CITY OF OAK HARBOR

ISLAND COUNTY **WASHINGTON**

COMPREHENSIVE STORMWATER PLAN

G&O #16625
MARCH 2020

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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WHIDBEY ISLAND, WASHINGTON

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CHAPTER 1

INTRODUCTION

As Whidbey Island's largest incorporated city, Oak Harbor has been developed and continues to grow, contributing to the need for effective stormwater management. The 2006 Stormwater Comprehensive Plan identified 36 existing flooding problem areas, two existing maintenance and erosion problem areas, and 59 potential future flooding problem areas. The 2006 Plan presented a solution with 20 capital projects, of which the City has completed or begun six projects. The City's 2016 Comprehensive Plan identifies development projections through the year 2036, including a population increase from 22,693 (2015) to 25,814. The 2016 Plan also presents the goal to "Preserve and enhance water quality in conformance with the Puget Sound Partnership's Action Agenda for Puget Sound and other Clean Water Act and Growth Management Act requirements" which will be supported by this Stormwater Comprehensive Plan.

Prior to the late 1970s, stormwater management in the U.S. and specifically the Puget Sound region consisted primarily of conveying runoff away from developed areas in order to preserve the health and safety of citizens and protect property, both public and private. Drainage improvement projects addressed large storm events and local flooding with little thought for upstream, downstream, or environmental impacts. With the passage of the Clean Water Act in 1972, completion of the Nationwide Urban Runoff Program in 1983, and subsequently other federal and state laws, the cumulative effects of smaller storms in developed/urbanized areas were formally recognized as a major contributor to water quality and habitat degradation.

Stormwater runoff collects sediment and pollutants from exposed construction sites and agricultural areas as well as pollutants from the street network, residential, commercial, and industrial developments. Pollutants in stormwater runoff include metals such as lead, cadmium, and copper; oil and grease; pesticides and fertilizers; nutrients; suspended solids; and harmful bacteria. In addition, urbanization increases the amount of impervious surfaces such as rooftops, streets, and parking areas. Impervious surfaces directly relate to an increase in runoff volumes and peak flow rates. The pollutant loads and increased volumes of stormwater runoff result in negative impacts to downstream properties and surface water bodies such as lakes, streams, and wetlands and reduced infiltration to groundwater. Due to regulations required under the Clean Water Act and the listing of anadromous (salmon, trout, char) species under the Endangered Species Act, it has become increasingly important for municipalities to implement stormwater quality and quantity (flow) control measures.

PURPOSE

The City of Oak Harbor Stormwater Comprehensive Plan (Plan) is a planning document that provides guidance to minimize adverse effects of stormwater runoff on ground and surface water. It is also a document to help ensure the City maintain compliance with government regulations such as the Clean Water Act and the City's NPDES Phase II Permit. It identifies water quality and quantity problems associated with stormwater runoff that may affect the environment and community, and provides recommendations for improvements and programs including a cost analysis and implementation schedule.

The Plan identifies specific structural and non-structural solutions to quantity and water quality problems within the City. Structural solutions include construction of capital projects such as stormwater detention and treatment facilities, infiltration facilities, pipelines, and culverts. Nonstructural solutions include stormwater management facility inspection and maintenance, public education and outreach, water quality monitoring, implementation of best management practices, and regulations encouraging vegetation preservation and low impact development.

AUTHORIZATION

The City of Oak Harbor contracted with Gray & Osborne, Inc. to complete the update to the Plan. Specific components in the Scope of Work include:

- Provide overall project management and oversight services;
- Update GIS information with data collected as part of the Plan;
- Identify drainage basins and describe hydrologic characterizations and existing stormwater facilities;
- Evaluate the impact of runoff to the existing conveyance systems under both current and future land use conditions;
- Evaluate the overall condition of the system by creating a map of aging stormwater facilities based upon GIS data or City staff knowledge;
- Identify the current level of maintenance of public and privately owned systems through discussions with maintenance personnel;
- Develop a maintenance schedule and associated costs for performing facility maintenance;
- Identify conveyance problems;

- Identify water quality problems;
- Identify potential structural and non-structural solutions to conveyance system and water quality problems;
- Review the City's NPDES Phase II Program for compliance with the current permit requirements and timelines;
- Propose a schedule and priority of capital improvements for the 6- and 20-year planning horizons;
- Review the current revenue and expenses to assist the City's budget development;
- Provide a draft Comprehensive Stormwater Plan for review by City staff; and
- Provide a final Plan to the City.

GOALS

As additional development and redevelopment occurs within the City, the amount of naturally vegetated areas will decrease while the amount of impervious surfaces will increase, leading ultimately to increased peak runoff rates and transport of more pollutants to the City's streams, wetlands, and the bay.

The primary goal of the Oak Harbor Comprehensive Stormwater Plan is to provide guidance to the City Council, staff, and citizens to preserve and protect the water quality and hydraulic regime within the City's natural and manmade stormwater drainage system, and the major receiving waters, Oak Harbor and Puget Sound.

To this end, the City intends to manage land development and stormwater programs to preserve natural areas, minimize water borne pollutants, mitigate the impacts of increased runoff, enforce permit conditions and erosion control BMPs on construction sites, and to preserve fish and wildlife habitat. Through careful planning of funds generated from the existing Stormwater Utility, the City's implementation of the Plan will meet the goals to protect the health, safety, and welfare of the local citizenry and to preserve surface water resources within, and downstream of, the City.

CHAPTER 2

DRAINAGE AREA CHARACTERISTICS

LOCATION

The City of Oak Harbor (City), Washington was incorporated in 1915. The City's current boundary and Urban Growth Area (UGA) encompass approximately 6.5 square miles (see Figure 2-1). The City is located in north central Whidbey Island in Island County, approximately 40 miles northwest of Everett. State Route 20 (SR 20) passes through the City, splitting the City into distinct east and west sections. Naval Air Station Whidbey Island (NAS Whidbey) is located about three miles north of Oak Harbor, with the secondary Seaplane Base is located on the east side of the City, above Crescent Harbor. There are three main access routes to the Island; the Deception Pass Bridge to the north, the Port Townsend-Coupeville ferry near the center of the Island, and the Clinton-Mukilteo ferry near the south end of the Island. This Plan will focus on stormwater issues within the city limits (excluding the Navy base located on the east side) and areas within the City's UGA. Island County has designated a joint planning area (JPA) just outside of the City's UGA. The JPA serves as a method to help facilitate joint planning efforts between the County and City including where UGA areas could potentially expand if needed, where coordination of joint planning efforts would occur such as shared transportation corridors and where land designated for protection would be secured between the two agencies.

Projections from the Washington State Office of Financial Management estimate the 2019 population at 22,970, representing 27 percent of the total population of Island County. Oak Harbor is a combination of residential and commercial communities. The commercial land use is mostly located along SR 20, with a mix of residential and commercial use to the east and newer residential areas to the west. Low density residential constitutes a major portion of the city and UGA, making up approximately 47 percent of the land.

TOPOGRAPHY

The City of Oak Harbor lies in a topographic bowl facing southeast towards the bay. Portions of the City are outside this bowl and instead slope down to the west towards the Strait of Juan de Fuca. The City is approximately 7 miles south of Deception Pass, connecting Whidbey Island to Fidalgo Island and subsequently the mainland. Elevations within the City range from sea level at the south end to 307 feet towards the north. Slopes range from zero to over 14 percent, with 3 to 6 percent being more typical. The topography of the City is shown in Figure 2-2.

CLIMATE

The climate of Oak Harbor is heavily influenced by Puget Sound and the Olympic Mountain Range to the west. The surrounding waters moderate the temperature fluctuations, keeping the average summer highs below 75 degrees F and average winter lows above freezing. The City lies within the Olympic Mountain Range rain shadow which reduces precipitation to an average of 21 inches annually, compared to a State average of 38 inches. Precipitation is lowest during the summer months and moderate during the winter months. Table 2-1 summarizes the historical monthly average temperature and rainfall data for the City.

TABLE 2-1

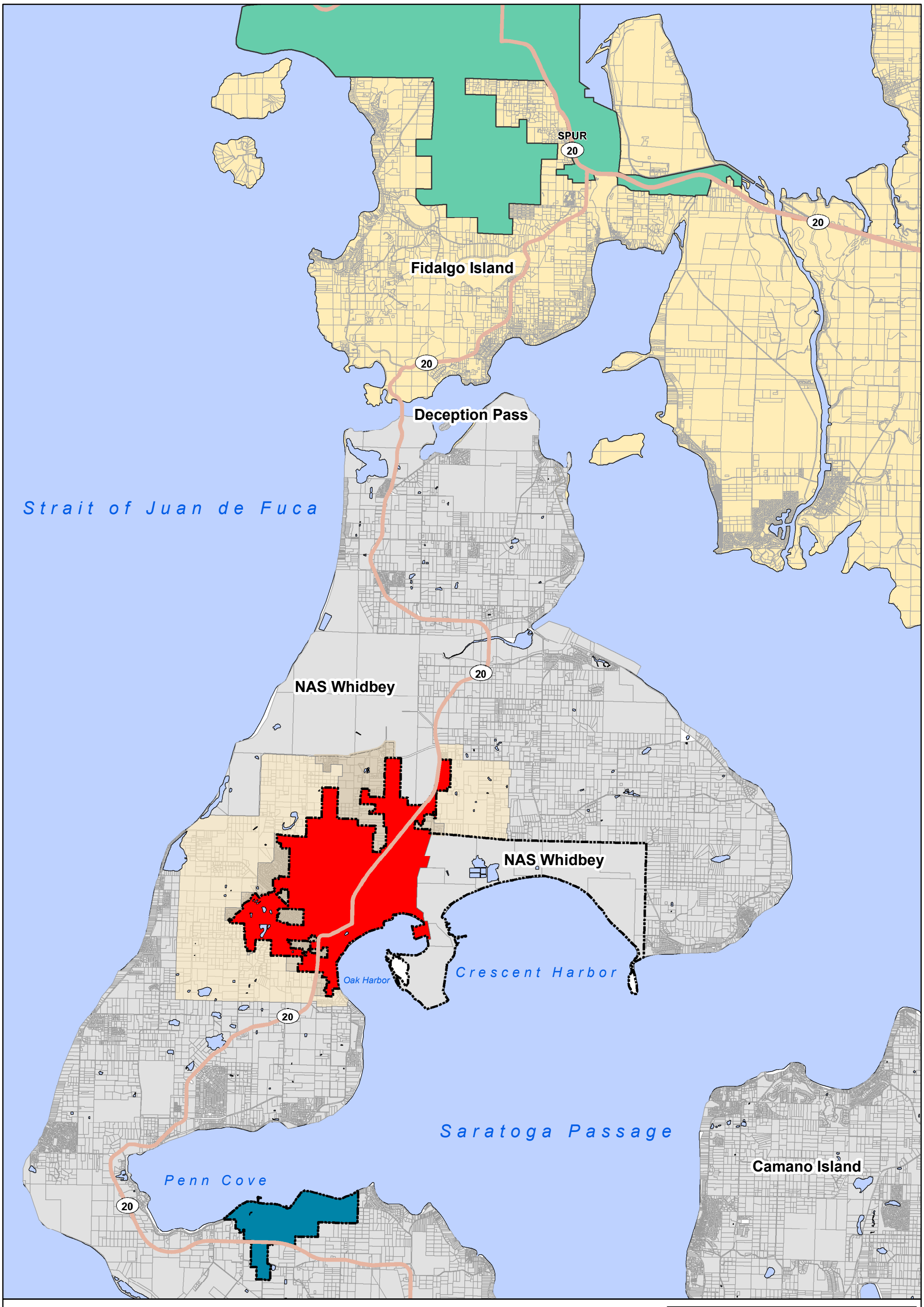
Average Monthly Climate Data

Month	High Temp. (°F)	Low Temp. (°F)	Precipitation (in)
January	45	34	2.5
February	48	35	1.8
March	52	37	1.8
April	57	40	1.6
May	63	44	1.6
June	67	48	1.3
July	72	51	0.8
August	72	51	0.9
September	68	47	1.3
October	58	42	1.8
November	50	38	2.7
December	45	35	2.7
Total			**20.7**

Source: www.wrcc.dri.edu, NOAA Cooperative Climatology Data Summaries for Coupeville, 1948 to 2005.

WATERWAYS AND WATERBODIES

Both marine and fresh waterbodies exist within the Oak Harbor city limits as shown in Figure 2-3. The largest fresh waterbody within the City is Loers Pond, located within the Whidbey Island Golf and Country Club golf course. Loers Pond receives surface water from the Golf Course and Waterloo Marsh basins and discharges to an unnamed stream. This unnamed stream, draining west to Swan Lake, has been added to the Department of Ecology 303(d) list due to bacteria and dissolved oxygen. Sampling locations for the unnamed stream are believed to be outside of the City limits, but exact locations are unknown.



LEGEND:

- Water Bodies
- Urban Growth Area (UGA)
- Joint Planning Area (JPA)
- Oak Harbor
- City Limits
- Coupeville
- Anacortes
- Island County
- Skagit County

N

0 5,000 10,000

Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
VICINITY MAP
FIGURE 2-1

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\Oak Harbor Vicinity map.mxd

Strait of Juan de Fuca

NAS Whidbey

W Sleeper Rd

W Clover Valley Rd

W Ault Field Rd

N Oak Harbor St

Keller Rd

State Rte 20

W Crescent Harbor Rd

Swantown Rd

W Whidbey Ave

E Whidbey Ave

NE Midway Blvd

SE Pioneer Way

Pioneer Way

Coral Sea Ave

Keller St

W Fort Nugent Rd

W Waterloo Rd

N Bobn Rd

Oak Harbor

Saratoga Passage

LEGEND:

- City Limits
- UGA
- JPA
- 25 ft. Contours
- Parcels

N

0 5,000

Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
TOPOGRAPHIC MAP
FIGURE 2-2

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\working maps\Oak Harbor Topo map.mxd

W Clover Valley Rd
W Ault Field Rd
Heller Rd
N Oak Harbor St
State Rte 20
W Crescent Harbor Rd
NE Midway Blvd
Swantown Rd
W Whidbey Ave
E Whidbey Ave
Heller St
Pioneer Way
E Pioneer Way
SE Pioneer Way
Coral Sea Ave
Loer's Pond
W Fort Nugent Rd
Freund Marsh
Oak Harbor
W Waterloo Rd
N Boon Rd
Saratoga Passage

LEGEND:

- Private Detention Pond
- City Owned Detention Pond
- Freshwater Emergent Wetland
- Estuarine and Marine Wetland
- Water Bodies
- City Limits
- UGA
- JPA

N

0 2,000 4,000 Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
WETLANDS AND WATERBODIES MAP
FIGURE 2-3

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\2-3 Wetlands and Waterbodies.mxd

Numerous smaller ponds and wetlands are located throughout the City, as shown in Figure 2-3.

Freund Marsh is a freshwater wetland located along the Oak Harbor waterfront, just west of Windjammer Park (also known as City Beach). It receives surface runoff from the City before discharging to the Bay. The marsh is classified as a 100-year floodplain by FEMA.

The primary marine waterway is Oak Harbor Bay which borders the city to the south, leading to Saratoga Passage. A portion of the Bay along Windjammer Park is listed on the Department of Ecology 303(d) list due to bacteria. The Whidbey Island Marina is located on the east end of the bay, adjacent to Crescent Harbor.

TIDAL DATA

Tidal fluctuations play an important role in the City's stormwater management. With most drainage within the City discharging to Oak Harbor, high tides can submerge the outfalls. This reduces drainage capacity, resulting in surcharging of pipes. Tidal conditions must be established in combination with extreme rainfall events to understand the effects on upstream drainage.

The National Oceanic and Atmospheric Administration (NOAA) Crescent Harbor station gives tidal data, shown in Appendix A. Based on NOAA extreme water levels data for nearby Seattle, the 1 percent annual exceedance probability (AEP) level is 3.2 feet above mean higher high water (MHHW), equal to 12.4 feet (NAVD88).

The Federal Emergency Management Agency (FEMA) provides floodplain maps depicting 100-Year floodplain elevations for Oak Harbor (FEMA, 2017). These floodplains are shown in Figure 2-4.

SOILS

The soils of Island County were surveyed by the United States Department of Agriculture (USDA) National Resources Conservation Service (NRCS). The NRCS website indicates 10 soil types (e.g., silt loam, gravelly sandy loam, muck, etc.,) within the general UGA of Oak Harbor, as shown in Figure 2-5 and Table 2-2. The NRCS classifies soils, from A to D, according to runoff potential. Type A has low runoff potential and type D has high runoff potential. The NRCS also provides information pertaining to the physical and chemical properties of the soils, including drainage class. Table 2-2 summarizes the significant soil groups and drainage class of the soils found within Oak Harbor's UGA.

TABLE 2-2

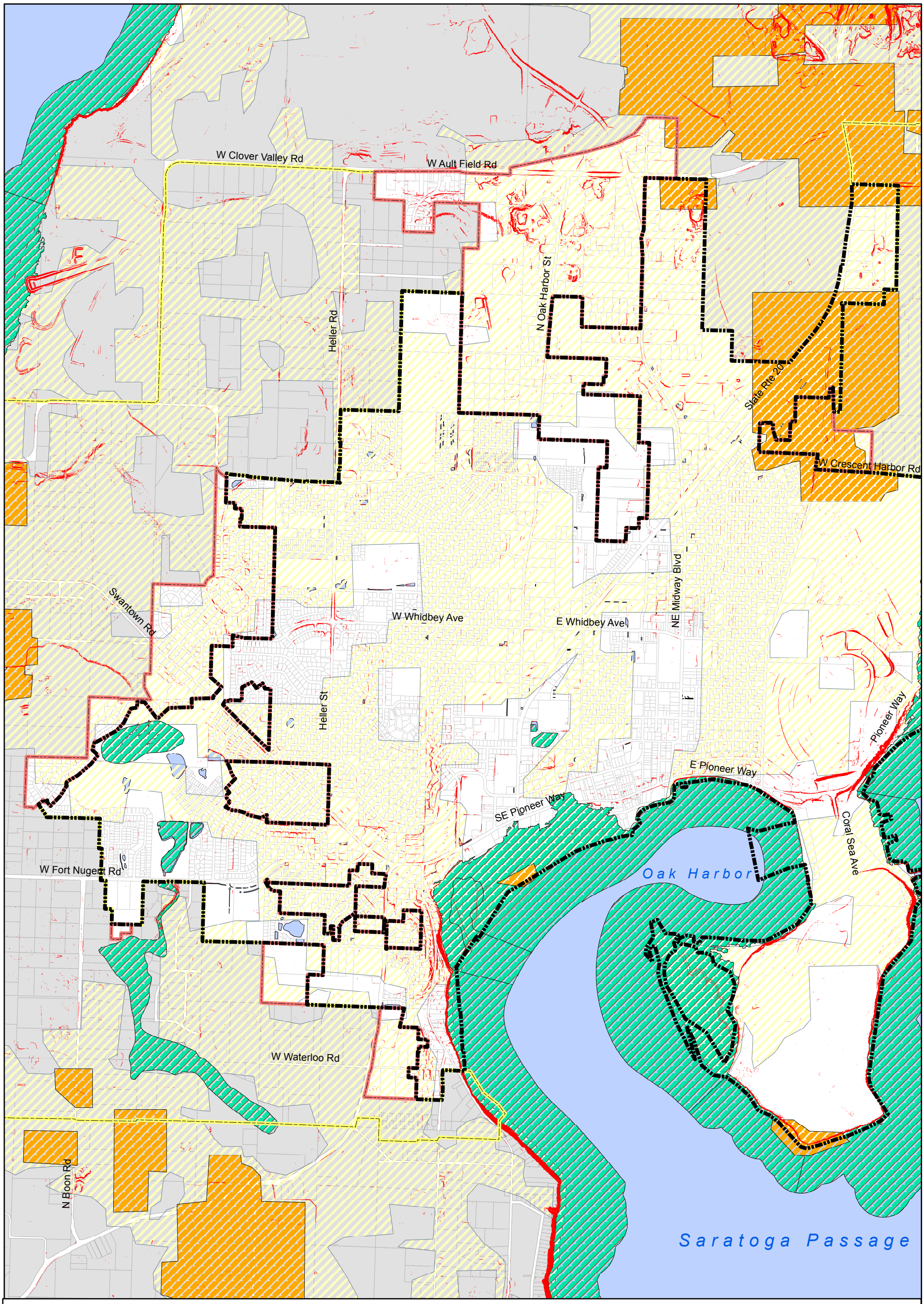
Soil Characteristics

Soil	Hydrologic Soil Group	Drainage Class Rating
Alderwood gravelly sandy loam	B	Moderately well drained
Coupeville loam	D	Poorly drained
Coastal beaches	B	Well drained
Coveland loam	D	Somewhat poorly drained
Dugualla muck	D	Very poorly drained
Elwha loam	B	Moderately well drained
Everett very gravelly sandy loam	A	Somewhat excessively drained
Frostad loam	D	Poorly drained
Hoypus sandy loam	A	Somewhat excessively drained
Indianola loamy sand	A	Somewhat excessively drained
Limepoint mucky silt loam	D	Poorly drained
Mitchellbay gravelly sandy loam	C	Somewhat poorly drained
Morancreek sandy loam	B	Moderately well drained
Puget silty clay loam	C	Poorly drained
Semiahmoo muck	D	Very poorly drained
Shalcar muck	D	Very poorly drained
Sholander gravelly loam	C	Somewhat poorly drained
Spieden mucky silt loam	D	Poorly drained
Sucia loamy sand	B	Moderately well drained
Whidbey gravelly loam	B	Moderately well drained
Zylstra loam	C	Somewhat poorly drained

CRITICAL AREAS

Discussed below are types of critical areas found within the City and which are identified by the Growth Management Act. Their presence can dictate where facilities should or should not be located. These areas include: shorelines and tidal flats, wetlands, fish and wildlife habitat conservation areas, geologically hazardous areas, frequently flooded areas, critical aquifer recharge areas, urban forests, surface water quality, air quality, stormwater management, and cultural resources. In addition, Oak Harbor Municipal Code designates and regulates the following critical areas:

- Frequently Flooded areas
- Wetlands
- Critical Aquifer Recharge areas
- Rivers and Streams
- Fish and Wildlife Habitat Conservation areas
- Geological Hazard areas



LEGEND:

Critical Aquifer Recharge Area

- High Susceptibility
- Moderate Susceptibility
- < 40% Slope

- City Limits
- UGA
- JPA
- 100 Year Flood Zone

N

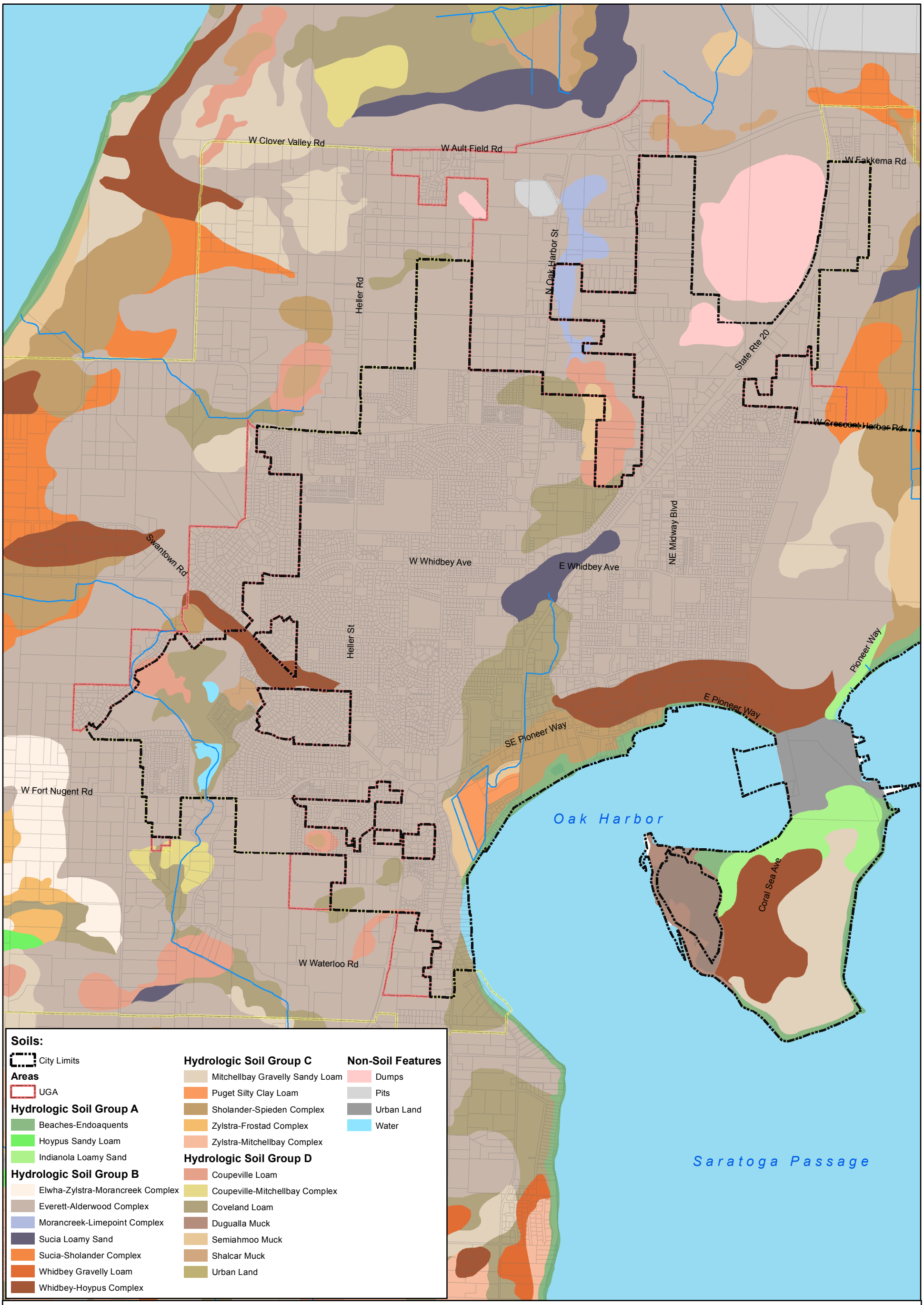
0 2,000 4,000 Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
CRITICAL AREAS MAP
FIGURE 2-4

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\2-4 Critical Areas Map.mxd



LEGEND:

- Parcels
- City Limits
- UGA
- JPA
- Water Bodies
- Streams

N

0 2,000 4,000

Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
SOIL MAP
FIGURE 2-5

Gray & Osborne, Inc.
CONSULTING ENGINEERS

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\2-5 Soils Map.mxd

- Garry Oak Tree Protection

FREQUENTLY FLOODED AREAS

The City of Oak Harbor is located in a topographic bowl that drains to Oak Harbor Bay. Within this bowl, certain areas lack adequate drainage to prevent flooding. In accordance with the federal National Flood Insurance Program and Oak Harbor Municipal Code, land development is regulated to prevent and/or discourage development within the flood plain, in order to avoid future losses due to flood events.

