20%		$219,588
Estimating Contingency	LS	30%		$329,382
Market Climate	LS	10%		$109,794
Construction Item Total				$2,086,086
Design, Permitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	5%		$104,304
Culvert Evaluation	LS	10%		$208,609
Engineering, Permitting, Survey, Geotechnical	LS	30%		$625,826
Construction Administration	LS	5%		$104,304
Project Total			TOTAL	$3,130,000

Low	$2,200,000
High	$4,700,000

Year	Inflation	Low	High
2025	5%	$2,310,000	$4,940,000
2030	14%	$2,510,000	$5,360,000
2035	22%	$2,690,000	$5,740,000
2040	31%	$2,890,000	$6,160,000

HWQ #5 Lower Slough Habitat Enhancements

DESIGN ASSUMPTIONS

Install levee-friendly habitat elements along the levee

ITEM	UNIT	Unit Cost	Quantity	Total Cost
Earthwork				
Clearing/ Grubbing	LS	$ 10,000	1	$10,000
General Earthwork/Excavation	CY	$ 30	3000	$90,000
Fill	TN	$ 20	7000	$140,000
Grading	SY	$ 10	3000	$30,000
Geotextile	SY	$ 30	2500	$75,000
Seeding	AC	$ 3,200	0.6	$1,920
Topsoil	CY	$ 30	500	$15,000
Aggregate	CY	$ 30	3000	$90,000
Large Woody Debris Structure	EA	$ 7,000	30	$210,000
Anchors	EA	$ 4,000	150	$600,000
Turtle Habitat	LS	$ 10,000	1	$10,000
Pollution Control Plan	LS	$ 10,000	1	$10,000
Turbididty Monitoring	LS	$ 10,000	1	$10,000
Project Sub-Total				$1,291,920
Contingencies and Multipliers (applied to construction subtotals)				
General Conditions	LS	15%		$193,788
Mobilization/Demobilization	LS	10%		$129,192
Erosion Control	LS	2%		$25,838
Overhead and Profit	LS	20%		$258,384
Estimating Contingency	LS	30%		$387,576
Market Climate	LS	10%		$129,192
Construction Item Total				$2,415,890
Design, Permitting, and Administration				
Agency (MCDD) Staff Budget (Management, Operations, Legal)	LS	5%		$120,795
Engineering, Permitting, Survey, Geotechnical	LS	30%		$724,767
Construction Administration	LS	5%		$120,795
Project Total			TOTAL	$3,380,000

Low	$2,370,000
High	$5,070,000

Year	Inflation	Low	High
2025	5%	$2,490,000	$5,330,000
2030	14%	$2,710,000	$5,780,000
2035	22%	$2,900,000	$6,190,000
2040	31%	$3,110,000	$6,650,000