The Federal Emergency Management Agency (FEMA) documented areas that are subject to 100-year floods within the City, updated in 2007. The 100-year flood has been adopted as the base flood for purposes of floodplain management. A 100-year flood area is defined as those lands, which are subject to a one percent or greater chance of flooding in any one year. Figure 2-4 delineates the 100-year floodplain boundaries within the City of Oak Harbor.

WETLANDS

Wetlands and riparian corridors perform valuable functions within the ecosystem. Clearing of vegetation, grading, filling, draining, and other activities associated with land development may decrease the ability of the riparian zone to provide drainage, stabilize stream banks, provide wildlife habitat, and filter pollutants from runoff. Wetlands receiving surface water from surrounding areas can filter entering pollutants by a combination of physical, chemical, and biological processes.

Wetlands also play a major role in flood control. During flooding, rivers and streams overflow their banks and spread out across the flood plain. Wetlands attenuate the peak flows from storm events by storing water during wet periods and discharging this stored water later during drier periods.

According to the National Wetlands Inventory, there are large wetland areas located at Freund Marsh Park and north of NE 7th Avenue between NE Goldie Road and North Oak Harbor Street. Smaller wetlands are located at the Whidbey Golf and Country Club and other areas of the City. Figure 2-3 shows the approximate location of wetlands within the City as identified by the National Wetlands Inventory. The inventory (completed in the early 1980s) only identified large wetlands and the map is not intended to show all such areas. Smaller wetlands throughout the City continue to provide varying degrees of ecological functions such as peak flow attenuation, natural water quality treatment, and wildlife habitat.

CRITICAL AQUIFER RECHARGE AREAS

The City receives 99 percent of its water from the City of Anacortes Water Treatment Plant, which sources its water from the Skagit River. In addition to supplying residential and commercial customers in Oak Harbor, the City also supplies water to NAS Whidbey Island, Deception Pass State Park, and North Whidbey Water District. The City has four reservoirs capable of storing 7.15 million gallons of water and maintains three deep wells as an emergency source.

The Growth Management Act requires that potable water sources such as wells be mapped and assessed for vulnerability to ground or surface water contamination. Depending on the depth of the aquifer, soil porosity, and other parameters, certain land uses or stormwater management practices may cause contaminants to percolate down into groundwater, having a negative effect on water quality for a specific well or an entire aquifer. These critical aquifer recharge areas have been delineated by the Island County Health Department through the 2514 Watershed Planning process and are included in Figure 2-4.

Swantown Water District, serving approximately 92 customers bordering the Oak Harbor City limits northwest of Whidbey Golf and Country Club, sources water from two wells at a depth of 130 feet. This water source is not treated. Other active drinking water wells, according to Ecology Well Logs, are located mostly to the north or west of the City. Water service providers and wells are shown in Figure 2-6.

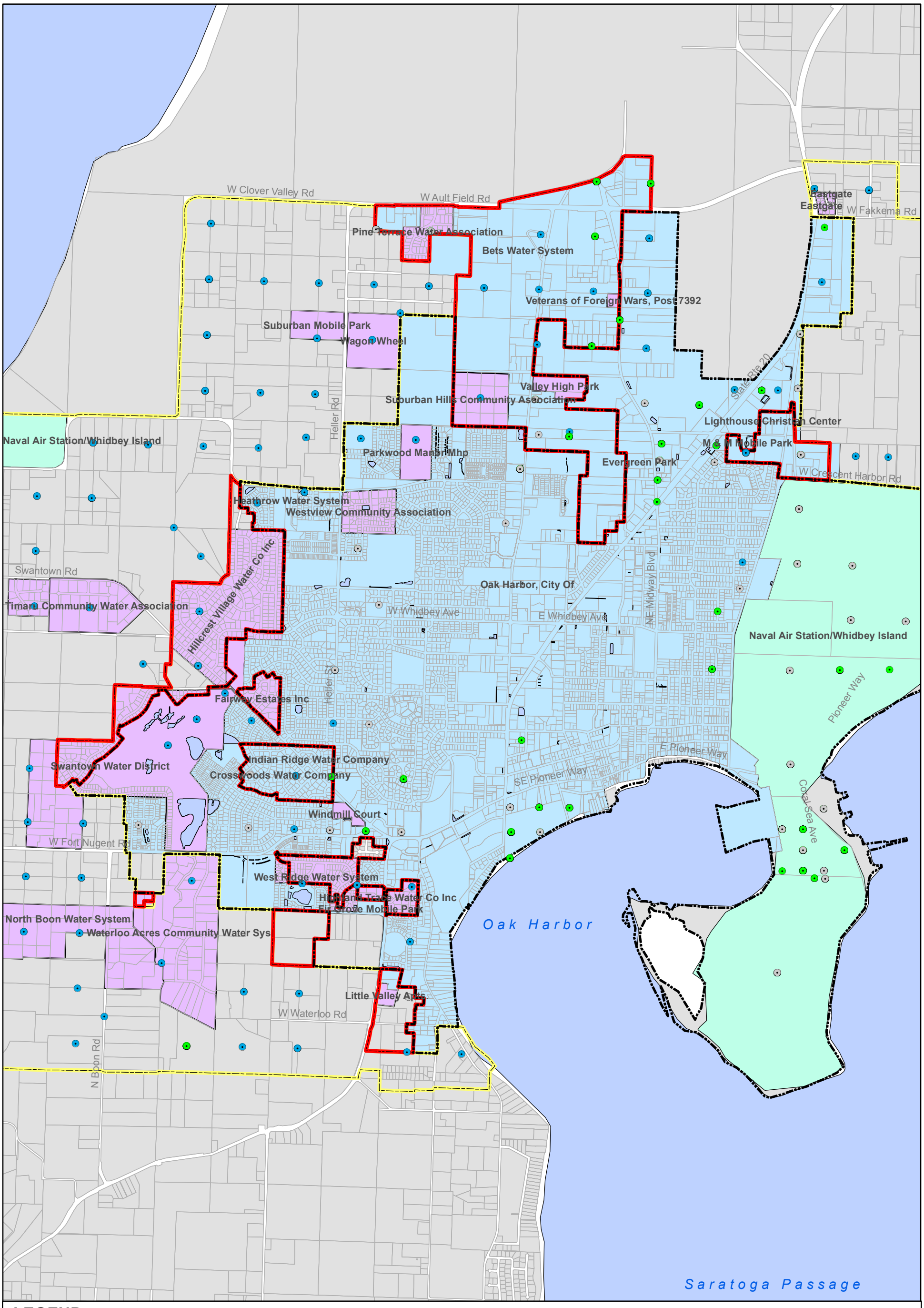
FISH AND WILDLIFE HABITAT CONSERVATION AREAS

The main areas of habitat within the city are associated with Oak Harbor Bay. The entire shoreline of Oak Harbor is a critical area for recovery of Puget Sound Chinook ESU (evolutionarily significant unit). There are also forage fish spawning areas along the waterfront and, at the south end of the city, bald eagle habitat. A critical area for Heron is located near the UGA boundary just north of West Ault Field Road. Other aquatic environment critical areas exist just outside of Oak Harbor Bay, including eelgrass, geoduck, harlequin duck, and shellfish areas.

The namesake for the City, the Garry Oak, has a concentration area south of East Whidbey Avenue, west of SE Regatta Drive, and east of SR 20. Preservation of Garry Oaks, as well as other urban components, is a major goal presented in the City's Comprehensive Plan.

GEOLOGICAL HAZARD AREAS

The City's Comprehensive Plan identifies geologically sensitive areas such as steep slopes, primarily those associated with the bluffs along the shoreline. Steep (>15%), potentially unstable slopes exist above the waterfront east of SW Scenic Heights Road and south of SE Pioneer Way. Areas of moderate to high liquefaction susceptibility are



LEGEND:

Water Systems
- Other
- Naval Air Station/Whidbey Island
- Oak Harbor, City Of

Wells
- Water
- Resource Protection
- Abandoned

- City Limits
- UGA
- JPA
- Water Bodies

N

0 2,000 4,000
Feet

Note: Well locations are only accurate up to quarter-quarter sections. Resource protection wells include monitoring wells, observation wells, piezometers, spill response wells, remediation wells, environmental investigation wells, vapor extraction wells, ground source heat pump boring, grounding wells, and instrumentation wells.

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
WATER SERVICES MAP
FIGURE 2-6

Gray & Osborne, Inc.
CONSULTING ENGINEERS

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\2-6 Water Services Map.mxd

located along the shoreline between SE Regatta Drive and Pete's Lane. Additional steep slopes throughout the City are shown in Figure 2-4. These areas are likely to have drainage challenges due to slope instability, erosion potential, infiltration limitations, or inadequate outfalls.

GARRY OAK TREE PROTECTION

Garry oak trees greater than six feet tall are protected under Oak Harbor Municipal Code Chapter 20.16. The code prohibits harm to, and conditionally permits removal, topping, and trimming of, Garry oak trees. Garry oak trees are also applicable as infeasibility criteria towards some LID BMPs and are considered by the Department of Ecology as historic prairie for modeling of predeveloped conditions.

ZONING AND LAND USE

The population in Oak Harbor grew by approximately 4 percent between the years 2000 and 2019. Land use and zoning play an important role in determining growth patterns and therefore, in the potential locations of future stormwater facilities. Future land use and changing population densities, as directed by applicable zoning ordinances, can significantly impact a system's ability to provide adequate services to specific areas.

Oak Harbor has a combination of commercial, industrial, open space, public facilities, and residential uses as shown in Figure 2-7. There are six types of commercial zoning: neighborhood commercial, community commercial, highway service commercial, highway corridor commercial, central business park, and planned business park. These commercially zoned areas are primarily located along SR 20 and along SE Pioneer Way, east of SR 20. Industrial areas are located on the north end of the City, west of SR 20. Open space areas are limited and located towards the north end of the city and also near the waterfront. Public facilities include parks, sports fields, schools, a wastewater treatment plant, and power transfer station and are spread out across much of the City. Residential zoning includes various levels of multi-family located just outside of the commercial areas and single-family generally further to the east and west of SR 20.

The land use classifications within the City are shown in Table 2-3.

TABLE 2-3

Land Use

Land Use Category		Acres	Description
C-1	Neighborhood Commercial	6	Limited commercial facilities serving residents of the surrounding residential district.
C-3	Community Commercial	175	Retail, wholesale, transportation, and service uses which, because of traffic and other requirements, depend upon particular locations to serve the needs of the community and its trading area.
C-4	Highway Service Commercial	80	Facilities oriented toward uses dependent upon highway location.
C-5	Highway Corridor Commercial	69	Uses which, because of traffic and other requirements, are regional in impact and may be located in the highway corridor.
CBD (CBD-1, CBD-2)	Central Business District	40	Mixed use developments, combining retail and visitor oriented activities on the ground floor with office, retail, and residential uses above. Subdistricts CBD-1 and CBD-2 provide for flexibility of residential development within specific areas of the district.
I	Industrial	50	Accommodates for certain industrial structures and uses having physical and operational characteristics which might adversely affect the adjoining residential and commercial uses.
OS	Open Space, Recreation, and Agriculture	82	Allows for the retention of natural, rural character, open space areas within the city of Oak Harbor, and allows for annexation of lands to the city without forcing immediate development, and generally conserves the land, water, and other natural resources of the City.
PBP	Planned Business Park	75	For the development of larger-scaled master planned developments relating to business while preserving or creating superior environmental amenities, encouraging a park-like environment, preserving natural characteristics of the land, establishing development standards, and maximize efficiency in layout.
PF	Public Facilities	370	Accommodates public facilities and institutional land uses, including but not limited to public parks, schools, churches, government offices, public works yards, utility structures, hospitals, and other similar public and quasi-public uses.
PIP	Planned Industrial Park	157	Encourages comprehensive planning of large industrial sites to create a park-like environment while preserving or creating superior environmental amenities, preserving natural characteristics of the land, establishing development standards, and maximize efficiency of layout.
R-1	Single-Family Residential	1269	Intended for low-density, urban, single-family residential uses, while providing sufficient density to allow the city to effectively provide needed urban services.

W Clover Valley Rd
W Ault Field Rd
Heller Rd
N Oak Harbor St
State Rte 20
W Crescent Harbor Rd
Swantown Rd
W Whidbey Ave
E Whidbey Ave
NE Midway Blvd
Heller St
Pioneer Way
E Pioneer Way
SE Pioneer Way
Coral Sea Ave
W Fort Nugent Rd
W Waterloo Rd
Oak Habor
Saratoga Passage

LEGEND:

- Residential Estate
- Low Density Residential
- Medium Density Residential
- Medium-High Density Residential
- High Density Residential
- Residential Office
- Public Facilities
- Open Space
- Planned Business Park
- Planned Industrial Park
- Industrial
- Central Business District
- Neighborhood Commercial
- Community Commercial
- Highway Corridor Commercial
- Auto/Industrial Commercial
- Maritime
- City Limits
- UGA
- JPA
- Water Bodies

N

0 1,000 2,000 3,000 Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
LAND USE MAP
FIGURE 2-7

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\working maps\Oak Harbor Zoning.mxd

TABLE 2-3 – (continued)

Land Use

Land Use Category		Acres	Description
R-2	Limited Multiple-Family Residential	180	Intended for medium density residential housing with a minimum of three units per gross acre and maximum of 12 units per gross acre.
R-3	Multiple-Family Residential	98	Intended to provide for and protect areas for medium- to high-density multiple-family residential development with a minimum of six units per gross acre and a maximum of 16 units per gross acre.
R-4	Multiple-Family Residential	166	Intended to provide for areas of high density multiple-family residential development for persons who desire to live in an apartment environment. The densities for this district range from a minimum of 12 units per gross acre and maximum of 22 units per gross acre.
RO	Residential Office	78	Provides for areas appropriate for professional and administrative offices and is intended to buffer residential districts.

Overall, the City is approximately 44 percent low density residential, 18 percent other residential, 13 percent public facilities, 11 percent commercial, 7 percent industrial, 5 percent business, and 3 percent open space.

DRAINAGE BASINS

The stormwater planning area (i.e., city limits and UGA regions) was divided into 11 major drainage basins as described below:

- **Ault Field Basin –** This basin is located at the northernmost edge of the City and UGA. It has mostly industrial land uses and drains to the north, eventually reaching the Strait of Juan de Fuca.

- **Northwest Basin –** This basin is minimally developed, and contains a large wetland and numerous drainage sinks. Stormwater runoff infiltrates into the groundwater, evaporates, floods, or reaches the wetland and follows an unnamed drainage course west, eventually reaching the Strait of Juan de Fuca.

- **Golf Course Basin –** The Golf Course basin covers the southwest portion of the City limits. It encompasses the Whidbey Golf and Country Club and primarily has residential and open space land uses. This basin includes Loers Pond as well as other smaller detention ponds which drain west towards Swan Lake and the Strait of Juan de Fuca.

- **Waterloo Marsh Basin –** Mostly outside of the City limits to the south and within the Joint Planning Area, this basin includes the Waterloo Marsh which directs drainage to Loers Pond to the north and into the Golf Course Basin, eventually reaching the Straits of Juan de Fuca.

- **Upper Dry Creek Basin –** This basin lies west of SR 20 near the north end of the City. It includes mostly open space, industrial, and commercial land uses. Drainage flows towards SR 20 and south toward Dry Creek Basin, eventually reaching Oak Harbor.

- **Midway Basin –** This basin includes most of the area south and east of SR 20 and boarders NAS Whidbey Seaplane Base to the east. It is heavily developed and drains through an extensive conveyance system to multiple outfalls into Oak Harbor.

- **High School Basin** – Located north of Dry Creek basin and separated from Northwest basin by a ridge. This basin drains south, contributing to flows in the Dry Creek basin.

- **Dry Creek Basin** – This is the most heavily developed basin, containing the central core of the city as well as Freund Marsh to the south. Drainage is piped through an extensive conveyance system to Freund Marsh with a large outfall directly to Oak Harbor.

- **Freund Marsh Basin** – This basin lies in the southern end of the City and includes mostly low density residential land uses. Drainage travels southeast towards Freund Marsh.

- **Oak Prairie Basin** – In the southeast corner of the city, Oak Prairie is the smallest basin and includes multiple outfalls discharging directly into Oak Harbor.

- **Eagle Vista Basin –** The Eagle Vista basin is located at the south end of the City limits above the cliffs overlooking Oak Harbor from the west. Drainage flows east over these unstable bluffs and into Oak Harbor. In the summer of 2018, a significant HDPE outfall was installed over the bluff to convey water from a collection point on SW Scenic Heights Street to the beach.

These basins were divided into 133 subbasins in the previous 2006 Plan to provide a higher level of resolution. To increase coverage since the 2006 Plan, three additional subbasins were added, creating a total of 136 subbasins. These areas are shown in Figure 2-8.

Strait of Juan de Fuca

W Sleeper Rd

W Clover Valley Rd

W Ault Field Rd

Heller Rd

N Oak Harbor St

State Rte 20

W Crescent Harbor Rd

Swantown Rd

Swan Lake

W Whidbey Ave

E Whidbey Ave

NE Midway Blvd

Heller St

Pioneer Way

E Pioneer Way

SE Pioneer Way

Coral Sea Ave

Loer's Pond

W Fort Nugent Rd

Windjammer Park

Freund Marsh

Oak Harbor

N Boon Rd

W Waterloo Rd

Waterloo Marsh

Saratoga Passage

LEGEND:

- City Limits
- UGA
- JPA
- Ault Field Basin
- Northwest Basin
- Golf Course Basin
- Waterloo Marsh Basin
- Upper Dry Creek Basin
- Midway Basin
- High School Basin
- Dry Creek Basin
- Freund Marsh Basin
- Oak Prairie Basin
- Eagle Vista Basin
- Flow Direction Boundary
- Subbasins
- Water Bodies
- Streams
- Flow Direction

N

Stream data is provided by WA State Dept of Natural Resources and downloaded from https://www.islandcountywa.gov/maps/Pages/Data.aspx in October 2019

0 2,400 4,800 Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
DRAINAGE BASIN MAP
FIGURE 2-8

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\working maps\Oak Harbor Subbasins.mxd

CHAPTER 3

STORMWATER SYSTEM ANALYSIS

INTRODUCTION

This chapter presents an analysis of the City of Oak Harbor's existing stormwater management system, and its ability to accommodate runoff for future development conditions. The analysis includes review of previous reports and plans completed by the City and also hydraulic/hydrologic modeling of the existing system under current and future land use conditions completed for this Plan.

EXISTING STORMWATER CONVEYANCE SYSTEM

The City of Oak Harbor's existing stormwater conveyance system consists of a combination of open ditches, pipes, catch basins, culverts, detention ponds, bioswales, and wetlands. Information about the existing stormwater conveyance system was obtained from the City's stormwater base map and updated through the review of existing as-builts provided by the City, discussions with City staff, and data collected during field visits. A base map of drainage facilities within the City is shown in Figure 3-1. A large fold-out map is also included in Appendix B.

Some of the City's infrastructure dates back 70 years. As such, numerous developments do not include stormwater detention or treatment systems, as is required by today's codes. Figures 3-2 through 3-8 show the approximate construction dates of the piping included within the City's system. These were created based on as-built drawings when available. In the absence of as-built or other information, it was assumed that stormwater infrastructure was constructed in the same year as the surrounding development. These maps may be useful in assigning dates for replacing aging infrastructure. The City may want to allocate a certain amount of funds per year to replace these pipes until all of the older infrastructure has been replaced as necessary.

IDENTIFIED STORMWATER CONVEYANCE PROBLEMS

City employee comments were reviewed in order to identify stormwater issues that have occurred since the 2006 Plan. Field investigations of specific problem areas were conducted to identify new projects. The City also provided an account of projects identified in previous plans that remain to be addressed. These projects were based upon hydrologic and hydraulic models developed by Tetra Tech for the 2006 Plan. Updated versions of these models were created for the current Plan using XPStorm software from XP Solutions. The XPStorm computer program is capable of modeling the hydraulic capacity of pipes, open channels, and detention/retention systems. The hydrologic/hydraulic model for the project area was developed to assess the capacity of the stormwater conveyance system under both existing and future land use conditions.

Background information used to populate the model as well as the model results are provided in Appendix C.

HYDROLOGIC MODEL

Hydrologic analysis addresses the movement of rainfall to the conveyance system. The purpose of a hydrologic model is to predict the flow of stormwater runoff into the conveyance system. The XPStorm model requires input parameters that describe physical drainage basin characteristics. Key parameters include the area of pervious and impervious surfaces, the interconnectivity of the impervious areas, topography, infiltration characteristics of the soil, and rainfall. XPStorm is capable of running either a design storm or an actual recorded rainfall event. For the purposes of this Plan, a single event using the Santa Barbara Urban Hydrograph Method was utilized to size conveyance pipes whereas a continuous runoff model (i.e., Ecology's WWHM software) was used to size detention facilities.

HYDRAULIC MODEL

Once the XPStorm model estimates the runoff from each sub-basin for a design event, the flow is inserted into the conveyance system, at each sub-basin's respective connection point. Hydraulic analysis is then used to assess the adequacy of the conveyance system. The water surface elevations are determined over time throughout the conveyance system for a given storm recurrence. Hydraulic analysis is based on the physical characteristics of the conveyance system, such as cross-sectional area, slope, and friction.

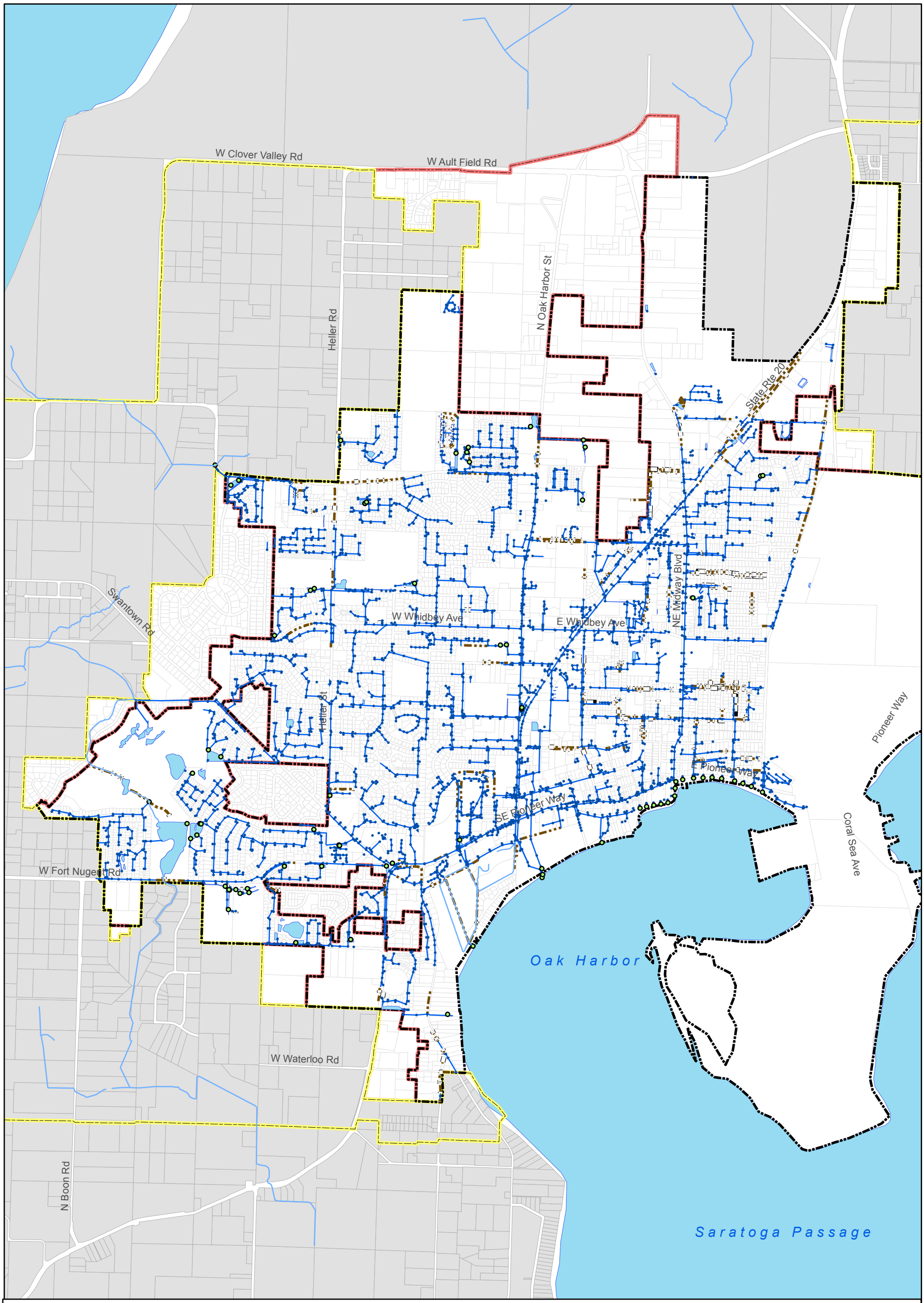
DESIGN STORM

All stormwater runoff models require the input of data describing rainfall volume, intensity, and duration over time. For this model, the SCS Type 1A design storm was used. The XPStorm computer program incorporates a user defined 24-hour rainfall depth to adjust the design storm for flow generation. The 2-, 10-, 25-, and 100-year modeled peak flow were used to analyze the conveyance system, with the 25-year event used to size all CIP designs. Cumulative rainfall amounts based upon NOAA Atlas 2 isopluvial maps are listed in Table 3-1 below.

TABLE 3-1

Cumulative Rainfall for Design Storms

Storm Return Period	2-Year	10-Year	25-Year	100-Year
24-hr Rainfall Amount (in)	1.00	1.75	2.25	2.70



LEGEND:

- Catchbasins
- Outlets
- Storm Drains
- Culverts
- Ditches
- Streams
- Parcels
- City Limits
- UGA
- Joint Planning Area

N

0 2,000 4,000

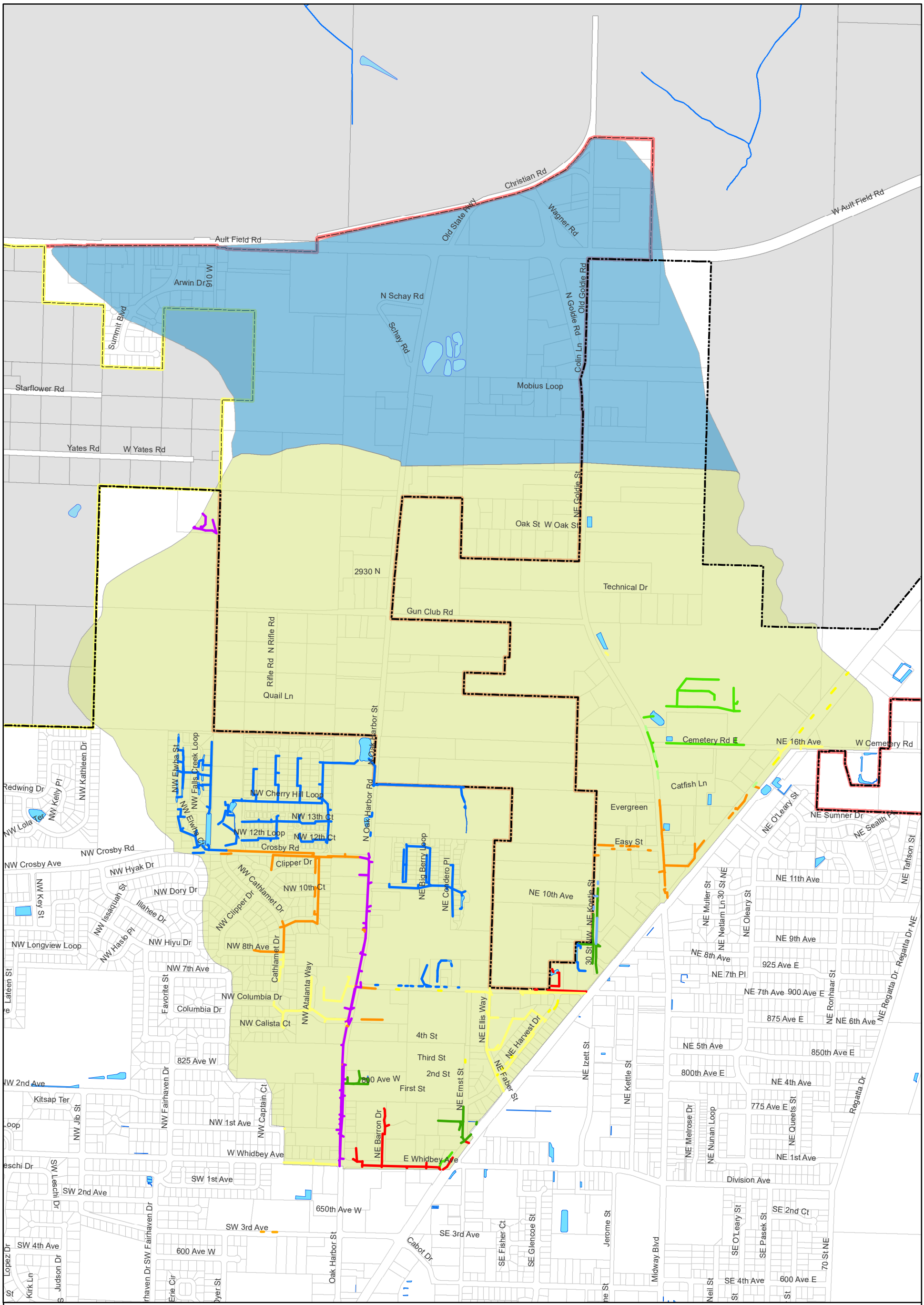
Feet

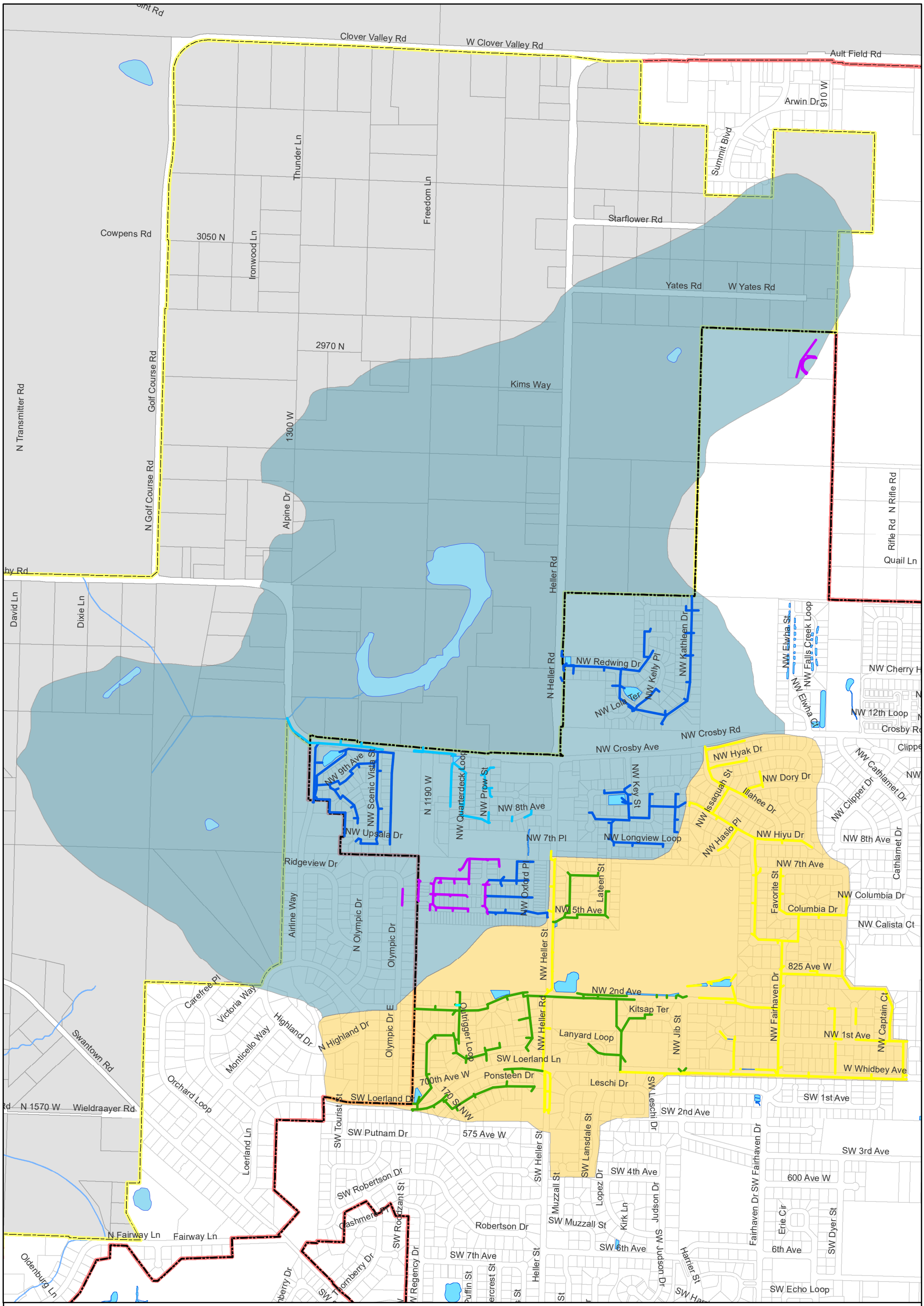
CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
DRAINAGE BASE MAP
FIGURE 3-1

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\Base Map.mxd


Christian Rd
Old State Hwy
Wagner Rd
W Ault Field Rd
Ault Field Rd
Arwin Dr
910 W
Summit Blvd
N Schay Rd
Schay Rd
N Goldie Rd
Old Goldie Rd
Colin Ln
Mobius Loop
Starflower Rd
Yates Rd
W Yates Rd
NE Goldie St
Oak St
W Oak St
2930 N
Technical Dr
Gun Club Rd
Rifle Rd
N Rifle Rd
Quail Ln
N Oak Harbor St
Cemetery Rd E
NE 16th Ave
W Cemetery Rd
Catfish Ln
Evergreen
Easy St
NE O'Leary St
NE Sumner Dr
NE Sealth Pl
NE Taftson St
NW Elwha St
NW Falls Creek Loop
NW Cherry Hill Loop
NW 13th Ct
NW 12th Loop
NW 12th Ct
Crosby Rd
Clipper Dr
NW 10th Ct
NW Cathlamet Dr
NW Clipper Dr
NE Big Berry Loop
NE Condero Pl
NE 10th Ave
NE Koetje St
30 St NW
NE 11th Ave
NE Muller St
NE Netlam Ln
30 St NE
NE Oleary St
NE 9th Ave
NE 8th Ave
NE 7th Pl
925 Ave E
NE 7th Ave
900 Ave E
NE Ronhaar St
NE Regatta Dr
875 Ave E
NE 6th Ave
NE 5th Ave
850th Ave E
800th Ave E
NE 4th Ave
775 Ave E
NE Queets St
NE 1st Ave
Division Ave
Regatta Dr
NE Melrose Dr
NE Nunan Loop
NE Izett St
NE Kettle St
NE Harvest Dr
NE Faber St
NE Ellis Way
NE Ernst St
NE Barron Dr
4th St
Third St
2nd St
First St
E Whidbey Ave
W Whidbey Ave
NW 8th Ave
Cathlamet Dr
NW Atalanta Way
NW Columbia Dr
NW Calista Ct
NW 7th Ave
Columbia Dr
Favorite St
NW Longview Loop
NW Hiyu Dr
Illahee Dr
NW Issaquah St
NW Haslo Pl
NW Dory Dr
NW Hyak Dr
NW Crosby Ave
NW Crosby Rd
NW Key St
NW Kelly Pl
NW Kathleen Dr
Redwing Dr
NW Lola Ter
Lateen St
825 Ave W
700 Ave W
600 Ave W
650th Ave W
NW 2nd Ave
Kitsap Ter
NW Jib St
NW Fairhaven Dr
NW Captain Ct
NW 1st Ave
SW 1st Ave
SW 2nd Ave
SW 3rd Ave
SW 4th Ave
SW Leschi Dr
Lopez Dr
Judson Dr
Kirk Ln
Erie Cir
Dyer St
Oak Harbor St
Cabot Dr
SE 3rd Ave
SE Fisher Ct
SE Glencoe St
Jerome St
Midway Blvd
SE 2nd Ct
SE O'Leary St
SE Pasek St
70 St NE
SE 4th Ave
600 Ave E
Neil St
LEGEND:
Est. Pipe Installation Dates
1947 - 1959
1960 - 1969
1970 - 1979
1980 - 1989
1990 - 1999
2000 - 2009
2010 - 2017
Ault Field Basin
Upper Dry Creek Basin
Detention Pond
City Limits
UGA
JPA
Streams
N
Feet
0
1,000
2,000
CITY OF OAK HARBOR
COMPREHENSIVE STORMWATER MANAGEMENT PLAN
AULT FIELD & UPPER DRY CREEK BASIN MAP
FIGURE 3-2
Gray & Osborne, Inc.
M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\3-2 Ault Field.mxd



LEGEND:

Est. Pipe Installation Dates

- 1947 - 1959
- 1960 - 1969
- 1970 - 1979
- 1980 - 1989
- 1990 - 1999
- 2000 - 2009
- 2010 - 2017

- Northwest Basin
- High School Basin
- Detention Pond
- Streams

- City Limits
- UGA
- JPA

N

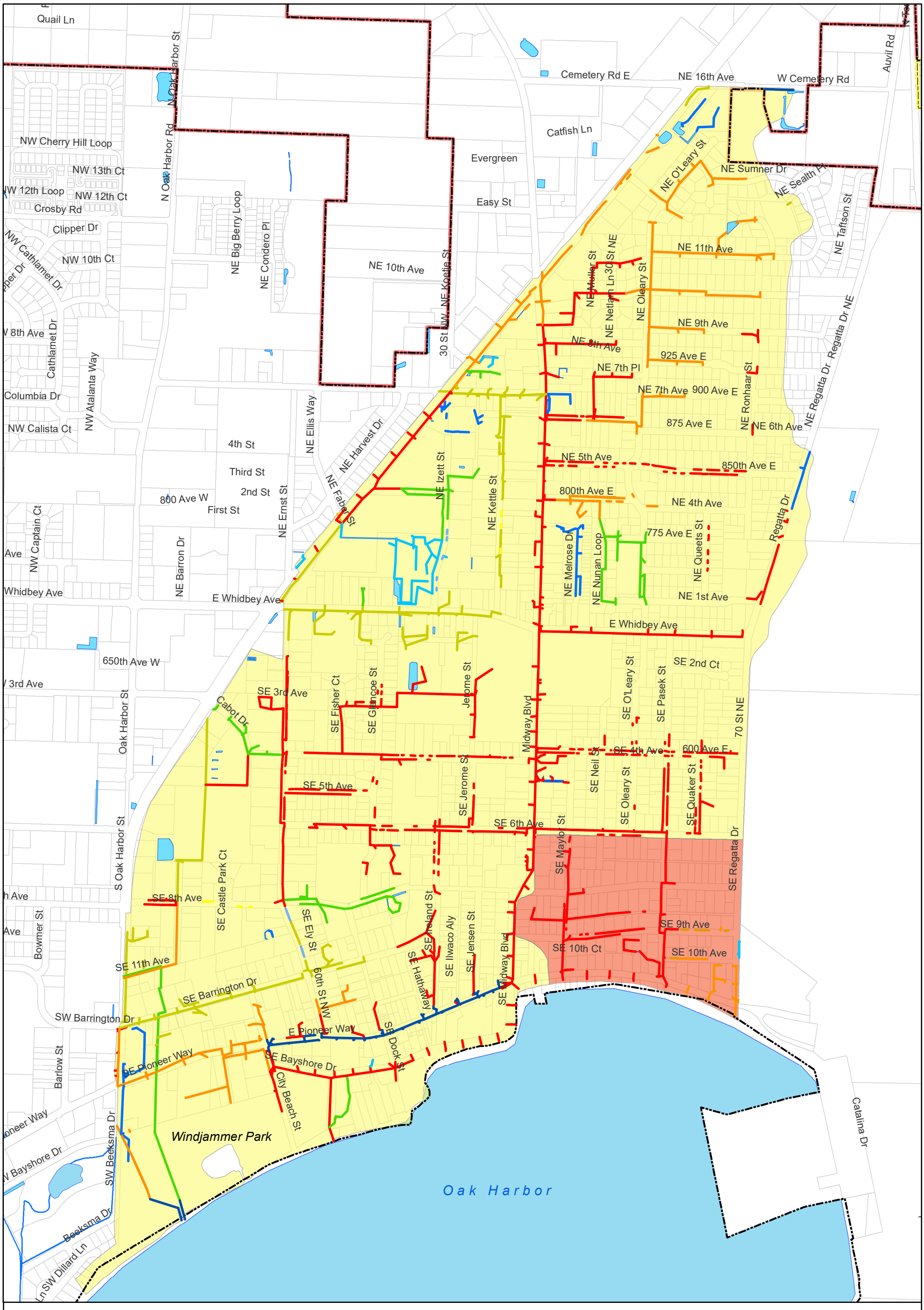
0 900 1,800 Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
HIGH SCHOOL & NORTHWEST BASIN MAP
FIGURE 3-3

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\3-3 High School & Northwest.mxd



LEGEND:

Est. Pipe Installation Dates

- 1947 - 1959
- 1960 - 1969
- 1970 - 1979
- 1980 - 1989
- 1990 - 1999
- 2000 - 2009
- 2010 - 2017

- Midway Basin
- Oak Prairie Basin
- Detention Pond
- City Limits
- UGA
- JPA
- Streams

0 800 1,600
Feet

N

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
MIDWAY AND OAK PRAIRIE BASIN MAP
FIGURE 3-4

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\3-4 Midway & Oak Prairie.mxd

W Whidbey Ave
E Whidbey Ave
NE Barron
Leschi Dr
SW Leschi Dr
SW 1st Ave
SW 2nd Ave
SW 3rd Ave
SE 3rd Ave
Cabot Dr
SW Lansdale St
SW Heller St
SW 4th Ave
Lopez Dr
Muzzall St
SW Muzzall St
Kirk Ln
Judson Dr
SW Judson Dr
Fairhaven Dr
SW Fairhaven Dr
Erie Cir
SW Dyer St
Oak Harbor St
SW 6th Ave
6th Ave
Heller St
Harrier St
SW Harrier Cir
SW Echo Loop
Echo Loop
S Oak Harbor St
SE Castle Park Ct
SW McCrohan St
London Ter
SW Kingma Ct
SW Inglewood Ln
SW Castilian Dr
SW 8th Ave
SE 8th Ave
SW Heller Rd
SW 10th Ct
SW Fleet St
SW 10th Ave
Bowmer St
SE 11th Ave
Kalama Loop
Looking Glass Loop
Kittitas Ct
SW 11th Ct
Fleet St
SE Barrington Dr
SW Barrington Dr
SW 13th Ct
300th Ave W
SW Swantown Ave
SW Founders St
Islander Ln
Barlow St
SE Pioneer Way
SW Erie St
Erie St
W Pioneer Way
SW Kimball Dr
Hemlock
Fir St
Harborview
SW Bayshore Dr
SW Beeksma Dr
City Beach St
Glenmont Ave
W Ida Pl
SW 18th Ct
SW 19th Ct
Oakmont Ln
Lamms Ln
2000
Beeksma Dr
Freund Marsh
SW Dillard Ln
Dillard Ln
W Poppys Pl
Capital St
W Capital St
SW Talon Loop
SW 24th Ave
SW Freund St
Freund St
SW Petes Ln
Pete's Ln
Oak Harbor

LEGEND:

Est. Pipe Installation Dates

- 1947 - 1959
- 1960 - 1969
- 1970 - 1979
- 1980 - 1989
- 1990 - 1999
- 2000 - 2009
- 2010 - 2017

- Dry Creek Basin
- Detention Pond
- City Limits
- UGA
- JPA
- Streams

N

0 600 1,200
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
DRY CREEK BASIN MAP
FIGURE 3-5

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\3-5 Dry Creek.mxd

Pinecone Pl
Wildberry Ln
Juan de Fuca Rd
Fern Pl
Moss Ln
McKinnon Dr
Swantown Rd
Wield Raayer Rd
N 1570 W
Wieldraayer Rd
NW 9th Ave
NW Scenic Vista St
N 1190 W
NW Quarterdeck Loop
NW Prow St
NW 8th Ave
NW Upsala Dr
NW 7th Pl
Ridgeview Dr
NW Oxford Pl
NW 5th
Airline Way
N Olympic Dr
Olympic Dr
NW Heller St
Carefree Pl
Victoria Way
Highland Dr
N Highland Dr
Monticello Way
Olympic Dr E
Ontrigger Loop
NW Heller Rd
Lanya
SW Loerland Ln
Orchard Loop
700th Ave W
Ponsteen Dr
170 St NW
SW Loerland Dr
SW Tourist Dr
Loerland Ln
SW Putnam Dr
575 Ave W
SW Heller St
SW Robertson Dr
Cashmere Pl
SW Rodgaard St
Muzzall St
SW Muz
Robertson Dr
N Fairway Ln
Fairway Ln
Oldenburg Ln
SW Thornberry Dr
SW Sunnyside Ave
Thornberry Dr
SW Regency Dr
1200 W
SW 7th Ave
Puffin St
Ottercrest St
SW Orcas St
Heller St
SW Upland Ct
SW Silverberry St
SW Quinault St
SW 9th Ave
SW 10th Ave
SW McCrohan St
SW Heller Rd
Country Club Ln
Wedgewood Ln
Links Way
Liberty Ln
Swantown Ave
Lato Dr
Looking Gl
Boulder Meadow Ln
SW Vanguard St
Heritage Way
SW Xavier Dr
SW Victory St
N Colonial Way
Crossroads Cir
N Crosswoods Cir
SW Swantown Ave
Fireside Ln
N 1675 W
Loer's Pond
SW Carnegie St
SW Berwick Dr
SW Fairway Point Dr
SW Ulysses St
SW 16th Ave
SW Downfield Way
SW Cooper Way
SW Aberdeen Ct
SW Waterside Ct
SW 17th Ave
SW Springfield Ct
SW Rock Rose Dr
Quince St
October Ln
2050 N
N 1525 W
Sage Ln
SW Union St
SW Tahoe St
SW Fort Nugent Ave
Rd
W Fort Nugent Rd
SW Stremler Dr
W Ida Pl
Old Cedar Ln
Country Ln
N Bonaparte Ln
Ridgeway Dr
SW Rosario Pl
W Sparrow Dr
Greenwood St
SW Navigator Loop
SW 24t
1380 W
Carlton WayW Carlton Way
Bonaparte Ln
W Wellington Dr
Waterloo Marsh
Wellington Dr
Conifer Ln
1790 N
Napoleon Dr
W Napoleon Dr

LEGEND:

Est. Pipe Installation Dates

- 1954 - 1959
- 1960 - 1969
- 1970 - 1979
- 1980 - 1989
- 1990 - 1999
- 2000 - 2009
- 2010 - 2017