Appendix I

Descriptions of Recommended Programs

Program Title	Description	Notes	Total Cost (in 2022 $)	Timeline	Annual Cost (in 2022 $)
CCTV Inspection and Condition Assessment Program	This is an annual, ongoing program to systematically clean and inspect the pipes and culverts in the critical conveyance network. This program will allow MCDD to identify, prioritize, and plan for short- and long-term infrastructure rehabilitation and/or replacement needs. Several pipes inside PEN1 have been inspected due to problems identified in the area or because the critical location of the pipe. Other pipes in PEN1 are known to be deteriorating based on visual inspections at culvert ends or structures. However, little information exists for large portions of the critical conveyance network regarding the current structural and operational condition. The program will fund CCTV inspection, NASSCO ratings, and engineering assessments of District's infrastructure.	It is assumed PEN1 will conduct CCTV inspections over a period of 5 years. PEN1 may rely on local partners to complete and finance the program. Engineering assessment of CCTV reports may be included in this program. The engineering assessment interprets the inspection results and recommends projects (rehabilitation, replacement, priorities) based on the NASSCO standards and review of field conditions. Assume ~ $10/LF of Pipe.	$ 90,000	Conduct over 5 Years	$ 18,000
Pump Station Testing and Monitoring	Ongoing program of annual testing and monitoring activities to measure the degradation and condition of the pump stations. Annual activities include general inspection of motors, pumps, and switch gears; Annual meggar testing (motor); Annual vibration analysis for both motor and pump; Annual oil sampling, and annual thermal inspection for the switch gear. Program also includes comprehensive flow and pressure testing w/ inspection of discharge lines and wet well every 5 years.	Results of annual testing and monitoring feed into risk tool and PEN1 plans for proactive maintenance activities.	N/A	Ongoing cost per year (average)	$ 10,000
District Wide Debris Barrier Program	MCDD's current debris removal procedures are maintenance intensive and pose a potential health and safety risk for staff conducting debris removal during storm events. MCDD has also implemented an aquatic invasive plants species management program that has reduced the time required to maintain the trash racks associated with these two pump stations. However, blockages are still occurring. Installing dispersed debris barriers on culverts throughout the critical conveyance network could reduce the amount of debris collected at pump stations. The proposed project will systematically install trash and debris barriers on culverts throughout PEN1's critical drainage network. The debris barriers could be designed to allow flow of water, even as debris is collected and removed from the system. This improvement it is expected to improve system performance, especially during rain events, and reduce maintenance efforts.	During the design process, the installation of automated debris removal systems at some locations may be considered. Also, the access and installation process should be considered for each site when selecting the trash racks models. Over 30 culverts in the critical network. Cost estimates is based on a 36" size culvert. Assumed that 20% of culverts will not require a debris barrier.	$ 500,000	10 Years	$ 50,000
Ongoing Periodic Pump Rebuilds	As pumps operate, components wear over time which reduces flow capacity. As such, these components needs to be replaced periodically. This includes components/maintenance such as re-winding motors, replacing bearings, and replacing the impeller. Typically at each pump rebuild the pump components are inspected and only components needing replacement are replaced.		$485,000 Assumes: Vanport PS, one pump at: 15 Year: $35000 (pump) 25 Year: $50,000 (pump + motor) 30 Year: $40,000 (pump) PIR PS, two pumps each at: 15 Year: $50,000 (pump) 25 Year: $75,000 (pump + motor) 30 Year: $55,000 (pump)	Evaluate for rebuild at 15, 25, and 30 years of pump age. Total pump life of 35 years	$ 14,000
Open Channel Sedimentation Control Program & Sediment Management Plan	Establish a program to conduct routine maintenance (invasive vegetation removal, sediment removal) and restorative maintenance (regrading, addition of amended soils, replanting, bank stabilization measures) for natural channels and open drainage ditches. Problem areas previously identified should be of highest priority, and addressed first (i.e.., refer to Figure 6. Problem Areas Map). Survey for sediment annually and again after high flow events. City should continue its construction stormwater permitting program (1200C and 1200CN) in collaboration with DEQ and in accordance with MS4 requirements to minimize erosion and sedimentation impacts from construction activity. Program benefits include stabilizing stream and channel banks to allow for natural plant growth, thus reducing sediment loads in the water, improving water quality and lessening maintenance demands. Controlling sediment would also provide an aesthetic improvement.	Partnerships with local businesses and property owners may be leveraged to share inspection responsibilities. Recommend creating a basin-wide GIS inventory of open channels and ditches, and develop ownership and Operations and Maintenance responsibility between PEN1, City and private properties owners.	N/A	Annually	$ 30,000
Beaver Management Program	Continue to support and Implement MCDD and BES BMPs to assist with beaver management in PEN1.	Beaver deterrence methods include: no action, vegetation management (wire mesh cages and abrasive paint), habitat modification (dam breaching and removal, pond levelers and beaver deceivers), removal via non-lethal means (trapping & relocation and evictions), and lethal removal. See City of Portland Environmental Services Beaver Management Plan for more information.	No additional cost	N/A	N/A
Flow Control Requirements Evaluation	PEN1 follows BES standards for stormwater design related to new development and redevelopment. For flow control, BES standards indicate that a new development in a drainage district does not require flow control. MCDD's design review manual contains guidelines that new development should mitigate impacts to downstream flows. Recent development in PEN1 is limited and no active flow control measures have been imposed due to the flow control exemptions in the BES standards. This program will conduct the necessary studies to evaluate the impacts on PEN1's conveyance and pump stations related to new development and redevelopment. Based on those impacts, this study will evaluate the whether PEN1 should require flow control for new development and redevelopment. The study could also evaluate whether a fee in lieu charge would be a more appropriate way to fund upgrades to conveyance and pump stations to accommodate increasing flows.	Engineering study only; detailed cost estimate not applicable. This study should be coordinated with BES since the study's result might impact BES standards. Study could be cost shared between all four drainage districts.	$ 20,000	One time joint study, 20% funded by PEN1	N/A
Pump Station Structural Evaluation and Resiliency Study	Evaluate all pump stations for structural stability and provide recommendations to improve resiliency during seismic events.	Study will include an assessment of each pump station Geotech assessment with recommendations.	$ 100,000	One time study, 20% funded by PEN1	N/A
Access and Easement needs Study	Evaluate access and easement needs within PEN1, including a description of mapping extents		$ 50,000	One time study	N/A

Program Title	Description	Notes	Total Cost (in 2022 $)	Timeline	Annual Cost (in 2022 $)
Water Quality Monitoring	Recommended Program of annual testing and monitoring activities to measure and monitor water quality throughout PEN1, including identifying sources of sediment within the PEN1 basin. Samples should be taken at locations within HLGC, PIR, and PIR PS Forebay. Sampling should occur every 2-5 years.	Results of annual testing and monitoring shall be used to inform maintenance activities and future capital projects. Sampling cost assumes approximately $700/sample for 20 samples in 3 locations.	N/A	Ongoing cost per sampling year (average)	$ 50,000
Sediment Load Source Evaluation	Recommended Program to conduct source evaluation and study to identify source(s) of high sediment loading within PEN1.	Results of evaluation shall inform maintenance activities and future potential capital projects.	$ 75,000	One time evaluation	N/A
Levee Seed Mix Evaluation	Recommended Program to review the existing levee seed mix and provide recommendations to enhance habitat and water quality.	MCDD is currently working on a levee seeding pilot project. The HLGC Vegetation Management Evaluation should work in conjunction and support this work.	$ 10,000	One time evaluation	N/A
HLGC Vegetation Management Evaluation	Recommended program to identify potential no-mow areas within HLGC and encourage HLGC adopt the BES BMP for nesting birds.		$ 25,000	One time evaluation	N/A
Water Quality Sampling/ Assessment of Stormwater to Marine Dr. ROW	Recommended program to sample and assess stormwater runoff from Marine Drive right-of-way that discharges directly to the Columbia River. Sampling should occur every 2-5 years.	Results of analysis shall inform maintenance activities and future potential capital projects. Sampling cost assumes approximately $700/sample for 20 samples in 3 locations.	N/A	Ongoing cost per sampling year (average)	$ 50,000