- Golf Course Basin
- Detention Pond
- City Limits
- UGA
- JPA
- Streams

N

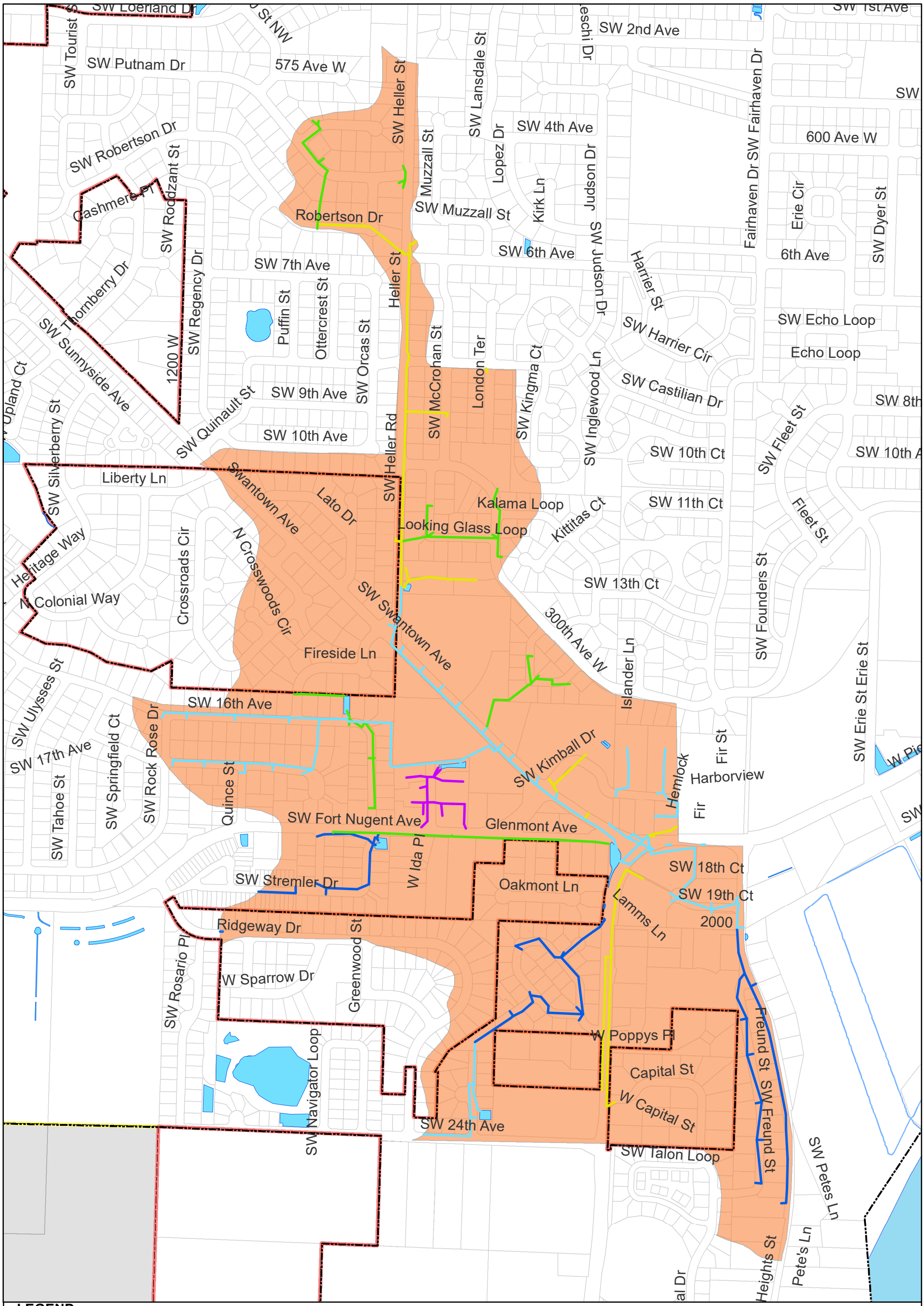
0 900 1,800
Feet

CITY OF OAK HARBOR

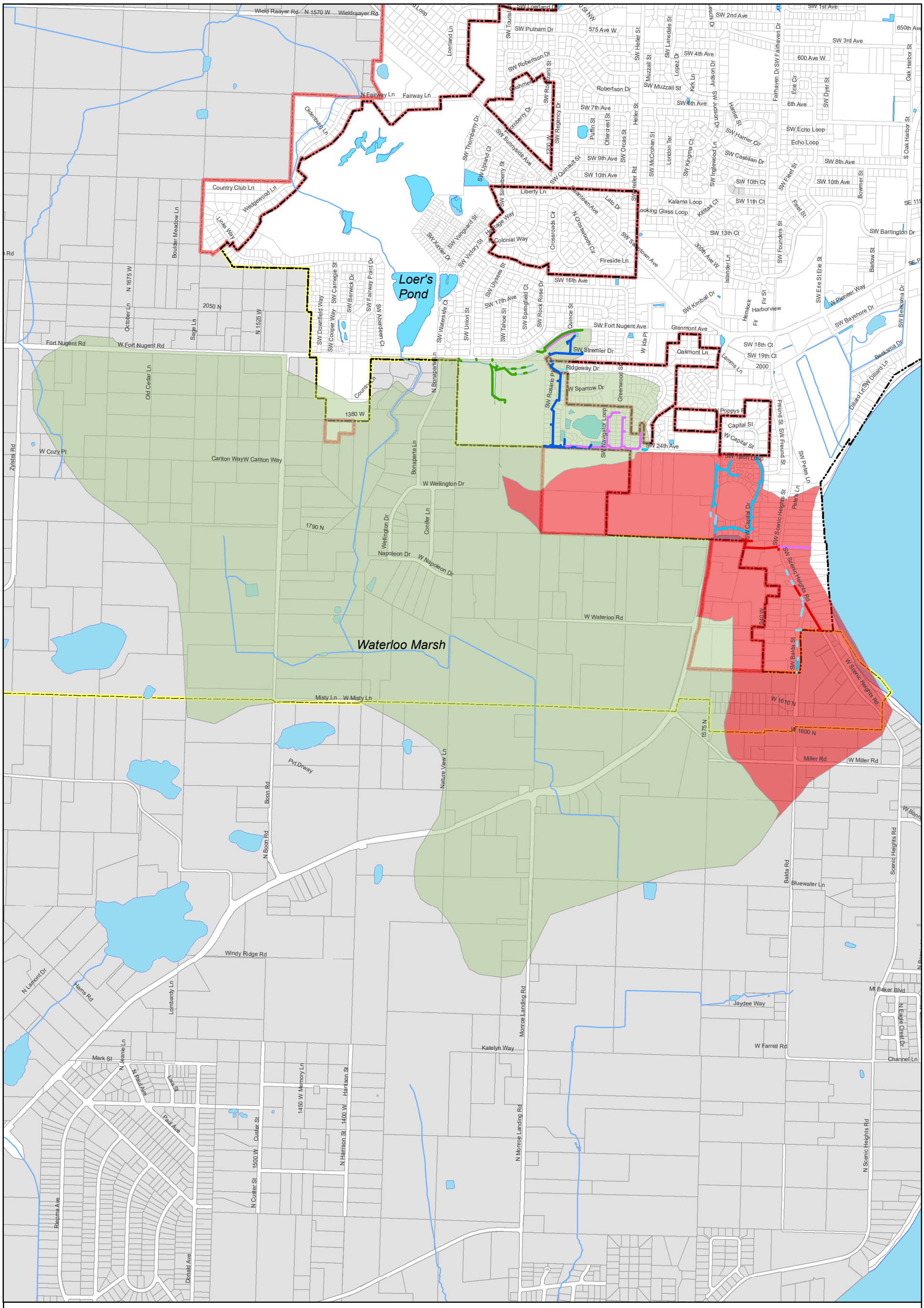
COMPREHENSIVE STORMWATER MANAGEMENT PLAN
GOLF COURSE BASIN MAP
FIGURE 3-6

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\3-6 Golf Course.mxd



M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\3-7 Freund Marsh.mxd



M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\3-8 Waterloo Marsh & Eagle Vista.mxd

MODELING RESULTS AND SYSTEM DEFICIENCIES

After review of the model results, deficiencies identified by the 2006 Plan, as well as staff comments, the following areas have been identified as having current or future deficiencies. These areas are named and organized by drainage basin, and described below. The two letters in the identification number of the problem area represent the initials of the drainage basin (e.g., GC-1 = Golf Course Area 1). The identification numbers also correspond to the number assigned to the recommended Capital Improvement Plan (CIP) projects presented in Chapter 6. For each section of stormwater infrastructure that is recommended to be replaced/upgraded, the GIS identification number (beginning with "SD") and the hydrologic/hydraulic model pipe identification number (beginning with "L") are provided. In the case that the GIS data does not provide a unique identification number, a "0" is used. Figure 3-9 shows the approximate location of the system deficiencies identified below. Further discussion regarding solutions or recommended CIPs for these problem areas is described in Chapter 6 (Capital Improvement Plan).

Numerous pipes within the model were assumed to be corrugated metal pipe (CMP). This provides a conservative modeling approach as CMP generally has a rougher interior than a smooth walled pipe. This assumption lends to a model that will demonstrate less capacity being available within the pipes. Unless stated otherwise, all recommended pipe upgrades should include verification of the presence of CMP pipe. This Plan assumes that a smooth-bore pipe will be installed (i.e., Mannings n=0.013 or less) and that the existing slope will be utilized in the future. However, the optimum slope should be analyzed prior to implementation of any recommended design projects in order to provide maximum capacity and minimum pipe size while also allowing sediment to transport through the pipe.

UPPER DRY CREEK

The project areas for the Upper Dry Creek basin may be found in Figure 3-10 and are described below.

UDC-1: Undersized Stormwater Pipes Along North Oak Harbor Street

Four sections of 18-inch pipe along North Oak Harbor Street (labeled A through D below) are shown by the model to be over capacity for the 25-year event under future buildout conditions. The GIS pipe identification number and the identification number provided within the model are both listed in parenthesis.

A. Approximately 200 feet of 18-inch pipe north of NW Crosby Avenue (SD 2408 and SD 0/L_C192).

B. Approximately 406 feet of 18-inch pipe south of NW Crosby Avenue (SD 1574 and SD 1575/L_C4).

C. Approximately 352 feet of 18-inch pipe between NE 10th Avenue and NE 7th Avenue (SD 1581 and SD 0/L_C6).

D. Approximately 422 feet of 18-inch pipe north of East Whidbey Avenue (SD 0/L_C10).

The recommended solution is to replace these sections with 24-inch pipe.

UDC-2/UDC-4: Flooding at NE 7th Avenue and NE Ellis

City staff reported flooding along NE 7th Avenue, west of NE Ellis Way. A site survey revealed that a section of 12-inch pipe (SD 1568/Link261) has a negative slope. The model shows surcharging of this pipe and flooding at the upstream catch basin during the 25-year event under future conditions. The recommended solution is to replace this and the following section of pipe (SD 1569/Link262) with 18-inch pipe at a constant slope of at least 0.3 percent. Per modeling results, replacing these pipes is not anticipated to create a problem downstream. It should be noted that in large events, runoff from the Harbor Ridge apartment complex located upstream near NE 10th Avenue and North Oak Harbor Street is directed toward this ditch along the south side of NE 7th Avenue. At a maximum, the pump from the apartments would release 368 gpm (or 0.8 cfs) of flow to the ditch. This appears to be a relatively minor amount and is not expected to be the cause of flooding along this area. In addition, City staff believe the wetland to the north of NE 7th Ave. is a source for large amounts of runoff. It is proposed that a feasibility study be conducted to potentially provide a flow control BMP in this vicinity. Implementation of a flow control BMP may resolve or partially resolve the flooding along NE 7th Avenue and NE Ellis, possibly negating the need for pipe replacement.

UDC-3: Retrofit Flow Control/Treatment Project at NE Goldie Street and Easy Street

The existing 12-inch culvert crossing NE Goldie Street, south of Easy Street, has been reported as undersized by City staff and a section of 15-inch pipe (SD 1720, SD 1719, SD 1718, SD 1717, SD 2264/L_C184) just north of the culvert is shown by the model to be undersized for the 25-year event under future conditions. The culvert crossing at NE Goldie Street will be relocated to the north in conjunction with efforts to retrofit the area by providing flow control and treatment facilities just west of Goldie Street and south of Easy Street.

POTENTIAL SOLUTIONS

UDC-1: N Oak Harbor St - Replace 18" pipe with 24" pipe
UDC-2: NE 7th Ave and NE Ellis - Replace 12" pipe with 18" pipe at a 0.3% minimum slope
UDC-3: NE Goldie St - Install conveyance, flow control and treatment
UDC-4: 7th Ave. Wetland BMP Study - Potential flow control and treatment BMP retrofit

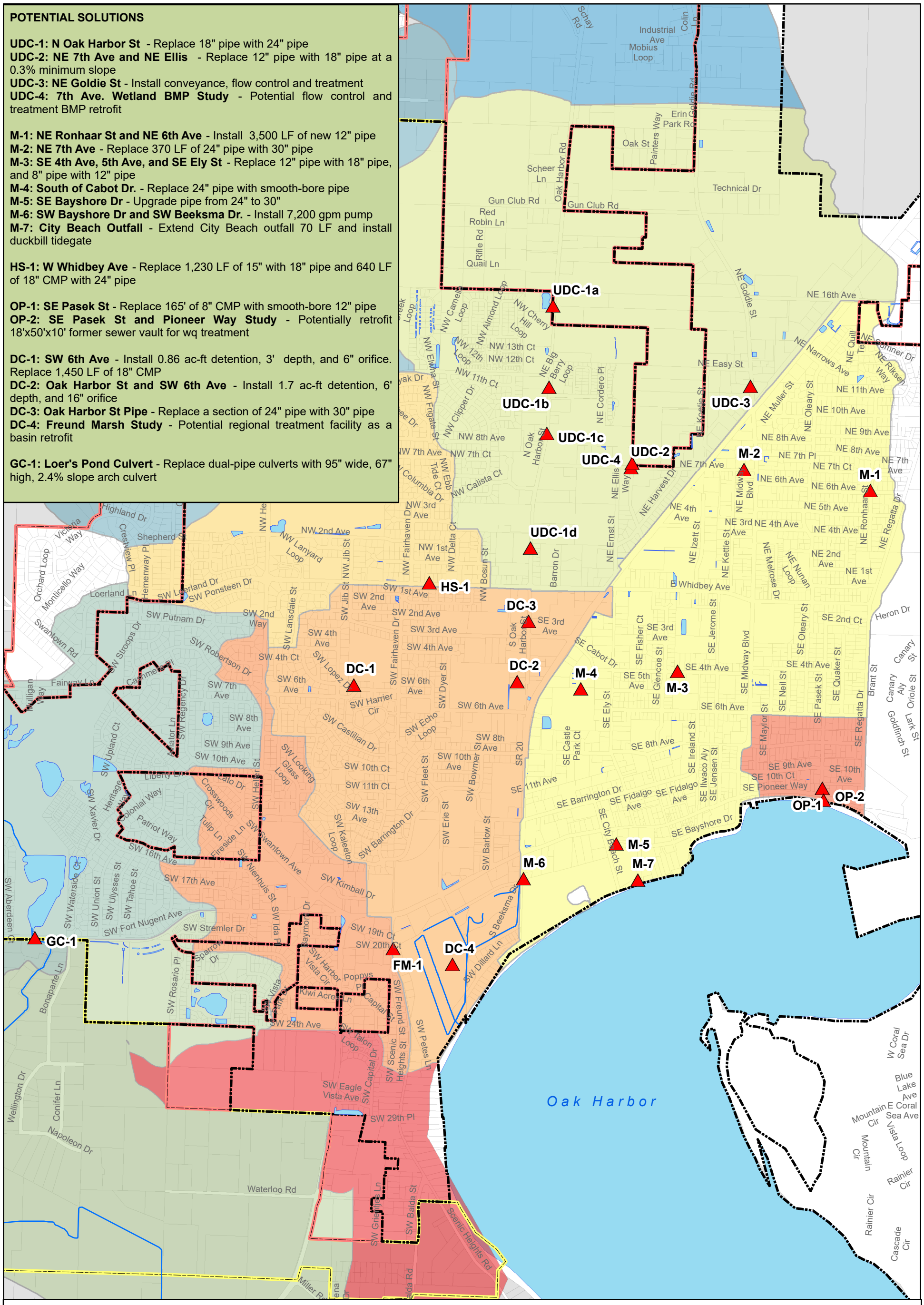
M-1: NE Ronhaar St and NE 6th Ave - Install 3,500 LF of new 12" pipe
M-2: NE 7th Ave - Replace 370 LF of 24" pipe with 30" pipe
M-3: SE 4th Ave, 5th Ave, and SE Ely St - Replace 12" pipe with 18" pipe, and 8" pipe with 12" pipe
M-4: South of Cabot Dr. - Replace 24" pipe with smooth-bore pipe
M-5: SE Bayshore Dr - Upgrade pipe from 24" to 30"
M-6: SW Bayshore Dr and SW Beeksma Dr. - Install 7,200 gpm pump
M-7: City Beach Outfall - Extend City Beach outfall 70 LF and install duckbill tidegate

HS-1: W Whidbey Ave - Replace 1,230 LF of 15" with 18" pipe and 640 LF of 18" CMP with 24" pipe

OP-1: SE Pasek St - Replace 165' of 8" CMP with smooth-bore 12" pipe
OP-2: SE Pasek St and Pioneer Way Study - Potentially retrofit 18'x50'x10' former sewer vault for wq treatment

DC-1: SW 6th Ave - Install 0.86 ac-ft detention, 3' depth, and 6" orifice. Replace 1,450 LF of 18" CMP
DC-2: Oak Harbor St and SW 6th Ave - Install 1.7 ac-ft detention, 6' depth, and 16" orifice
DC-3: Oak Harbor St Pipe - Replace a section of 24" pipe with 30" pipe
DC-4: Freund Marsh Study - Potential regional treatment facility as a basin retrofit

GC-1: Loer's Pond Culvert - Replace dual-pipe culverts with 95" wide, 67" high, 2.4% slope arch culvert



LEGEND:

- System Deficiency
- Streams
- Water Bodies
- Parcels
- City Limits
- Unincorporated UGA
- Joint Planning Area

stormwater_basins

Basin

- Ault Field Basin
- Northwest Basin
- Golf Course Basin
- Waterloo Marsh Basin
- Upper Dry Creek Basin
- Midway Basin
- High School Basin
- Dry Creek Basin
- Freund Marsh Basin
- Oak Prairie Basin
- Eagle Vista Basin

N

0 2,000 Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
SYSTEM DEFICIENCIES
FIGURE 3-9

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\3-9 CIPs.mxd

UDC-1a: Undersized Pipe N. Oak Harbor St.
Issue: Capacity
Potential Solution: Replace existing 18" pipe with 24" pipe

UDC-3: N.E. Goldie St.
Issue: Capacity
Potential Solution: Conveyance, flow control, treatment improvements

UDC-1b: Undersized Pipe N. Oak Harbor St.
Issue: Capacity
Potential Solution: Replace existing 18" pipe with 24" pipe

UDC-1c: Undersized Pipe N. Oak Harbor St.
Issue: Capacity
Potential Solution: Replace existing 18" pipe with 24" pipe

UDC-4: N.E. 7th Ave. Wetland Study
Issue: Capacity
Potential Solution: Potential flow control BMP

UDC-2: N.E. 7th Ave.
Issue: Capacity
Potential Solution: Replace existing 12" pipes with 18" pipe at a constant slope.

UDC-1d: Undersized Pipe N. Oak Harbor St.
Issue: Capacity
Potential Solution: Replace existing 18" pipe with 24" pipe

DC-1

DC-3

M-2

LEGEND:

- System Deficiencies
- Storm Drains
- Culverts
- Ditches
- Streams
- Water Bodies
- Parcels
- City Limits
- Incorporated UGA
- Joint Planning Area

N

0 500 1,000
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
UPPER DRY CREEK BASIN RESULTS
FIGURE 3-10

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\3-10 UDC CIPs.mxd

MIDWAY

The project areas for the Midway basin may be found in Figures 3-11 through 3-13 and are described below.

M-1: Stormwater Infrastructure Along NE Ronhaar Street and NE 6th Avenue

City staff have identified a large portion of both NE Ronhaar Street and NE 6th Avenue that does not have any stormwater drainage infrastructure. Runoff currently flows uncontrolled down the shoulders of the roads. Installation of 12-inch storm drains along approximately 1,500 feet of NE 6th Avenue and 2,000 feet of NE Ronhaar Street to control the flow of stormwater runoff is recommended.

M-2: Undersized Pipe Along NE 7th Avenue

Approximately 370 feet of 24-inch pipe along NE 7th Avenue (SD 2184, SD 2186/L_C165), between NE Kettle Street and NE Midway Boulevard, is shown by the model to be over capacity in the future for the 25-year storm. The recommended solution is to replace this pipe with 30-inch pipe.

M-3: Undersized Stormwater Pipes Along SE 4th Avenue, SE 5th Avenue, and SE Ely Street

As shown in Table 3-3, multiple sections of pipe along SE 4th Avenue, SE 5th Avenue, and SE Ely Street are shown by the model to be over capacity for the 25-year event. As this issue is predicted under future conditions, upgrades to these pipes are considered less critical and therefore, it is recommended that upgrades take place during a road resurfacing project to minimize costs. The recommended pipe sizes are listed in Table 3-2.

TABLE 3-2

Recommended Upgrades Along SE 4th Avenue, SE 5th Avenue, and SE Ely Street

GIS Pipe ID No.	Model Pipe No.	Existing Size (in)	Recommended Size (in)
2460, 1795, 1796, 1797	L_C151	8	12
1804, 1803, 1800	L_C153	8	12
1778, 1779, 1780, 1781,	L_C155	8	12
-	L_C156	8	12
1790	L_C157	12	18
-	L_C158	8	12
1733, 1734, Unidentified	L_C159	8	12

M-4: Corrugated Stormwater Pipe Restricting Flow North of Home Depot (South of Cabot Drive)

A 24-inch section of pipe to the north of Home Depot (SD 1965/L_C148) is shown by the model to be a CMP pipe and to be over capacity for the 25-year event. The recommended solution is to verify the material of the pipe and then replace the pipe with a smooth lined, 24-inch diameter corrugated polyethylene (CPEP) pipe.

M-5: Undersized Pipe Along SE Bayshore Drive

Model results show a 24-inch pipe along SE Bayshore Drive (SD 47, SD 48/L_C96) to be over capacity for the 25-year event. The recommended solution is to upgrade this pipe to a 30-inch pipe.

M-6: Flooding at SW Bayshore Drive and SW Beeksma Drive

Flooding occurs along SW Beeksma Drive due to backwater effects associated with high tides in the bay. The area is relatively flat, reducing the hydraulic efficiency of the existing 42-inch pipes. Due to this area being archaeologically sensitive, minimal digging is allowed. Therefore, the recommended solution is to install a pump station near the intersection of SW Bayshore Drive and SW Beeksma Drive. This pump station would accommodate the excess flows during a 25-year storm. A valve would be installed in a new manhole (MH 1) where during a large storm, the valve would manually be closed and flows would be directed to a sediment/trash collection facility. From there, flows would enter a new pump station. The pump station would then pump flows through a new section of force main to another new manhole (MH 2) located just downstream of the first, utilizing the existing 42-inch storm drain from that point on as a force main (see Figure 3-13). . This project includes approximately 50 feet of pipe from the manhole (MH 1) to the pump station, a 7,200 gpm pump (at 20 feet total dynamic head), and 50 feet of 22-inch HDPE force main from the pump station back to the 42-inch pipe at MH 2. The three catch basin lids downstream of the pump station would need to be solid lids to maintain pressure to the outfall and a check valve would be located just upstream of MH 2 to ensure flows do not back upstream. New catch basins with duckbill valves (or similar) would be inserted next to the three solid lid (water-tight) catch basins to ensure that local drainage can enter the system while the 42-inch pipe leading to the outfall can remain under pressure. Additionally, the City may want to add a spill control or treatment vault with trash screening just prior to the pump station where a portion of diverted flow could be treated prior to being discharged to the Harbor. The vault could be used as a potential area for collecting debris and/or oil prior to entering the pump station. Use of a bending weir may help divert flows to vaults as needed.

M-2: Undersized Pipe along N.E. 7th Ave.
Issue: Capacity
Potential Solution: Replace existing 24" pipe with 30" pipe

UDC-3

UDC-2

M-1: N.E. Ronhaar St. and N.E. 6th Ave.
Issue: No Stormwater Infrastructure
Potential Solution: Install approximately 3,500 LF of new 12" pipe

M-3: Undersized Pipe Along S.E. 4th Ave., 5th Ave., and Ely St.
Issue: Capacity
Potential Solution: Replace existing 8" pipe with 12" pipe and existing 12" pipe with 18" pipe

M-4: Pipe South of Cabot Drive
Issue: Capacity
Potential Solution: Replace existing 24" CMP pipe with 24" smooth interior pipe

OP-1

Catfish Ln
Evergreen
Easy St
State Rte 20
Narrows Ave
NE Sumner Dr
NE Big Berry Loop
NE Condero Pl
NE 10th Ave
NE 11th Ave
NE Riksen Way
NE Multer St
30 St NE
NE Meeter Ln
NE Netlam Ln
NE O'Leary St
NE 10th Ave
NE 9th Ave
NE 8th Ave
30 St NW
NE 7th Pl
925 Ave E
NE 8th Ave
NE 7th Ave
NE 7th Ct
900 Ave E
NE Ronhaar St
NE 6th Ave
875 Ave E
4th St
Village Dr
3rd St
Third St
2nd St
First St
Pass St
NE Ellis Way
NE Harvest Dr
NE Faber St
NE Ernst St
800 Ave W
NE Izett St
NE Kettle St
NE 3rd Ave
NE 5th Ave
850th Ave E
Regatta Dr NE
Regatta Dr
775 Ave E
NE Goldie St
NE Melrose Dr
NE Nunan Loop
NE Queets St
NE 2nd Ave
NE Regatta Dr
NE 1st Ave
725th Ave E
E Whidbey Ave
Heron St
SE 2nd Ct
SE Fisher Ct
SE Glencoe St
SE Jerome St
SE Ely St
Cabot Dr
SE Pasek St
Clover St
SE O'Leary St
SE 4th Ave
600 Ave E
Midway Blvd
SE Neil St
SE Quaker St
Goldfinch St
60th St NW
550 Ave W
Reed St
Meadow Dr
Canary Aly
Lark St
Jay St
Jay Aly
70 St NE
SE 6th Ave
Park Ct
SE Regatta Dr
Brant St
SE 8th Ave
SE 9th Ave
SE 10th Ct
SE 10th Ave
SE Pioneer Way
E Pioneer Way
SE Barrington Dr
SE Fidalgo Ave
SE Hathaway
SE Ireland St
SE Iwaco Aly
SE Jensen St

LEGEND:

- System Deficiencies
- Storm Drains
- Culverts
- Ditches
- Streams
- Water Bodies
- Parcels
- City Limits
- Incorporated UGA
- Joint Planning Area

N

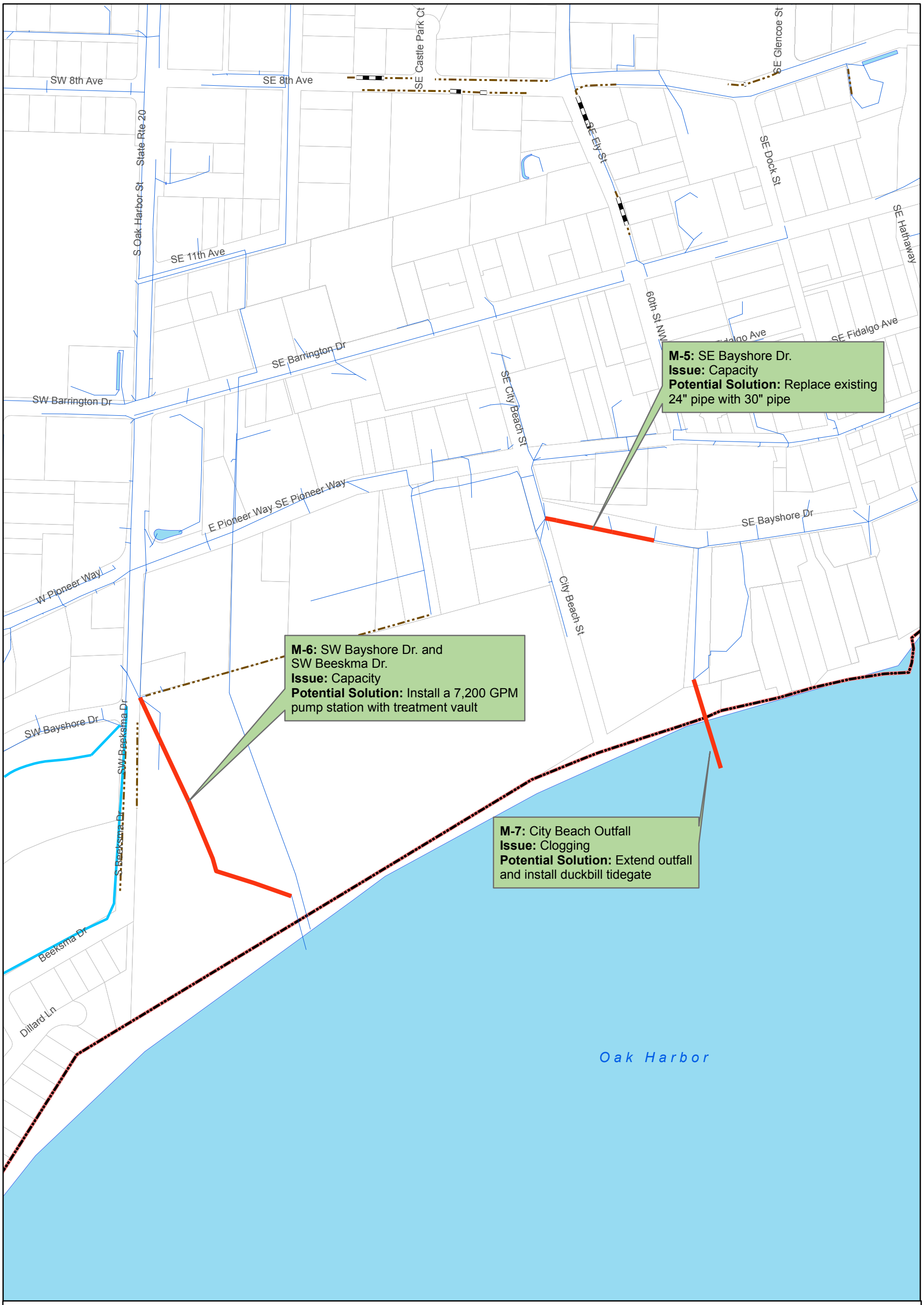
0 550 1,100
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
MIDWAY (NORTH) BASIN RESULTS
FIGURE 3-11

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\M1 CIPs.mxd



M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\M2 CIPs.mxd

MH 1

MH 2

P

SW Bayshore Dr

SW Beeksma Dr

M-6: S.W. Beeksma Dr.
Issue: Flooding
Potential Solution: 7,200 GPM pump station and treatment vault

CB 598

CB 100

CB 99

CB 592

Windjammer Park/City Beach

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

LEGEND:

- New Force Main
- Existing Pipe used as Force Main
- Storm Drains
- Treatment Vault
- New Pump Station
- New Valve
- New Manholes
- Catchbasins to be Sealed
- Catchbasins

N

0 60 120 Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
MIDWAY (CITY BEACH) BASIN RESULTS
FIGURE 3-13

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\Pump Station.mxd

M-7: SE City Beach Outfall Clogging

City staff has reported that the outfall south of SE City Beach Street (SD 113/L_C89) periodically clogs with sand/debris from the bay. The recommended solution is to extend the outfall further into the bay approximately 70 feet and install a duck bill type tidegate.

HIGH SCHOOL

The project area for the High School basin may be found in Figure 3-14 and is described below.

HS-1: Corrugated and Undersized Stormwater Pipe Along West Whidbey Avenue

Model results show the existing 15-inch pipe along West Whidbey Avenue and east of Northwest Fairhaven Drive (SD 1670, SD 1673/L_C32) to be over capacity during the 25-year event, restricting flow and causing flooding. The recommended solution is to replace four sections (SD 1670, SD 1673/L_C32 and SD 1675, SD 1678/L_C33) of pipe with 1,230 linear feet of smooth-bore 18-inch pipe and replace the next two downstream sections of pipe (SD 1681, SD 1683/L_C34) with 640 linear feet of 24-inch smooth-bore pipe. To mitigate downstream effects of these upgrades, it is recommended that this be completed along with the DC-2 and DC-3 projects identified below.

OAK PRAIRIE

The project area for the Oak Prairie basin may be found in Figure 3-15 and is described below.

OP-1: Corrugated Stormwater Pipe Restricting Flow Along SE Pasek Street

Model results show that a section of 8-inch pipe along SE Pasek Street from SE 10th Avenue to SE Pioneer Way (SD 177/L_C115) is slightly over capacity for the 25-year event under future conditions. The recommended solution is to replace the pipe with a smooth-bore, 12-inch pipe.

OP-2: Retrofit Treatment Vault at SE Pasek Street and Pioneer Way

A significant portion of the Oak Prairie Basin is not treated. A large portion of the Oak Prairie Basin could be diverted toward a former sewer pump station overflow vault located at SE Pasek Street and Pioneer Way, approximately 8 feet from the existing outfall pipe. This vault is approximately 18-feet wide x 50-feet long x 10-feet deep with a concrete lid that was replaced in 2019. The top of the vault is currently being used as a scenic overlook. A study would be conducted to determine the feasibility of using this vault as a retrofit for water quality purposes. It can be retrofitted by such measures as installing baffles, treatment cartridges or treatment media. Retrofitting the vault in this manner would provide great benefit by providing an end of pipe solution to treating

runoff prior to being discharged to the Harbor. This retrofit would also fulfill Ecology's requirement for planning future retrofit projects within the City.

DRY CREEK

The project areas for the Dry Creek basin may be found in Figure 3-16 and are described below.

DC-1: Flooding Near SW 6th Avenue

City staff has reported that flooding occurs along SW 6th Avenue, east of SW Judson Drive, as catch basins overflow and runoff exceed capacity. To alleviate this problem, a stormwater detention pond or vault could be installed and the existing 18-inch pipe (SD 596, SD 601, SD 603, SD 609, SD 611, SD 613, SD 615, SD 620, SD 624, SD 627/L_C44, L_C43) can be replaced with smooth-lined 18-inch pipe for approximately 1,450 feet. The necessary detention volume needed to alleviate flooding during a 25-year storm is 0.86 acre feet. This equates to 6,243 sf area (or approximately 111' x 111') with an active depth of 3 feet and a flow control structure with a 6-inch orifice. The City owns a parcel adjacent to the intersection of SW 6th Avenue and SW Harrier Street which spans both the north and south sides of the road. This site can be used to house the flow control facility; however, it is important that the facility be lined or enclosed as there are concerns of water infiltrating along a well on the property north of the road (currently capped) and contaminating the aquifer.

DC-2: Flooding Near Oak Harbor Street and SW 6th Avenue

City staff has reported that flooding occurs near the intersection of SR 20 and SW 6th Avenue. The model results show that during the 25-year event, as flows from the north and west converge at the intersection, flow backs up in the 24-inch pipe along S. Oak Harbor Street (SD 680/L_C15). To prevent flooding during the 25-year storm, one solution is for the City to obtain an easement for a detention vault to be located in the open space west of the South Oak Harbor Street cul-de-sac owned by the Southern Baptist Church. The recommended detention volume is 1.7 acre feet. This equates to a vault approximately 245' x 50' with an active depth of 6 feet and a 16-inch orifice.

DC-3: Undersized Stormwater Pipe along Oak Harbor Street

The model results show that a section of 24-inch pipe along Oak Harbor Street, north of SE 3rd Avenue, (SD 681, SD 682, SD 689, SD 692/L_C13) is over capacity during the 25-year event under future conditions. The recommended solution is to upgrade the pipe to 30 inches.

HS-1: W. Whidbey Ave.
Issue: Capacity
Potential Solution: Replace approximately 1,230 LF of existing 15" and 18" CMP with 18" pipe, and 640 LF of 18" CMP with 24" pipe

UDC-1d

DC-3

DC-2

DC-1

NW 7th Ave
NW 7th Ct
Cathlamet Dr
NW Atalanta Way
NE 7th Ave
NW Fairhaven Dr
Favorite St
NW Ebb Tide Ct
NW Ensign Dr
Columbia Dr
NW Columbia Dr
NW Calista Ct
NW 3rd Ave 825 Ave W
NW 2nd Ave
800 Ave W
NW Delta Ct
NW Captain Ct
NW 1st Ave
N Oak Harbor Rd
First St
NW Bosun St
W Whidbey Ave
E Whidbey Ave
SW Festival Ct
SW Cruise St
SW 1st Ave
SW 25th Ave
SW 2nd Ave
650th Ave W
SW 3rd Ave
SE 3rd Ave
600 Ave W
SW 4th Ave
Fairhaven Dr
SW Erie Cir
Erie Cir
SW Dyer St
S Oak Harbor St
State Rte 20
SW 6th Ave
SW 6th Ave 6th Ave
Erie St
SW Harrier Cir
Service Layer Credits:
SW Erie St

LEGEND:

- System Deficiencies
- Potential Solutions
- Storm Drains
- Culverts
- Ditches
- Streams
- Water Bodies
- Parcels
- City Limits
- Incorporated UGA
- Joint Planning Area

N

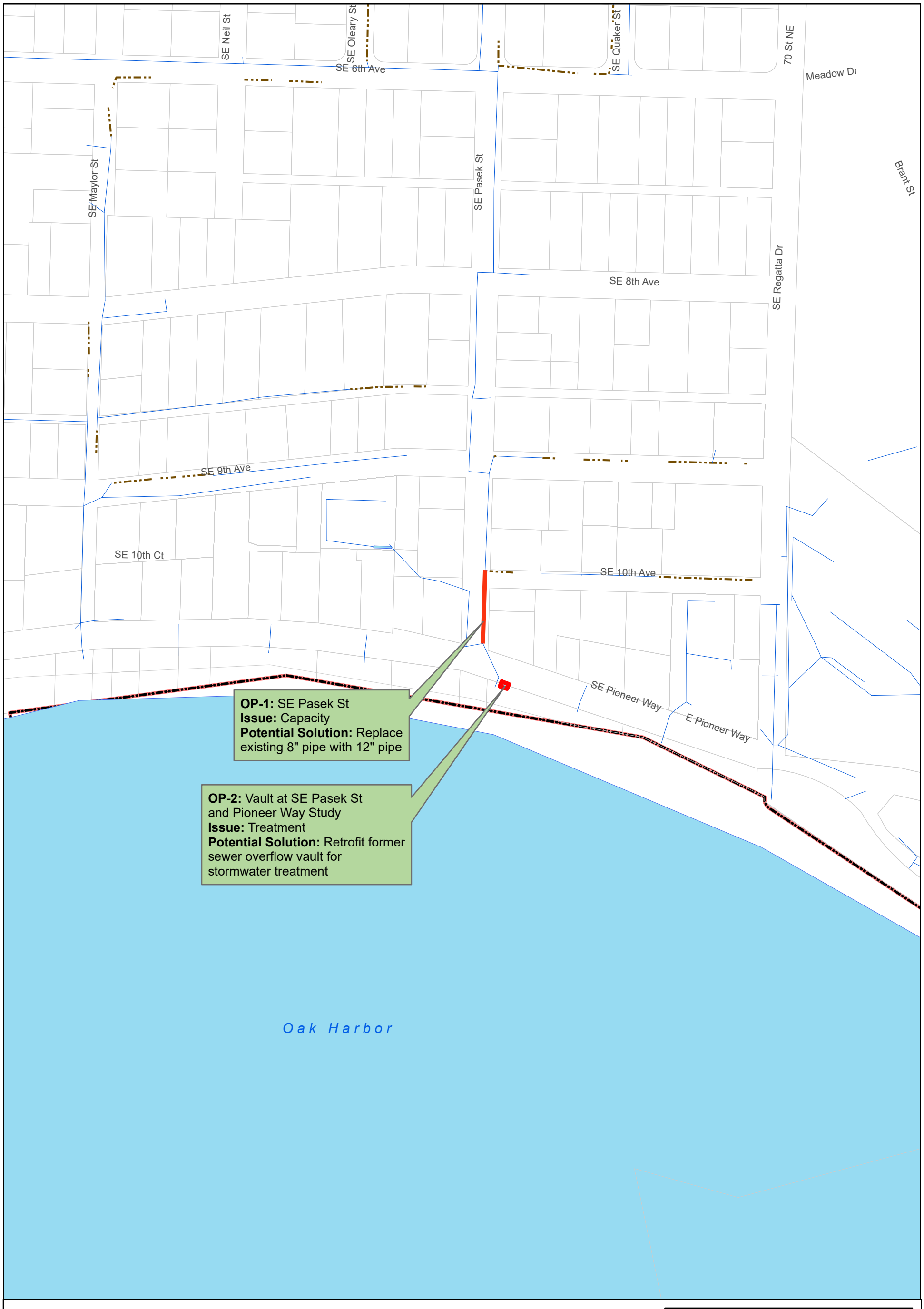
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Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
HIGH SCHOOL BASIN RESULTS
FIGURE 3-14

Gray & Osborne, Inc.

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DC-3: Oak Harbor St.
Issue: Capacity
Potential Solution: Replace existing 24" pipe with 30" pipe

DC-2: Oak Harbor St. and SW 6th Ave
Issue: Capacity
Potential Solution: Install a 1.7 ac-ft detention facility

DC-1: S.W. 6th Ave.
Issue: Capacity
Potential Solution: Construct a 0.86 acre-ft detention facility and replace 18" CMP with smooth interior 18" pipe

DC-4: Freund Marsh Study
Issue: Stormwater Treatment
Potential Solution: Construct a regional stormwater treatment wetland

M-4

M-6

FM-1

Oak Harbor

LEGEND:

- System Deficiencies
- Potential Solutions
- Storm Drains
- Ditches
- Culverts
- Water Bodies
- Parcels
- City Limits
- Incorporated UGA
- Joint Planning Area

N

0 500 1,000
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
DRY CREEK BASIN RESULTS
FIGURE 3-16

Gray & Osborne, Inc.

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DC-4: Freund Marsh Regional Treatment Facility

Chapter 4 discusses the potential for a regional treatment facility in the Freund Marsh area. The concept includes diverting water from the west (away from the flooded area at Windjammer Park/City Beach) towards Freund Marsh to provide treatment prior to entering the bay while also alleviating the flooded region on SW Beeksma Drive. Options include providing a biofiltration swale, using engineered soil, or constructing a treatment wetland.

GOLF COURSE

The project area for the Golf Course basin may be found in Figure 3-17 and is described below.

GC-1: Undersized Culvert at West Fort Nugent Road and Loer's Pond

The culvert crossing West Fort Nugent Road, conveying water from Waterloo Marsh to Loer's Pond, currently consists of two 18-inch CMP pipes at different elevations. Model results show that the culvert is over capacity for the 25-year event under future conditions. It has also been reported that the lower pipe collects sediment and is difficult to clear. The minimum recommended upgrade is an arch culvert with a bottom width of 95 inches, a height of 67-inches, and a bed slope of 2.4 percent.

FREUND MARSH

The project area for the Freund Marsh basin may be found in Figure 3-18 and is described below.

FM-1: Road Runoff Draining to Scenic Heights Trailhead Area

City staff reported that the pervious concrete parking lot for the Scenic Heights Trailhead on SW Scenic Heights Street has been receiving runoff from the street due to the mistaken removal of an existing City catch basin during a WSDOT drainage project. The removal of the catch basin removed the interception and conveyance of runoff from the east side of SW Scenic Heights Street that drains to the Trailhead Park from the north. The catch basin should be replaced and a drainage analysis should be completed for the area to determine the best alternative to directing street runoff away from the pervious pavement area.

EAGLE VISTA

The City recently completed an outfall project on Scenic Heights SW during the Summer of 2018 to help eliminate storm issues within this basin. There are no remaining project areas for the Eagle Vista basin at this time.

ADDITIONAL DRAINAGE CONCERNS

PREDEVELOPMENT FLOW REQUIREMENTS

Oak Harbor is known for its historic ecosystem rich with Garry Oak trees. Development within the City has removed many of these native trees and their associated prairies, but recent efforts have been made to preserve remaining Garry Oaks and foster new saplings. These existing Garry Oaks have been inventoried and locations where they thrived prior to development have been delineated as "Garry Oak prairie." These areas are shown in Figure 3-19. Per Section 2.5.7 of the 2012 Manual, development occurring within the delineated Garry Oak region that requires detention, may match developed discharge durations to the prairie (or pasture) predeveloped condition as opposed to a forested predeveloped condition. This will result in nearly a 40 percent decrease in the size of facilities required for flow control within this area.

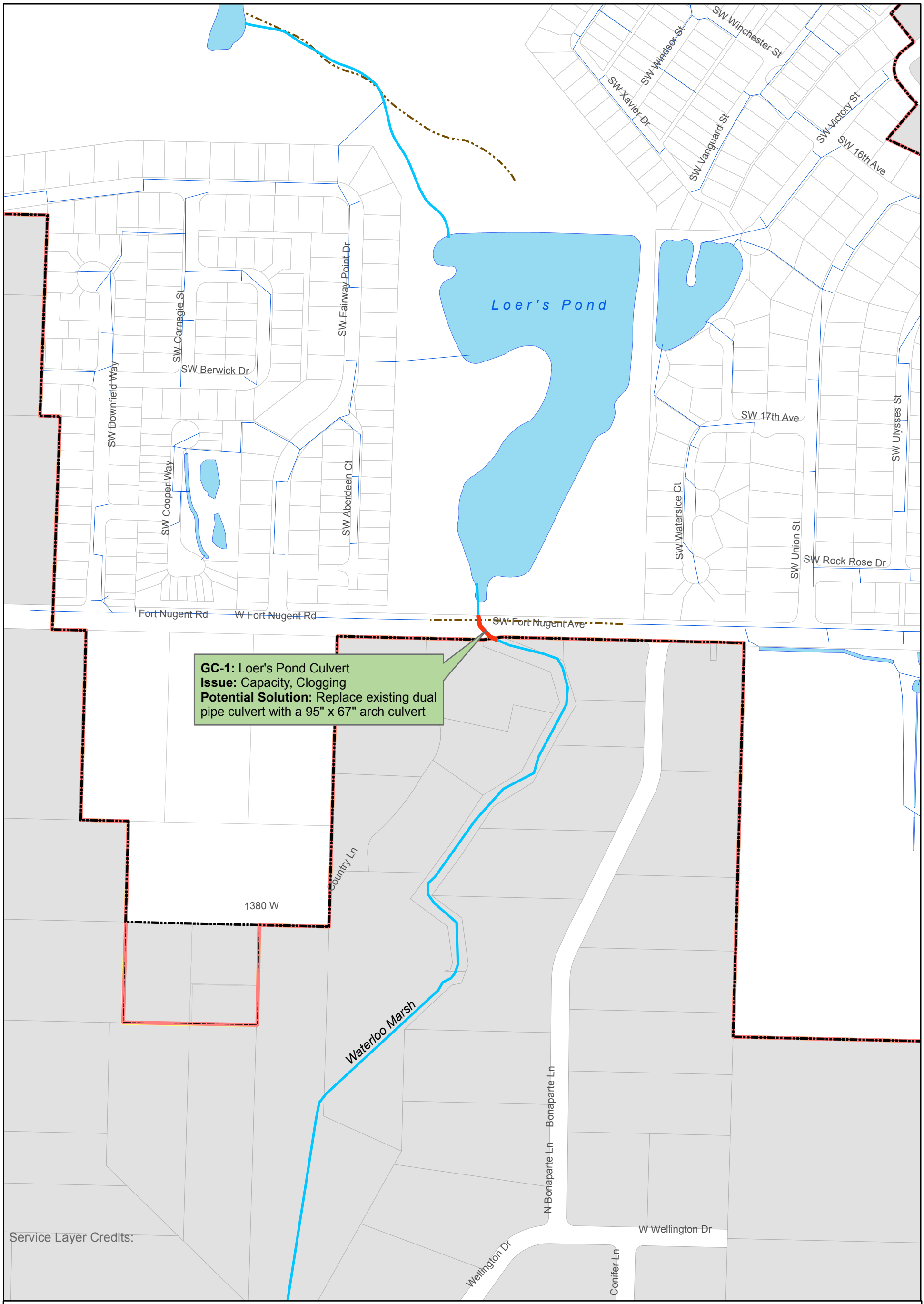
DETENTION EXEMPT AREAS UPSTREAM OF OVER CAPACITATED AREAS

City staff has expressed the desire for developers to install a detention system for areas that are typically exempt from flow control requirements (due to entry into an entirely manmade conveyance system to a flow control exempt body of water) and yet, are tributary to locations where capacity is a concern. In areas where downstream capacity is a concern, the City may opt to have developers install a detention system that would match the 2-, 10- and 100-year storms under existing conditions (similar to the method noted in the 1992 Ecology Stormwater Management Manual for the Puget Sound Basin). This allowance would be different from the typical flow control facility which is sized using a continuous runoff model that takes into consideration a post-developed site that mimics a forested condition. For locations in the lower elevations of the city, if approved by the City Engineer, developers may potentially be allowed to forgo the flow control requirement however, measures shall be taken to not exacerbate the current condition.

GOLF COURSE BASIN

The Golf Course Basin is a particular area of concern for the City. As development continues, increases in surface water runoff into Loer's Pond and the adjoining golf course conveyance system must be analyzed. Currently the City maintains a contract with Island County and the Whidbey Golf & Country Club for the purposes of establishing operation and maintenance responsibilities. This contract will be renegotiated in 2022. To aid in future contract negotiations, the existing and future 100-year flow rates were determined.

Peak flow rates from the Waterloo Marsh Basin to the Golf Course Basin at the culvert under Southwest Fort Nugent Avenue were compared for the 100-year event under existing and future conditions. The existing condition produced a peak flow of 150 cfs, and the future condition produced a peak flow of 205 cfs. The design flow capacity of


Loer's Pond
SW Winchester St
SW Windsor St
SW Xavier Dr
SW Vanguard St
SW Victory St
SW 16th Ave
SW Fairway Point Dr
SW Carnegie St
SW Berwick Dr
SW Downfield Way
SW Cooper Way
SW Aberdeen Ct
SW 17th Ave
SW Waterside Ct
SW Union St
SW Ulysses St
SW Rock Rose Dr
Fort Nugent Rd
W Fort Nugent Rd
SW Fort Nugent Ave
GC-1: Loer's Pond Culvert
Issue: Capacity, Clogging
Potential Solution: Replace existing dual pipe culvert with a 95" x 67" arch culvert
1380 W
Country Ln
Waterloo Marsh
N Bonaparte Ln
Bonaparte Ln
W Wellington Dr
Wellington Dr
Conifer Ln
Service Layer Credits:
LEGEND:
System Deficiencies
Storm Drains
Culverts
Ditches
Streams
Water Bodies
Parcels
City Limits
Incorporated UGA
Joint Planning Area
N
0
300
600
Feet
CITY OF OAK HARBOR
COMPREHENSIVE STORMWATER MANAGEMENT PLAN
GOLF COURSE BASIN RESULTS
FIGURE 3-17
Gray & Osborne, Inc.
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SW 14th Ct
Islander Ln
SW Barrington Dr
Fairhaven Dr
Barlow St
SW Erie St
Erie St
State Rte 20
W Pioneer Way
One Way St
Fir St
Hemlock
Harborview
SW Kimball Dr
Hemlock
SW Fort Nugent Ave
SW Swantown Ave
Fir
Willow
SW Bayshore Dr
Glenmont Ave
Baymont Dr
Oakmont Ln
SW 18th Ct
SW Scenic Heights St
SW 19th Ct
Lamms Ln
2000
DC-4
Beeksma Dr
SW Harbor View Ln
SW Dillard Ln
FM-1: Scenic Heights Trailhead
Issue: Runoff Controll
Potential Solution: Install CB west of LID facility; Drainage analysis to divert excess runoff from LID area
Scenic Heights Rd
SW Vista Park Dr
Dillard Ln
W Poppys Pl
W Kiwi Acres Ln
Freund St
SW Freund St
N Scenic Heights Rd
SW Capital St
Capital St
W Capital St
SW 24th Ave
Pete's Ln
SW Talon Loop
Oak Harbor
SW Petes Ln
Dawnview Ter
SW Scenic Heights Rd
SW Eagle Vista Ave
SW Capital Dr
Service Layer Credits:

LEGEND:

- System Deficiencies
- Potential Solutions
- Storm Drains
- Culverts
- Ditches
- Streams
- Water Bodies
- Parcels
- City Limits
- Incorporated UGA
- Joint Planning Area

N

0 300 600
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
FREUND MARSH BASIN RESULTS
FIGURE 3-18

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\FM CIPs.mxd

W Whidbey Ave
E Whidbey Ave
NE Midway Blvd
State Rte 20
SE Pioneer Way
E Pioneer Way
Pioneer Way
Coral Sea Ave
Oak Harbor
Saratoga Passage

LEGEND:

- Parcels
- Parcels Within Garry Oak Prairie
- Water Bodies
- City Limits
- Incorporated UGA
- Joint Planning Area

N

0 1,100 2,200
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
GARRY OAK DELINEATION MAP
FIGURE 3-19

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\Garry Oak.mxd

the culvert is exceeded under both conditions, resulting in flooding occurring at the next upstream node (south of Southwest Fort Nugent Avenue). CIP Project GC-1 addresses this problem as described earlier. Flow rates from Loer's Pond are 54.9 cfs under both conditions, and pond capacity is not exceeded.

The second largest pond (identified as Fairway 8 Pond in the Golf Course Drainage Basin 2007 Update, located just north of Loer's Pond) in the Golf Course Basin receives runoff from four separate subbasins. The 100-year event under existing conditions produced a peak flow of 49.1 cfs entering the pond, and under future conditions produced a peak flow of 51.2 cfs entering the pond. The flow rates from the pond are controlled by a pump system which is capable of maintaining 6.6 cfs for the 100-year event under both the existing and future conditions without exceeding pond capacity. No problems are expected at this pond in the future. City staff recommends that the Golf Course potentially irrigate with water from the ponds, thereby lowering the amount of volume within the pond to allow for more storage during the winter months. If this option is pursued, the implication on water rights should be evaluated.

LOW IMPACT DEVELOPMENT (LID)

At the end of 2016, the City of Oak Harbor was mandated by Ecology through the City's National Pollutant Discharge Elimination System (NPDES) Phase II Municipal Permit to require developments over a certain threshold to implement low impact development facilities unless infeasible. These facilities/best management practices include:

Lawn and landscaped areas:

- Post-Construction Soil Quality and Depth (i.e. amended soils)

Roofs:

- Full Dispersion or Downspout Full Infiltration
- Raingardens/Bioretention Systems
- Downspout Dispersion Systems
- Perforated Stub-Out Connections

Other Hard Surfaces:

- Full Dispersion
- Permeable Pavement or Rain Gardens (Ecology List 1) or Bioretention (Ecology List 2)
- Bioretention
- Sheet Flow Dispersion

The LID expectation is to try to maintain as much stormwater on-site as possible. However, it is apparent that not all sites are conducive to low impact development BMPs

due to critical areas such as steep slopes, wetlands, and critical aquifer recharge areas. Figure 3-20 displays the areas within the City where LID may not be feasible due to these features. Implementation of any future LID BMPs often requires an on-site geotechnical evaluation to ensure that the proper soils exist for the facility to be functional. This is dependent upon the size of the project.

If the soil on a development site is conducive to LID BMPs, one of the first menu items that must be considered for on-site stormwater management per the 2012/14 Manual is roof downspout full infiltration systems. These underground trenches infiltrate roof runoff into the ground as opposed to conveying it offsite. The Ecology Manual has the same prescriptive trench lengths for all of Western Washington regardless of local precipitation rates. Due to Oak Harbor being located within a rain shadow and receiving significantly lower precipitation amounts than many other Puget Sound communities, City Staff discussed and corresponded with Ecology staff regarding the extensive prescriptive lengths required in the Ecology Manual. (The required trench lengths shown in Section III-3.1.1 of the Manual are longer than what is necessary for Oak Harbor's drier climate.) Ecology responded that the trenches may be shortened, but must provide equivalent environmental protection. A memorandum was prepared by Gray & Osborne which describes WWHM modeling efforts showing that with finer soils such as loam, a shorter infiltration trench may be utilized to infiltrate 100 percent of roof runoff in the Oak Harbor vicinity as compared to the required trench lengths prescribed in the 2012 Manual. In addition, it was apparent from the modeling that these trench lengths could be even shorter if utilizing an underground chamber system, which has significantly more storage volume per lineal foot. The full memorandum is provided in Appendix D.

It should be noted that the Ecology LID BMP lists require the consideration of full downspout infiltration for roof runoff prior to considering implementation of rain gardens or bioretention and the conservative "one size fits all" prescriptive lengths of the trenches can deem them infeasible. If the trenches are too long for the site, the next prioritized LID BMP to be utilized (if feasible) is a rain garden (List 1) or bioretention (List 2).

Another approach to providing equivalent environmental protection via a shorter infiltration trench is to provide the equivalent runoff storage volume in the trench that is required for a rain garden or bioretention BMP. Since the subgrade soils are the same for all three of these BMPS and the subgrade infiltration depths of all three are within the top 2 to 2.5 feet, the infiltration of water back into the ground should actually be superior in a linear trench utilizing chambers than a localized rain garden or bioretention. A chamber system increases the BMP bottom subgrade surface area available for infiltration by about 70 percent to 100 percent over a rain garden, depending upon the rain garden geometry and specific chamber utilized. Since the DOE lists downspout infiltration as a prioritized BMP to rain gardens for roof runoff, an infiltration trench that provides the same storage volume but twice the infiltrative soil interface is an acceptable alternative to a rain garden and provides equivalent or better environmental protection. A trench is also significantly less likely to be removed by one of the transitory homeowners that comprise a large percentage of this Navy based town. A comparison of raingarden and infiltration

Strait of Juan de Fuca

W Sleeper Rd

W Clover Valley Rd

W Ault Field Rd

Heller Rd

N Oak Harbor St

State Rte 20

W Crescent Harbor Rd

Swantown Rd

NE Midway Blvd

W Whidbey Ave

E Whidbey Ave

Heller St

Pioneer Way

E Pioneer Way

SE Pioneer Way

Coral Sea Ave

W Fort Nugent Rd

Oak Harbor

N Boon Rd

W Waterloo Rd

Saratoga Passage

LEGEND:

Areas that may not be feasible for LID

City Limits

UGA

JPA

Parcels

Note: Areas shown are based upon a combination of mapped critical areas including wetlands, steep slopes (>15%), unstable slopes, septic areas, and critical aquifer recharge areas. Site specific studies should be performed to determine the suitability of LID facilities.

N

0 2,400 4,800

Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
SITE SUITABILITY MAP FOR LID FACILITIES
FIGURE 3-20

Gray & Osborne, Inc.

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chamber trench volumes and surface area of the infiltrative soil is also provided in Appendix D.

Another option under the LID menu includes full dispersion. As a requirement of full dispersion, the land owner can disperse runoff into native vegetative areas however, they must preserve 65 percent of the site in a forested or native condition as long as they ensure that the developed impervious areas draining to this native area are less than 10 percent of the entire site. The City believes this ratio of 65 percent to 10 percent should be allowed to vary from the Ecology Manual within the City of Oak Harbor due to the city lying within a rain shadow. Staff believe that the 65 percent native area can be reduced and that the 10 percent impervious surface can be increased. In conversations held between City staff and Department of Ecology staff prior to 2019, Ecology agreed that such a modification could be made. The exact ratio to be used shall be calculated and included in the City's Development Standards and/or municipal code.

CHAPTER 4

WATER QUALITY

INTRODUCTION

Oak Harbor's surface water features play a big part in its natural beauty and rich heritage. Fish and wildlife habitat, clean water, and aesthetic appeal are benefits of the surface water resources, which must be managed wisely to protect their value. Without proper management, land development and the associated stormwater runoff may degrade these surface water resources.

Stormwater runoff can be defined as precipitation that does not percolate into the ground, but rather flows overland (and also directly beneath the surface as interflow) into a drainage system, eventually discharging into a surface water body such as a pond, lake, stream, wetland, or sea. Runoff can flow over urban, rural, or natural areas, with the effects on surface water different for each case.

In Oak Harbor, stormwater runoff flows predominantly over residential, commercial, and other urbanized areas. As rain falls and runs off of these areas, sediments and pollutants are entrained in the runoff and transported to downstream surface waters where they may cause damage to aquatic organisms, impact typical water uses, and reduce the aesthetic value of the water body. In addition, as natural vegetated areas are converted to rooftops, streets, parking lots, and urban landscaping, there is a significant increase in the volume and rate of runoff, causing flooding out of catch basins and ditches. The decreased water quality and sediment deposition (sedimentation) can cause significant damage to aquatic organisms, including permanent habitat degradation.

HISTORICAL WATER QUALITY DATA

Pollutants in stormwater are largely uncontrolled, due to the diverse characteristics of the land over which the water flows and the diffuse manner in which small amounts of pollution are entrained, transported, and later discharged into downstream water bodies. Research in Western Washington has shown that the concentrations of many pollutants found in stormwater from residential, commercial, and industrial areas exceed established State and Federal water quality criteria.

NATIONWIDE URBAN RUNOFF PROGRAM (NURP)

The Nationwide Urban Runoff Program (EPA, 1983) included extensive field monitoring throughout the United States to characterize urban stormwater runoff flows and pollutant concentrations. Listed below are the conclusions reached in the Nationwide Urban Runoff Program Study:

1. Heavy metals (especially copper, lead, and zinc) are the most prevalent priority pollutants. Urban runoff produces frequent exceedances of ambient water quality criteria for heavy metals. Copper, lead, and zinc pose a significant threat to aquatic life uses in some areas of the country. Copper is suggested to be the most significant of the three.

2. The organic priority pollutants were detected less frequently and at lower concentrations than the heavy metals.

3. Coliform bacteria are typically present at high levels and may exceed EPA water quality criteria during and immediately after storm events in most rivers and streams.

4. Nutrients (i.e., phosphorous and nitrogen) are present, but typical concentrations are not high, and generally not a concern in rivers and streams.

5. Oxygen-demanding substances are present at concentrations approximating those in secondary wastewater treatment plant discharges. Urban runoff is typically well-oxygenated and adds water to stream flow, so dissolved oxygen problems due solely to runoff are not considered widespread.

6. Total suspended solids concentrations are fairly high in comparison with wastewater treatment plant discharges.

7. Contaminated stream, lake, and wetland bottom materials (substrate) can be attributed wholly or in part to urban runoff.

8. Bank erosion and streambed scour can be significant causes of habitat disruption. Habitat changes associated with streambed scour and sedimentation produced by urban runoff may be more significant than pollutant concentrations.

NATIONAL WATER QUALITY INVENTORY

Point source pollution (predominantly industrial and municipal wastewater discharges) has been highly regulated and controlled for years, even prior to the passage of the Clean Water Act. The National Water Quality Inventory, 1986 Report to Congress (EPA, 1986), concluded that diffuse sources of water pollution, including runoff from urban areas, are a leading cause of water quality impairment.

CLEAN WATER ACT, SECTION 303D

The 303(d) Program, issued by EPA and administered by the Washington State Department of Ecology, is a program that assists with listing and prioritizing impaired waters for the purpose of developing Total Maximum Daily Loads (TMDLs). A TMDL establishes the maximum amount of pollutant allowed in a waterbody and helps lay the framework for how the water quality within that particular waterbody will be restored. Each waterbody is given a category such as Category 1 (Meets tested standards), Category 2 (Waters of concern), Category 3 (Insufficient data), Category 4 (Polluted waters that do not require a TMDL) and Category 5 (Polluted water requiring a TMDL). The 303(d) categories for water bodies in or tributary to Oak Harbor are listed in Table 4-1.

TABLE 4-1

303(d) Categories for Water Bodies In or Tributary to Oak Harbor

Water Body	303(d) Category
Unnamed Creek from Loer's Pond to Swan Lake	Category 5 for bacteria and dissolved oxygen; Category 2 for temperature
Oak Harbor along Windjammer/City Beach Park	Category 5 for bacteria
Oak Harbor and Saratoga Passage	Category 2 for sediment (4-methylphenol, benzoic acid, benzyl alcohol, and phenol)
Unnamed Creek to Crescent Harbor	Category 2 for bacteria

As noted, Category 5 waters are polluted waterbodies that require a TMDL or other water quality improvement (WQI) project, however, a WQI project has not been established for the unnamed creek or Oak Harbor. Category 2 waters have some evidence of a water quality problem, but not enough to require production of a WQI project.

WATER QUALITY STANDARDS

The following discussion focuses on the criteria used to evaluate water quality contaminants most common in runoff. General water quality problems in the Oak Harbor area are identified later in this chapter. Appropriate strategies for addressing problem areas and reducing impacts are then summarized.

Stormwater runoff constitutes the primary transport mechanism for nonpoint pollution. Pollution problems associated with urban land use and development encompass typical pollutants such as sediment, metals, bacteria, pesticides, fertilizers, and petroleum products. A further problem stemming from residential, commercial, and industrial land uses is the higher volume of runoff because of the higher amount of impervious area. In developed areas, certain pollutants are more prevalent than in undeveloped areas. Pollutants accumulate in surficial soils and on paved surfaces from vehicular emissions,

atmospheric deposition, spills, leaks, improper waste storage/disposal practices, and fertilizer/pesticide application. They are then washed off the land surface during subsequent storm events and transported via stormwater runoff to nearby water bodies or infiltrated to shallow groundwater.

Although these specific pollutants can be attributed to an individual source (e.g., bacteria from pet waste and livestock), their intermittent, diffuse, and widespread nature makes them difficult to contain and control. Parameters of interest in nonpoint pollution are discussed below in terms of State standards and potential sources.

PARAMETERS OF CONCERN

There are numerous classes of water quality parameters that are affected by stormwater runoff including suspended solids (sediment), nutrients, and metals; oxygen demanding and inert material; particulate and dissolved substances; chemical, biological, and physical characteristics; toxic and nontoxic substances; and organic and inorganic substances. Several pollutants may be incorporated into one classification if their effects on receiving waters are similar. Receiving waters can assimilate a limited quantity of many substances, but there are thresholds beyond which the substance becomes a pollutant and results in an undesirable impact. The following section provides a brief description of contaminants/characteristics, potential environmental effects, and likely sources.

Dissolved Oxygen

Dissolved oxygen is necessary in water to maintain healthy aquatic life. Oxygen from water is consumed by fish, insects, and microorganisms in the oxidation of organic matter by biological activities (i.e., feeding and decomposition). Low dissolved oxygen levels puts stress on aquatic organisms and can lead to fish kills and reduction in aesthetic values. Low dissolved oxygen results when the rate of oxygen consumption exceeds the rate of replenishment.

Oxygen in water is replenished by plant respiration and via gas exchange at the air-water interface. The amount of oxygen that can be dissolved into water depends mostly on water temperature – the colder the water, the greater the amount of dissolved oxygen. Dissolved oxygen levels are especially important during summer when low stream flows and high temperatures make oxygen less available to aquatic life. Concentrations of dissolved oxygen vary with season and location. These natural variations are caused by differences in such things as light intensity (as it affects photosynthesis), nutrient levels, and organic input. Natural variation can also be driven by groundwater or water draining bogs and marshes that typically have lower dissolved oxygen concentrations.

Dissolved oxygen concentrations may become critical when wastes (organic material) that require oxygen for decomposition enter the water. Common significant sources of organic wastes include effluent from wastewater treatment plants (point source), leaking

sewers and failed septic systems, poor livestock grazing and waste management practices, illicit connections, and poor management of garbage and waste areas for grocers, restaurants, and food processing facilities.

pH

pH is a measure of the activity of hydrogen atoms in water, and provides a basis for measuring the relative acidity or alkalinity of water. Similar to dissolved oxygen, pH responds to natural environmental factors. Changes in pH affect the degree of dissociation of weak acids and bases, which affect the toxicity, reactivity, and solubility of many compounds. Diurnal variations in pH occur as a result of changes in plant production and respiration rates (photosynthesis), and different water sources such as groundwater or water draining wetlands. Generally speaking, rainwater is slightly acidic (low pH), due to the adsorption of carbon dioxide, and substances such as cement concrete are very basic (high pH), due to the presence of lime. Significant sources of high pH substances include the pouring, finishing, and washing of cement concrete.

Temperature

Water temperature extremes (higher than normal) affect stream productivity and eventually may result in loss of aquatic life. Temperature also affects a stream's chemical properties, specifically the solubility of oxygen, carbon dioxide, and metals, and varies diurnally and seasonally. Water temperatures are most affected by the removal of riparian vegetation that provides shade.

Turbidity

Turbidity is not a measurement of mass or concentration, rather it is a water quality attribute pertaining to the amount of light that can penetrate the water column. It is therefore affected by the amount of suspended solids and dissolved substances. It cannot be used as a quantitative measure to calculate loadings, but is used qualitatively to compare against a standard. High turbidity can impact the available light to plants for photosynthesis. Turbidity responds to physical factors such as proximity to exposed erodible soils and stream flow.

Nutrients

Nutrients are chemicals that are required for cell metabolism and growth of animals and plants, such as algae and water plants. The primary nutrients of concern in freshwater systems are nitrogen and phosphorous, with phosphorus often being the controlling nutrient for algae growth. Nitrogen can affect the trophic status of receiving waters. Nitrogen (in the form of nitrate) is also an important parameter for water used as drinking water supplies.

The typical nutrient concentrations in stormwater runoff are often more than sufficient to stimulate the growth of algae and other plant species. The increased algal activity will initially raise dissolved oxygen levels, through increased plant growth. However, such "algal blooms" only last until phosphorous levels drop, or sufficient light (intensity and daily amount) for photosynthesis begins to fade (as in the late summer or early fall). Once decomposition of the dead algae begins, surface algal scums form, dissolved oxygen levels rapidly drop, and water discoloration and odors may occur. If dissolved oxygen levels in receiving waters drop too much, die-off of fish and other aquatic life may occur.

Natural sources include organic decomposition byproducts and soil erosion. Typical anthropogenic sources include detergents, fertilizers, septic system effluent, and livestock manure.

Pathogens/Bacteria

Pathogens and bacteria commonly refer to fecal coliform bacteria, which are found in the intestinal tracts of warm-blooded animals, including humans. Concentrations of fecal coliform bacteria in surface water have historically been used as an indicator of waterborne pathogenic bacteria or viruses. Therefore, fecal coliform bacteria concentrations are used as indicators of potential public health concerns. High levels in surface waters can indicate failing septic systems, poor livestock management practices, poor wastewater treatment facility performance, pet wastes, and leaking municipal sanitary sewers.

Oil and Grease

High oil and grease concentrations are associated with stormwater runoff from roadways, parking lots, and industrial property. The presence of oils and grease can serve as indicators of a wide array of hydrocarbon compounds that can be toxic to aquatic life at low concentrations. Typically, oil and grease concentrations are low in receiving waters and are usually associated with recent runoff events.

Total Suspended Solids

Total suspended solids (TSS) represents particulate material that is suspended in the water column due to velocity and turbulence. The higher the velocity of the water, the larger a particle can be suspended. High amounts of TSS can affect the oxygen exchange in the gills of aquatic organisms, and, as suspended solids settle out, may smother bottom-dwelling organisms, cover breeding areas, and smother eggs.

Total suspended solids generally originate from soil erosion or scour within a stream. Also, materials that are washed off paved surfaces are transported by runoff and discharged to receiving waters. Land-clearing activities associated with urban development as well as poor livestock and crop management can accelerate soil erosion

and increase sediment transport to receiving waters. The conversion of forest and open land to urban uses can result in sedimentation, increases in impervious surfaces, and accelerated stormwater runoff. As the total volume and peak rate of stormwater increases, scouring occurs, thereby increasing the suspended solids loading in the channel.

Heavy Metals

Most metals are adsorbed onto suspended solids present in the runoff and are probably not toxic to aquatic life. However, the accumulation of heavy metals in the substrate can pose a problem, should the pH in the water change, dissolving the metals into the water column and becoming available for ingestion by fish and insects. Metals commonly found in stormwater runoff typically originate from road surfaces and parking areas and include lead, zinc, copper, chromium, arsenic, cadmium, and nickel. Other potential sources of metals originate from commercial car washes, auto repair facilities, and industrial operations.

Toxic Organic Compounds

Toxic organic compounds include a variety of contaminants such as pesticides, petroleum hydrocarbons, and volatile organic compounds. Compounds that are most frequently found in runoff include phosphates, polyaromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and some pesticides. The availability of toxic organic compounds to aquatic life is difficult to determine because of their adsorption to particulate matter. Potential nonpoint sources of these contaminants include urban and agricultural runoff, hazardous substance spills, improper disposal of waste products, and industrial discharges.

Organic Material

Organic material is an integral component of topsoil and detrital matter deposited by plants and animals. The organic content is primarily produced by microorganisms during the degradation of dead plant and animal material. The microbial degradation of organic matter in aerobic systems results in the consumption of oxygen. Waters high in organic matter may experience depressed oxygen concentrations. Manmade sources of organic matter include yard waste and materials deposited in surface waters from soil erosion and landslides.

CRITERIA

Water quality standards for surface water in Washington State are established in Chapter 173-201A, Washington Administrative Code (WAC). Standard criteria allow for comparison of the water quality data to a safe or desired level. Management practices that violate or exceed established standards are subject to further investigation and ultimately appropriate corrective measures.

The State adopted revised water quality standards for surface waters in 2006, with EPA approved updates through 2011, and further revisions in 2016 based on EPA's partial approval. The standards assign specific designated uses to surface waters of the State, such as aquatic life uses, recreational uses, and miscellaneous uses. Each use then has categories that are ranked, generally speaking, from a higher quality to lower quality. Water quality standards have been assigned to each specific designated use category, for parameters such as fecal coliform, dissolved oxygen, temperature, pH, turbidity, and toxic, radioactive, and deleterious substances.

The Island Water Resource Inventory Area (WRIA #6) includes Whidbey and Camano Islands along with several smaller islands and does not have any designated uses for fresh water identified under WAC 173-201A-602. Saratoga Passage, including Oak Harbor, is identified under WAC 173-201A-612 with the following use designations for marine waters:

- Aquatic Life Uses – Excellent Quality; salmonid and other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.

- Recreational Uses – Primary Contact Recreation.

- Miscellaneous Uses – Wildlife Habitat, Harvesting, Commerce/Navigation, Boating, and Aesthetics.

The Strait of Juan de Fuca, west of Whidbey Island, is identified under the same section with the following use designations:

- Aquatic Life Uses – Extraordinary Quality; salmonid and other fish migration, rearing, and spawning; clam, oyster, and mussel rearing and spawning; crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing and spawning.

- Recreational Uses – Primary Contact Recreation

- Miscellaneous Uses – Wildlife Habitat, Harvesting, Commerce/Navigation, Boating, and Aesthetics.

Table 4-1 displays water quality criteria for marine waters per WAC 173-201A-612. In addition to the water quality parameters listed in Table 4-2, concentrations of toxic substances, such as organic compounds and metals, must not exceed standards specified in WAC 173-201A-240. These standards are based on the EPA Quality Criteria for Water (1986), which are derived from federal water quality criteria based on aquatic toxicology. The WAC defines both acute and chronic criteria for toxic substances.

Acute toxicity criteria are based on death percentages of test organisms within 24 hours. Chronic toxicity criteria are defined as the concentration that causes long-term adverse effects on an organism's functions. Standards also exist for radioactive and deleterious materials and aesthetics, as described in Table 4-1.

The criteria shown in Table 4-2 is only a brief summary of the full water quality criteria for marine waters. Since there is wide variability in natural systems, and the level of tolerance is different for each species of interest, there are exceptions and/or ranges of the criteria pertaining to specific species' acclimations, background conditions, or during specific time periods. A full reading of WAC 173-201A is encouraged to achieve a complete understanding of the criteria.

TABLE 4-2

Water Quality Criteria for Marine Surface Water (WAC 173-201A-210)

Parameter	Criteria
Temperature	The 1-day maximum temperature (1-DMax) shall not exceed 16 degrees C for excellent quality and 13 degrees C for extraordinary quality. When natural conditions exceed these limits, no temperature increases are allowed that raise the receiving water's 1-DMax more than 0.3 degrees C.
Dissolved Oxygen(1)	The 1-day minimum dissolved oxygen content shall not be less than 6.0 mg/L for excellent quality and 7.0 mg/L for extraordinary quality. When natural conditions are lower than these limits, no decreases are allowed that decrease the dissolved oxygen by more than 0.2 mg/L.
Turbidity	For both the excellent and extraordinary quality criteria, turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.
pH	pH shall be within the range of 7.0 to 8.5 with a human-caused variation within a range of less than 0.5 units for excellent quality and 0.2 units for extraordinary quality.
Fecal Coliform(1)	Fecal coliform organism levels shall not exceed a geometric mean value of 14 colonies/100 ml, with not more than 10 percent of samples exceeding 43 colonies/100 ml.
Toxic, Radioactive, or Deleterious Materials(2)	Toxic, radioactive, or deleterious material concentrations must be below those which have the potential, either singularly or cumulatively, to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health (see WAC 173-201A-240, toxic substances, and 173-201A-250, radioactive substances).
Aesthetic Values(2)	Aesthetic values must not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste (see WAC 173-201A-230).

(1) Primary Contact Recreation Use Criteria
(2) Miscellaneous Uses Criteria

SOURCES OF NONPOINT POLLUTANTS

The significant sources of pollutants/water quality parameters found in urban stormwater runoff was discussed briefly under the description of each water quality parameter. The major types of nonpoint pollution sources in the Oak Harbor area are generically related to urban development, including commercial and industrial activities; transportation-related facilities; and agricultural activities. Other important sources of nonpoint pollution may include illicit connections to the storm drain system and on-site sewage systems.

Urban Development

The construction-related activities of land clearing and site preparation for developing properties are potential sources of stormwater pollution. Areas that have been cleared of vegetation are more prone to erosion and can significantly increase sediment loading to nearby water bodies. Sediment can be deposited in natural and constructed channels, thereby reducing the hydraulic capacity. The efficiency and capacity of associated stormwater control structures such as culverts, pipes, and detention facilities may also be affected by the deposition of sediment.

The amount of stormwater runoff usually increases during construction activities as vegetative cover is removed. Leaf interception and infiltration provide a natural detention benefit, while plant roots generally improve a soil's water holding capacity. When vegetation is removed from an area, the total runoff volume and peak runoff rate increase, which can accelerate channel scouring and erode stream banks. This in turn can damage property, destroy riparian habitat, and degrade water quality.

In addition to soil erosion and the transport of sediment, other pollutants can be generated by construction activities. Pesticides, fertilizers, petroleum products, cleaning solvents, paints, asphalt byproducts, acids, and salts as well as solid wastes are potential sources of stormwater pollution if improperly handled or stored on a construction site. The pouring and finishing of concrete can also adversely affect water quality by potentially increasing the pH of the water.

Stormwater problems caused by land development does not stop after construction. The volume of stormwater runoff and peak discharge rate increase as a direct result of the decrease in vegetation and increase in the amount of impervious area. Higher flow rates accelerate bank erosion and scour in the receiving systems, which result in an increase in sediment deposition further downstream. Higher flow rates can also cause localized flooding where the carrying capacity of natural streams and conveyance systems is exceeded. The removal of vegetation from riparian areas reduces habitat and can cause dramatic increases in water temperature, destabilize stream banks, and reduce the natural input of organic materials.

The pollutant load of stormwater in residential areas also increases as development increases. The potential pollutant sources in residential areas include fertilizers, pesticides and herbicides from landscaping activities, biological loads from pet wastes, waste oil disposal from vehicle maintenance activities, improper disposal of household and yard wastes and illegal connections of sanitary sewers to the storm sewer system.

Commercial development in the City includes many small- and medium-sized businesses such as professional offices, retail, restaurants, grocery stores and convenience stores, gas stations, car washes, tire shops, hardware stores, hotels, and storage facilities. Schools and churches could also be included in this category. More intense types of commercial development are present with the large supermarkets, warehouses, and equipment and vehicle repair centers. Potential sources of pollution from these developments include oil and grease, suspended solids and metals from the parking lots; bacterial loads and garbage from improper waste storage and disposal practices at grocery stores and restaurants; and fertilizers, pesticides, and herbicides from landscaping activities.

Based on national studies, runoff from commercial development most likely contributes metals, such as cadmium (a catalyst used in tire manufacture) and lead, to stormwater runoff. These contaminants are produced by dryfall from vehicle emissions, vehicle wear and tear, and chemical products. Other contaminants that may be associated with the commercial establishments in the City include toxic organic compounds such as pesticides and PAHs. VOCs, such as solvents, may also be present in urban runoff and are typically associated with spills and improper waste disposal activities. Improper chemical storage and waste disposal practices are common sources of contaminants migrating off site from commercial and industrial establishments. The improper use of garbage dumpsters, such as exposing the contents to rain or depositing garbage on the ground rather than in the dumpster, are also potential sources of stormwater pollution.

Highways and Roads

Stormwater runoff from highways as well as City collectors and residential streets can contain elevated concentrations of metals, suspended solids, and organic compounds such as petroleum hydrocarbons. Studies have shown that pollutant loading is directly related to the amount of vehicle traffic. Also, heavy trucks and equipment tend to be larger contributors than passenger vehicles and light trucks. Major highways with high vehicle use can be significant sources of nonpoint pollutant loading. Sanding in the winter further contributes material to the drainage system. Major thoroughfares in the City include State Route 20 (West Pioneer Way and South Oak Harbor Street), and Regatta Drive.

Domestic Activities

Nonpoint pollution from domestic activities in the City consists primarily of pet waste and runoff from residential gardens and landscaping. Pet wastes are likely the most significant source of nonpoint pollution from residential activities. Runoff laden with animal wastes, fertilizers, pesticides, or herbicides can contribute to nonpoint pollution.

Additional Pollutant Sources

In addition to the pollutant sources discussed above, the following activities may contribute to stormwater pollution:

- Inconsistent application of land development regulations;
- Inadequate maintenance of stormwater facilities;
- Pollutant wash-off from car and truck parking areas; and
- Dumping of used motor oil, anti-freeze, paint and solvents, yard waste, etc., into the City's storm drainage system or on the ground.
- The Oak Harbor Wastewater Treatment Plant has an individual Stormwater Industrial NPDES permit from the Department of Ecology. The Stormwater Industrial permit includes requirements the permittee must follow to prevent stormwater pollution in runoff from the property.

Water Quality Control: Source Control vs. Treatment

Source controls are methods that prevent pollutants from coming into contact with stormwater. Implementation of source control best management practices (BMPs) prevents the generation or release of pollutants at the source. Source control BMPs are generally more effective and less expensive than treatment devices. Downstream treatment is generally located some distance from the source and designed to remove pollutants once they are in stormwater.

Source control measures (such as enclosing or covering a pollutant source) are usually applied at multiple locations, while a single downstream treatment facility (such as a constructed wetland) often receives runoff from an entire development. In some cases, a single regional downstream facility (such as a regional wet pond) can serve multiple properties covering a large area.

STRUCTURAL QUALITY CONTROL

The quality of runoff can be controlled by biofiltration, wet pools, media filtration, and oil/water separation amongst other best management practices. Depending on the target pollutants and receiving water, utilizing a water quality facility in combination with another facility (two-train treatment system) may be required. Specific design criteria are provided in Volume 5 of *the Stormwater Management Manual for Western Washington*. As mentioned previously with detention facilities, regional facilities can also be utilized for water quality treatment.

Biofiltration

Bioswales and filter strips are among the oldest stormwater quality control measures, having been used alongside streets and highways as well as by farmers for many years. A bioswale is a shallow ditch with flatter side slopes (i.e., 3H:1V); thick vegetation such as grass for soil stabilization, stormwater treatment, and nutrient uptake; and contiguous areas of standing or flowing water following rainfall events. A filter strip is simply a strip of land across which stormwater from a street or parking lot sheet flows before entering adjacent conveyance systems or receiving waters. A newer technology involves installation of a rain garden (or bioretention system). A rain garden is a shallow depression with deep-rooted plants which are provided for soil stabilization, nutrient uptake and aesthetics. Also included is an engineered soil mix for increased stormwater treatment and filtration.

For smaller storms, bioswales, filter strips, and rain gardens remove pollutants from stormwater by: (1) slowing the water and settling or filtering out solids as the water travels over the vegetated area; and (2) allowing infiltration into the underlying soil. Heavy metals are typically trapped in the upper regions of the soil column. In addition, the vegetation tends to function as fixed media to support growth of microorganisms, which can break down dilute concentrations of organics such as oil residues.

Maintenance of these facilities is an important consideration both for aesthetics and hydraulic efficiency. In the case of the bioswale, care must be taken to ensure that flows during large storms are not impeded by overgrown vegetation, or cause erosion and scour. To prevent this, the vegetation planted in the channel should be suitable for mowing, and the channel designed so that mowing machines can be easily and efficiently operated along the swale. Rain gardens can be designed for low maintenance, but may still require pruning and weeding to maintain functionality and aesthetics.

Wet Pools

A wet pool is a facility that maintains a permanent pool of water, and treats stormwater both by gravity settling and biological uptake of algae and microorganisms. Wet pools typically contain two cells and are designed to reduce turbulence so that previously captured pollutants are not disturbed and entrained into the water column and washed out

of the facility. Several options are available such as a wet pond, combined wetpond/detention facility, wet vault/tank, or stormwater wetland. If properly designed and maintained, wet ponds can provide effective water quality protection and ancillary benefits such as enhanced aesthetics and wildlife habitat. Different design criteria target different pollutants. All wet pools remove suspended solids, but removal of metals and phosphorus require different variations to the basic design principles.

Media Filtration

Stormwater filtration systems consist of either an open pond or closed vault wherein stormwater is allowed to flow through an engineered sand/soil mix and then typically, into a collection discharge pipe. Such facilities are subject to clogging, so pre-settling is required to remove larger solid particles before the water enters the facility. For some facilities, a level spreader is required to allow the water to evenly and gently spread across the filter. Maintenance on large sand filters can be expensive, since the sand media must be removed and replaced. Proper design to assist in this effort is essential.

As an alternative to using a large vault or pond filled with sand as the filter media, several companies have developed filtration technologies that are more modular, so they come in various sizes and configurations. Depending on the application, a vault with canisters of a specific filter media can be designed for any number of canisters, to target several different pollutants. Maintenance is achieved by vactoring the vault and replacing the canisters (or the filter media in each). Current Ecology approved media filtration devices include AquaFilter, BayFilter, MWS Linear Modular Wetland, the Kraken, CDS stormwater treatment system, Filterra unit, Jellyfish unit, Stormfilter, and the Flo-gard Perkfilter among others. A complete and current list of approved devices may be found on Ecology's website at:

http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html.

Oil/Water Separation

Oil water separators are devices, usually installed in parking lots or streets, which remove oil from stormwater prior to discharge into the main conveyance system or treatment facility. They are required in all areas subject to high volumes of traffic, where vehicle fueling is exercised, or other industrial uses prone to fuel, oil, and hydraulic leaks. Oil/water separators may include vault systems that contain baffles to help separate oil from runoff being discharged out of the facility or they may contain coalescing plates to draw oil particles out of runoff. Proper operation of these devices requires regular maintenance.

Catch basin inserts serve as spill control to capture oil right at the source, prior to entering the drainage system. These inserts can be in the form of a tee (or riser pipe) or they can include more of a proprietary system such as a hooded catch basin outlet cover (i.e., SNOUT). These devices block floating debris and oil from entering the outlet pipe

while allowing heavy sediment to settle at the bottom for reduced downstream pollution. Maintenance is the same as for a typical catch basin, where sediment is periodically vactored out of the catch basin sump.

To implement further water quality measures throughout the City, staff intends to implement a spill control retrofit program that would install tees or hoods in existing catch basins to better contain spills prior to being discharged to sensitive water bodies.

Regional Treatment Facility

The current NPDES Phase II Permit requires cities to provide stormwater comprehensive planning that promotes examining watersheds on a basin by basin approach. Each basin is to be prioritized and then reviewed for potential retrofit possibilities which would provide water quality and/or flow control to a specific area. One approach to providing retrofit projects is to install a regional treatment facility. A regional treatment facility is a large containment area designed to provide high levels of treatment to high volumes of runoff. These facilities typically incorporate detention and biofiltration or media filtration for a large basin. Designing a regional treatment facility in conjunction with a park for public recreation can help increase public awareness and appreciation for stormwater treatment. Maintenance for a regional treatment facility can include mowing, pruning, and weeding along with media replacement and/or sediment removal.

Freund Marsh Treatment Facility

The Freund Marsh area along the bay would be a suitable location for an "end-of-pipe_ type of regional treatment facility in the upland areas as much of the flow entering the bay is currently untreated. The 2006 Plan listed this area as a capital improvement project, referencing a future passive park where the amount of earth removed from the area would be equal to the amount of runoff diverted from the area west of the intersection of SR 20 and SW Erie Street. A plugged flow diversion structure was placed in this intersection with the intent that flow will be diverted towards Freund Marsh uplands to a treatment facility, away from the flooded area downstream near SW Beeksma Drive and Windjammer Park/City Beach. If space allows, this facility may also be used for flow control.

Today, numerous types of treatment facilities are available as described earlier. Table 4-3 lists a number of treatment options for the Freund Marsh area as well as benefits and limitations of each. The depth of the facility is also listed as there may be a concern related to potential archeological findings in this area and/or a high groundwater table. Preliminary archaeological research suggests a facility in this location should not be deeper than 8 to 9 feet due to the potential for finding historical remains.

TABLE 4-3

Freund Marsh Treatment Options

Treatment Type	Advantages	Limitations	Specific Requirements
Traditional Types of Facilities			
Bioretention	• Aesthetically pleasing for park setting. • Shallow depth needed.	• For smaller drainage areas, not to be used w/in 1/4 mile of phosphorus sensitive water bodies. • High maintenance.	2.5-3' of depth necessary (18" soil,6"-12" ponding area with 6" freeboard)
Permeable pavements	• Allows for driving and walking surface.	• Potential high groundwater so may not be suitable for Freund Marsh. • Not for concentrated runoff. • Not conducive to the passive park concept in the marsh area.	6" sand layer and ~12" gravel ballast beneath surface (~2' total thickness of pavement section)
Sand filters	• Located underground. • High sediment, BOD, and fecal coliform removal rates.	• Need them offline; Pretreatment is necessary (floatables, oil, debris) possibly through open cell. • Concern with high groundwater. • Subject to freezing (use underground). • Does not provide efficient metal or nutrient removal.	4' drop needed from inlet to outlet
Biofiltration Swales	• Can be aesthetically pleasing and incorporated in a meandering park setting. • Effective in reducing sediment and metals. • Lower cost to construct and maintain.	• Not the best water quality treatment method (use wet ponds/sand filters first).	Minimal depth/slope needed
Wetponds	• Adequate for high groundwater if the first cell is lined.	• Needs two cells. • Encourage plug flow to keep flow moving through (i.e., use baffles).	5' depth for first cell, not more than 8' depth for second cell; can vegetate bottom of cells for extra nutrient removal

TABLE 4-3 – (continued)

Freund Marsh Treatment Options

Treatment Type	Advantages	Limitations	Specific Requirements
Treatment Wetland	• Aesthetically pleasing for park setting. • Beneficial for habitat.	• Need two cells. • Maintenance needed, especially just after installation. • Liner Needed.	5' min. depth (1st cell), avg 1.5' depth after that
Wetvault	• Underground location allows for land to be utilized for other uses.	• Expensive to maintain (per Manual) • Need maintenance access for vactor	3' min. depth + 1' sediment storage
Emerging Technologies			
Landscaped Filter Media [i.e., trees/shrubs in a box] *(Silva Cells, Stratacell, Filterra)*	• Aesthetically pleasing. • Promotes tree growth. • Removes nutrients, hydrocarbons and TSS. • Low to no maintenance. • Shallow depth.	• Relatively new so not sure how long media will last (literature maintains it may not ever need to be replaced).	~ 2.5' - 5' total depth needed
Cartridge w/ Media *(BayFilter, StormFilter, Flo-Gard Perk Filter, Up-Flo Filter)*	• Underground location allows for land to be utilized for other uses. • Allows for metals reduction. • Could purchase media only (instead of the structure) which would allow for shallower depths.	• Need to replace media; proprietary product. • Potential higher maintenance cost.	~ 4' - 7' total depth needed (shallower if just using media)
EcoStorm Plus	• Reduces dissolved solids and metals. • Underground location allows for land to be utilized for other uses. • Filters cleaned by backflushing.	• Deeper structure. • Likely need to replace media.	Estimated 5' depth (need more specific info)

TABLE 4-3 – (continued)

Freund Marsh Treatment Options

Treatment Type	Advantages	Limitations	Specific Requirements
MWS Modular Wetland	• Can provide aesthetic look while being contained within a structure. • Only needs 16 inches between inlet and outlet pipe.	• Need to replace media and remove sediment for maintenance.	~ 4.5' total depth
Jellyfish Filter	• Filters cleaned by backflushing. • Cartridges reused and then replaced every 2 to 5 years.	• Deep structure needed. • Not as efficient for metal removal.	~ 8'+ total depth

Of the options shown in Table 4-3, the most suitable for the project site include biofiltration swales, treatment wetlands or use of landscaped media filter (i.e., Filterra soil). Figure 4-1 shows the subbasins that are likely to contribute flow to this regional treatment facility at Freund Marsh in part, due to a diversion structure recently placed at the intersection of West Pioneer Way and SW Bayshore Drive. This diversion structure was installed with the intent that flows west of this intersection would flow to a future regional treatment facility at Freund Marsh. Collectively, the basins shown in Figure 4-1 comprise approximately 466 acres, of which, 132 acres are anticipated to be impervious under buildout conditions. Ecology's WWHM software was used to calculate the water quality volume or flow rates that would be necessary to treat all 466 acres if they were considered to be part of a redevelopment project. The model is conservative as it assumes that no treatment is currently being provided upstream. The following facilities are sized only for the treatment volume and/or flow rate. All additional flow is anticipated to be bypassed directly to the Harbor either through the existing ditches at Freund Marsh or further east towards South Beeksma Drive SW toward the existing 42-inch outfalls. Table 4-4 shows the results of the model.

TABLE 4-4

Freund Marsh Water Quality Treatment Flow Rates and Volume

	Volume/Flow Rate
24-Hour Volume	10.78 ac-ft (469,577 cf)
On-line Flow Rate	16.52 cfs
Off-line Flow Rate	9.34 cfs

As seen in Figure 4-2, approximately 6.5 acres are available for a treatment facility. The area shown in Figure 4-2 takes into consideration previously delineated wetlands ("Wetland A" and "Wetland B") and their buffers as determined in the May 2007 Freund Marsh Delineation Memorandum prepared by Adolfson. Any future project in this area will need to include a new delineation of the wetlands as regulations have changed since 2007 and the wetlands may be considered to be different sizes and/or categories then what was previously determined.

Should a bioswale be considered to treat the area flowing to Freund Marsh, Ecology Manual guidelines specify the bioswale to be 530 feet in length with a bottom width of 50 feet and 3 to 1 side slopes. Since the bottom width would be greater than 16 feet, multiple divider berms would be necessary in the middle of the bioswale running the entire length. Maintenance of the facility would include regular mowing of the bioswale.

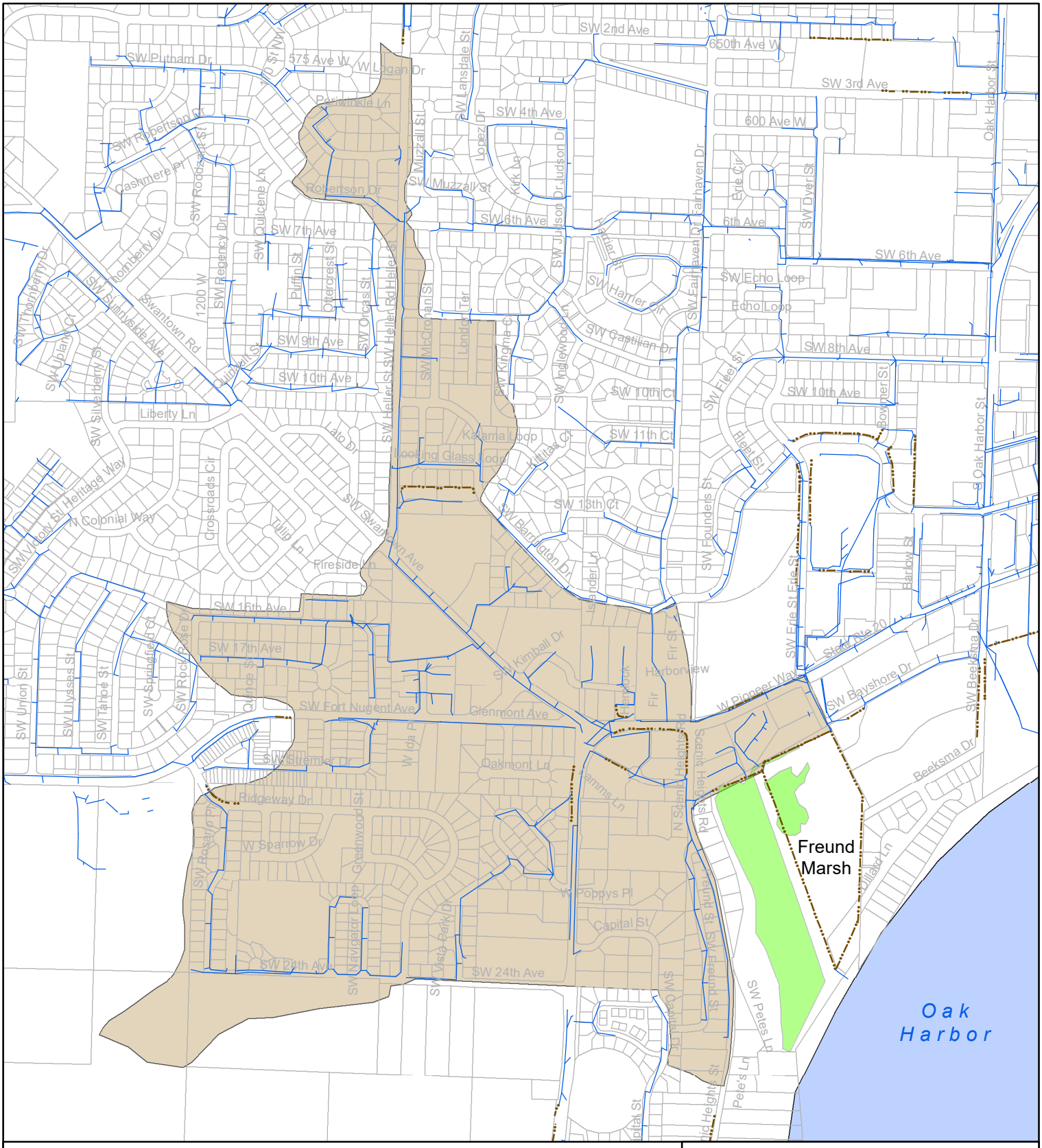
Also available is the use of landscape media, similar to the soil used in Contech's Filterra water quality treatment units. For planning purposes, Filterra media was assumed to be utilized over a 4,200 sf area within a concrete vault-like structure with an open top. The cross section of this treatment facility would include 10 inches of underdrain stone overlaid by 21 inches of engineered media (i.e., proprietary, specialized soil), topped with

3 inches of mulch (see Figure 4-3). Various plants would be installed within the media so as to provide the biological uptake necessary to clean pollutants from the runoff. Only the water quality flow rate (i.e., 9.34 cfs) would be diverted to this structure and then dispersed into the 4,200 sf area with a distribution trough, allowing runoff to enter the media every 12 feet, so as not to have one concentrated inlet into the facility. All other runoff from upstream would be bypassed around the facility. Maintenance of this facility would include replacing the 3-inch mulch layer on an annual basis.

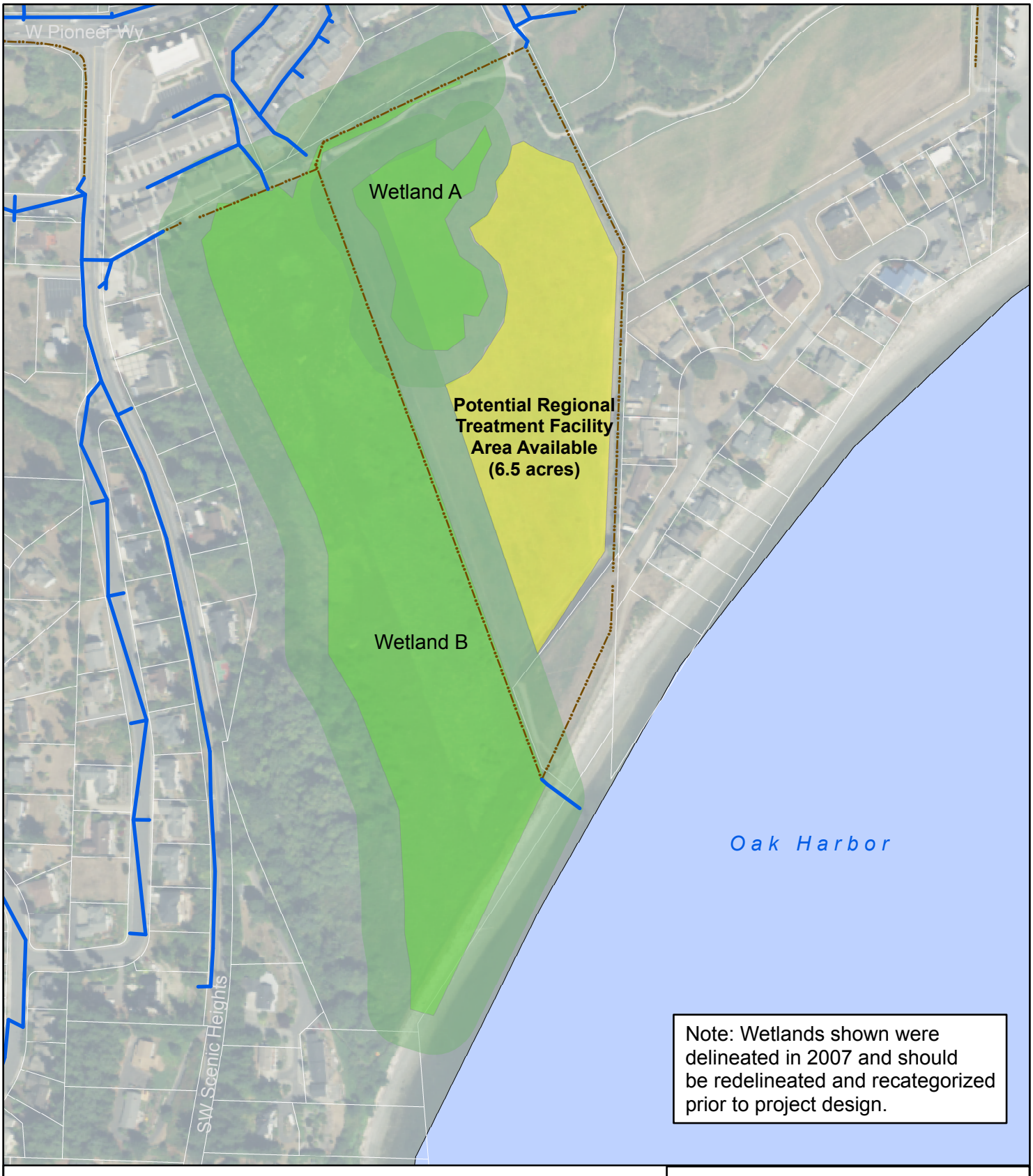
Another option includes construction of a treatment wetland which includes a 9-feet deep pre-settling cell to deposit sediments followed by a wetland cell consisting of plants to help with the biological uptake of pollutants. The wetland cell would consist of a shallower depth of 1.5 feet. Utilizing the goal of treating the 24-hour water quality volume shown in Table 4-4 (i.e., 469,577 cf), the pre-settling cell would need to be approximately 19,730 sf or 33 percent of the entire 24-hour volume. The remaining 67 percent of the volume is calculated for the wetland cell which would consist of approximately 209,745 sf at a depth of 1.5 feet. In total, 229,115 sf of surface area or 5.25 acres would be utilized to treat the region upstream of Freund Marsh with a treatment wetland. Figure 4-4 shows a representative area needed for a treatment wetland. This shape may be adjusted into a more aesthetic landscaping approach as long as the volumes of each cell are maintained.

For all of these facilities, it is recommended that a trash removal system be located upstream so as to reduce the amount of floatable debris from entering the treatment system. The trash collection system may also incorporate spill control as well.

Whatever method is chosen, the City's goal for a Freund Marsh facility includes providing a treatment system that is low maintenance and provides adequate flood plain protection while also providing treatment in a natural park like atmosphere that additionally, can provide an educational experience. A detailed feasibility study will occur prior to design to ensure that the method chosen will maximize the City's goals for this project.



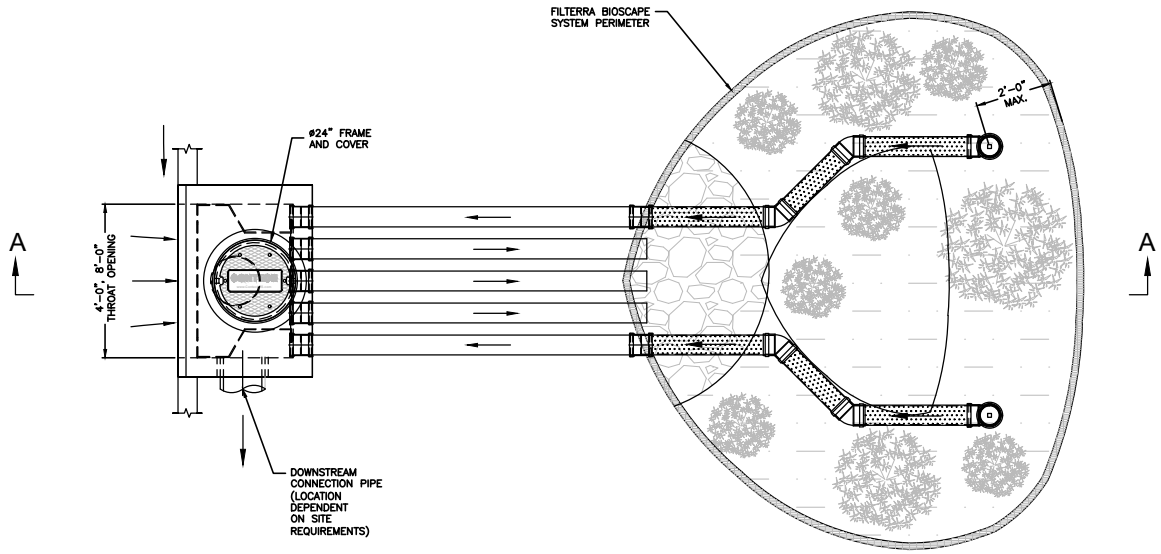
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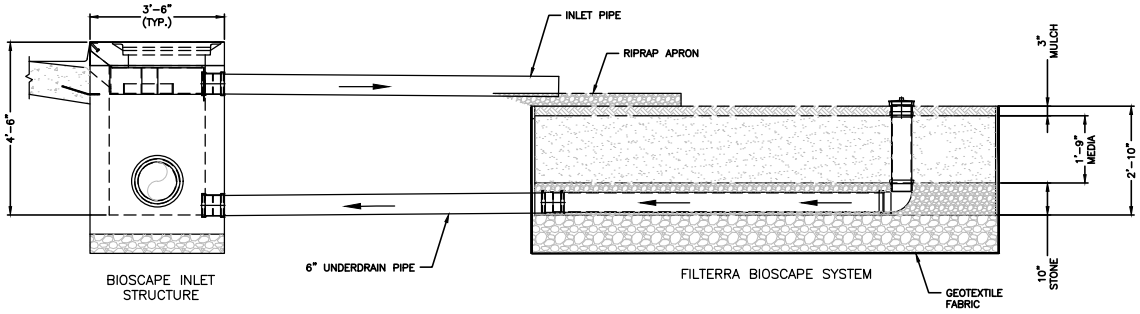
M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\4-2 Freund Marsh Treatment area.mxd

THIS IS A SCHEMATIC LAYOUT ONLY. ACTUAL CONFIGURATION WILL VARY BASED ON THE SITE SPECIFIC CONSIDERATIONS.

30' 15' 0 30' 60'
SCALE: 1"=30'



PLAN VIEW



SECTION A-A VIEW

0 1"
ONE INCH AT FULL SCALE.
IF NOT, SCALE ACCORDINGLY

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN

FIGURE 4-3

LANDSCAPE MEDIA ALTERNATIVE

Gray & Osborne, Inc.
CONSULTING ENGINEERS



Legend

- Potential Regional Treatment Wetland
- Storm Pipe
- Drainage Ditch

N

0 100 200 400 Feet

CITY OF OAK HARBOR
COMPREHENSIVE STORMWATER MANAGEMENT PLAN
POTENTIAL WETLAND TREATMENT AREA
FIGURE 4-4

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\4-4 Wetland Treatment area.mxd

CHAPTER 5

OPERATION AND MAINTENANCE

The following sections summarize considerations for the control of stormwater pollution from the sources identified in Chapters 3 and 4 and presents specific recommendations for the City of Oak Harbor. It examines and compares current maintenance efforts and needs with the minimums required to remain in compliance with Department of Ecology's NPDES Phase II Permit. A detailed water quality BMP operations and maintenance schedule is presented within this Chapter. This Chapter does not reflect the rate analysis and inputs that HDR Engineering Consultants prepared as part of the City's comprehensive utility rate analysis (Revised January 2020).

FACILITY OPERATION AND MAINTENANCE PROGRAM

The objective of a stormwater maintenance program is to assure the continued function of stormwater management facilities. A complete maintenance program includes more than the physical tasks of cleaning catch basins, pipes, and open ditches; maintenance of vegetation in biological treatment structures; and proper disposal of debris from the maintenance activities. Maintenance programs also involve management items such as completing and maintaining a facilities inventory, updating a base map, scheduling inspections and maintenance activities, assessing costs for contract maintenance versus staff maintenance, and record keeping in order to comply with the NPDES Phase II permit.

In order to perform inspections and maintenance at the appropriate time, a budget, staff, and priority schedule should be established. Certain types of maintenance are more important than others. It is important that catch basins and conveyance facilities be inspected before the wet season to assure that debris has not blocked a channel or taken up capacity in a catch basin. Not only are inspections important from a function standpoint, but they are also a requirement of the NPDES Phase II permit where catch basins are required to be inspected every two years. Street sweeping in the fall is important because leaves block catch basin grates, which could result in ponding or minor flooding on private property or roadways. Loss of vegetative cover in treatment swales and filter strips during summer drought conditions can result in reduced effectiveness. Maintaining adequate vegetative cover in treatment swales and filter strips during summer drought conditions is important to preserve effectiveness.

Reports and record keeping are important feedback mechanisms that enable management to compare actual versus planned costs, production, and efficiency. Reports provide a database for improved budgeting and resource allocation. Records and reports should include personnel hours, equipment hours, materials used, and the unit of work completed.

Maintenance control establishes accountability for specific results within a specific time frame and budget. The maintenance program needs a control hierarchy to establish a chain of command to complete the work.

One item of critical importance is inspecting privately owned facilities to ensure that they are properly maintained. The proper operation and maintenance of stormwater facilities benefits the public as a whole; therefore, the City should utilize innovative solutions to accomplish the goals of stormwater management in those cases where a private entity cannot or will not maintain its facility. Through the development review process, it is recommended that all private facilities be designed and constructed under the same standards as public systems. If the private system is ever turned over to the City for operation and maintenance, the transfer should be seamless and not require the City to further train employees or purchase new maintenance equipment. Also, private systems should be designed and located to allow easy inspection by City staff as is mandated by the NPDES Phase II Permit.

MAINTENANCE STANDARDS

Volume 5 of the Department of Ecology's Stormwater Management Manual for Western Washington (SWMMWW) identifies maintenance standards for flow control, conveyance, and water quality facilities that should be established by the City.

The following is a brief description of the recommended maintenance procedures and the impact on stormwater pollution and flow control that could result from not maintaining a facility. Appendix E contains complete descriptions of maintenance activities the City should complete.

INFILTRATION PONDS

Infiltration areas must be protected throughout future development and maintained to ensure adequate infiltration and flood prevention. The City should maintain basin floor and side slopes to promote dense turf with extensive root growth. Bare spots should be stabilized and revegetated. Vegetation growth should be mowed to maintain a height of 18 inches or less. This can generally be accomplished by mowing twice each year for slow-growing grasses. Additionally, any trash/debris and poisonous or nuisance vegetation should be removed on a yearly basis, and groundwater quality should be protected by providing cleanup of any contaminants/pollutants on site.

STREET SWEEPING

Streets with concrete curb and gutter or thickened edges are part of the stormwater conveyance system. All streets accumulate particles, silt, leaves, debris, and other pollutants that could enter the stormwater conveyance system. Street sweeping (not washing) is an important maintenance item to reduce pollution from entering receiving waters and to reduce the potential for blocking of the conveyance system.

High-efficiency street sweepers are recommended due to the fact that they are able to pick up small particulates that accumulate pollutants along City streets. The City has approximately 153 miles of streets. The City intends to sweep 25 miles at a time for a total of 37 trips per year. They are currently deployed two times per week.

CATCH BASIN CLEANING

The City has mapped over 4,200 storm drainage catch basin and manhole structures. Catch basin sumps are important features that allow deposition of particulate matter carried in the stormwater. When sumps become filled to 60 percent of their volume, the efficiency of silt removal diminishes significantly. Maintenance is recommended when the sediment exceeds this 60 percent threshold. The NPDES Phase II Permit requires that catch basins be inspected at least once every 2 years; however, the City has historically inspected catch basins once per year. Depending on the location, this frequency may be relaxed or increased, based on past maintenance records. Catch basins are normally cleaned with a vactor truck that removes the sediment from the basin. This sediment must be disposed of properly as described in Appendix 6 of the Western Washington Phase II Municipal Stormwater Permit (modified in 2015).

PIPE CLEANING

The City has over 50 miles of stormwater pipe to maintain. Pipes in the City vary in size from 2-inch to 42-inch diameter. Pipe types include concrete, corrugated metal, ductile iron, HDPE, and PVC. Although there are no specific guidelines, a typical schedule for pipe cleaning is to clean storm drain pipes on a 3- to 5-year rotating basis. The City currently inspects and cleans approximately 400 linear feet of pipe each year, which is equal to 0.15 percent of the network. This is lower than the recommended maintenance and should be increased based on observed conditions. The primary maintenance activity for stormwater pipes is removal of accumulated sediment once the accumulated sediment or debris exceeds 20 percent of the diameter of the pipe. Sediment can decrease conveyance capacity or can be washed out of the pipes during storm events causing downstream sediment and pollution problems. When jetting and flushing pipes, adequate downstream siltation control must be in place. This is usually accomplished by using a vactor truck at the nearest downstream structure. Additionally, it is recommended that the City implement a television inspection program with a goal of inspecting pipes on a 10-year rotating basis.

OPEN DITCH MOWING AND CLEANING

The City currently has mapped over 13.8 miles of open channels. Ditches and swales can provide biofiltration, if vegetation is allowed to remain within the channel and on the sides. The primary pollutant removal mechanism of a bioswale (or ditch) involves filtration by grass blades, which enhance sedimentation, as well as trapping and adhesion of pollutants to the grass and thatch. To be most effective, the vegetation within the ditch should be cut down to a height between 3 and 4 inches. The City currently mows each

ditch approximately five times per year. Mowing is the first method that should be used to reduce capacity loss. If the ditch must be reshaped to promote drainage or remove excess materials, the work should be performed during dry weather. Two methods to clear obstructions or reshape the ditch include the following:

1. Swales can be cleaned with a backhoe, taking care not to remove more material than is necessary. Clean areas only where there is a flow restriction. Small amounts of sediment should be removed by hand.

2. Under the close supervision of City staff, yearly maintenance may be performed by a qualified contractor. A contractor can utilize an auger attachment mounted on a dump truck. The auger removes sediment from the swale/ditch and places the material directly into the truck.

DETENTION SYSTEM CLEANING

There are 20 City maintained and 134 privately maintained detention ponds located within the City. Upon installation of a detention system, the City should obtain a manual regarding specific maintenance requirements for facilities such as detention ponds. At a minimum, these ponds should be monitored annually for sediment accumulation. It should be noted that providing inspection of both city owned and privately owned facilities on an annual basis is a requirement of the NPDES Phase II Permit. Removal of accumulated sediment is anticipated to be required once every 5 years, or when accumulated sediment takes up more than 10 percent of the pond depth. Failure to maintain detention systems has the potential to cause flooding of the facility, upstream, and downstream and to prevent the facility from performing adequate treatment.

CULVERTS

There are 268 culverts documented in the City's GIS database. Culverts should be inspected annually and after every significant runoff event to check for blockages, excessive scour, and deposition of new sediment and debris. Especially in the wet season, any potential blockage or loss of capacity should be immediately removed. For culverts within state waters, this type of maintenance activity will require a Hydraulic Project Approval (HPA) from the Washington Department of Fish & Wildlife (WDFW). The HPA is usually valid for 5 years. In emergency situations, immediate work is allowed with notification to WDFW, with an HPA issued after-the-fact.

RECOMMENDED MAINTENANCE PROGRAM

The City's current Stormwater Management Program Plan identifies the Phase II Permit requirements, ongoing activities, and planned activities. Ongoing activities include annual inspection, and maintenance as required, of all City-owned stormwater treatment and flow control BMPs/facilities, spot checks of facilities after large storm events, adherence to Stormwater Pollution Prevention Plans, and providing appropriate staff

training. In addition to continuation of ongoing activities, the City will assess maintenance standards to identify any facilities that currently do not have maintenance standards and begin the process of updating stormwater facility standards. The stormwater facilities the City must inspect and maintain are shown in Table 5-1.

TABLE 5-1

Inventory of Stormwater Facilities

Facility	Quantity
Catch Basins	4,229
Storm Pipe	303,885 LF
Ditches	72,615 LF
Detention Facilities*	154
Water Quality Facilities	5
Outfalls	77

*134 stormwater facilities in City limits are privately owned. 20 detention facilities are owned by the City.

In addition to the maintenance of the facilities listed in Table 5-1 the City will continue the practice of street sweeping to remove sediment and debris, before it enters the system.

The stormwater maintenance activities anticipated by City staff in the future and the corresponding production units, estimated personnel hours, and estimated labor costs are shown in Table 5-2. This information is used to estimate the cost of the stormwater maintenance program and to estimate the staff required to implement the program. It has been assumed that all maintenance activities will be completed by City staff and that the cost to the City per manhour is an average of $40 independent of equipment costs.

It should be noted that the costs presented in Table 5-2 reflect only the estimated cost of labor and equipment to perform specified tasks. These costs do not reflect the total operating budget for the Storm Drain Division which includes office and operating supplies, equipment repair and maintenance, contributions to equipment replacement, insurance, professional services, contributions toward engineering and indirect cost allocations. The estimated annual operating budget is shown within the draft 2019 Rate Study included in Appendix F.

TABLE 5-2

Annual Maintenance Expenses

Activity	Units	Daily Production Rate	Total Units	Schedule (per year)	Staff	Equipment	Equipment (hours/ year)	Annual Equipment Cost	Staff (hours/ year)	Annual Staff Cost[(1)]	Combined Annual Cost
Clean catch basin	Catch Basins	30	4,229	25%	2	Vactor	283	$7,641	459	$18,360	$26,001
Detention pond mowing	Pond	3	21	3 times	1	Mower	168	$1,008	168	$6,720	$7,728
Ditch/swale mowing	Linear Feet	7,000	58,050	5 times	1	Mower	332	$1,992	332	$13,280	$15,272
Ditch maintenance	Linear Feet	100	72,615	1%	4	Backhoe, Dump Truck, Pickup	174	$2,784	232	$9,280	$12,064
Pipe inspection (CCTV)	Linear Feet	200	303,885	0.15%	2	Camera Van	18	$162	32	$1,280	$1,442
Storm pipe cleaning	Linear Feet	200	303,885	0.15%	2	Vactor	18	$162	32	$1,280	$1,442
Street sweeping	Miles	25	70	37 times	1	Sweeper	829	$19,896	829	$33,160	$53,056
Miscellaneous repairs and inspections	N/A	N/A	N/A	As Needed	2	Pickup, Vactor	150	$3,600	300	$12,000	$15,600
Flow Control Device Inspections	Each	1	244	1	1	Pickup	450	$1,350	550	$22,000	$23,350
Shoulder Work	Linear Feet	300	72,615	As Needed	4	Pickup, Grader, Dump Truck	225	$2,700	900	$36,000	$38,700
Catch Basin Inspection	Each	50	4,229	1	2	Pickup	676	$2,028	1,103	$44,120	$ 46,148
Rendering Tank Inspection	Each	16	73	12	1	Pickup	438	$1,314	438	$17,520	$18,834
Illicit Discharge	N/A		N/A	N/A	1	Pickup	80	$240	80	$3,200	$3,440
Spill Cleanup	N/A	N/A	N/A	N/A	4	Pickup, Vactor, Sweeper	50	$2,700	200	$8,000	$10,700

TABLE 5-2 – (continued)

Annual Maintenance Expenses

Activity	Units	Daily Production Rate	Total Units	Schedule (per year)	Staff	Equipment	Equipment (hours/ year)	Annual Equipment Cost	Staff (hours/ year)	Annual Staff Cost[(1)]	Combined Annual Cost
Outfall Inspections	Each	4	4	52	1	Pickup	104	$312	104	$4,160	$4,472
Outfall Maintenance	Each	N/A	4	As Needed	2	Backhoe, Pickup	50	$550	100	$4,000	$4,550
Manual Vegetation Cutting	Linear Feet	1,400	7,000	5	2	Pickup	200	$600	400	$16,000	$16,600
NPDES Activities	N/A	N/A	N/A	As Required	1	Pickup	650	$1,950	2,080	$83,200	$85,150
Stormwater Code Enforcement	N/A	N/A	N/A	As Required	1	Pickup	180	$540	180	$7,200	$7,740
Annual Totals							**5,125**	**$51,139**	**8,509**	**$340,360**	**$392,039**

(1) Assuming $40 per manhour

STAFF REQUIREMENTS

The total City staff hours required for the maintenance activities identified in Table 5-2 is approximately 8,509 hours. This includes 2,080 hours for a new position related to NPDES Phase II activities.

EQUIPMENT NEEDS

The Public Works Department has not expressed a need for any new equipment related to stormwater maintenance activities. This topic should be revisited on an annual basis to address any aging equipment needs and as low impact development BMPs are incorporated into public infrastructure.

INSPECTION

To meet the NPDES Phase II Permit requirements and to provide an efficient stormwater conveyance system, the City should inspect all private and City-owned stormwater treatment and flow control facilities annually, unless there are maintenance records to support a different frequency. Reducing the inspection frequency should be based on records of double the length of time needed for maintenance. Although the requirement is an annual inspection, the City currently inspects private facilities twice a year.

Spot checks must be performed to detect potentially damaged permanent treatment and flow control facilities (other than catch basins) after a major (greater than 24-hour, 10 year) storm event. If spot checks indicate widespread damage/maintenance needs, the City should inspect all stormwater treatment and flow control facilities that may be affected. Repair or appropriate maintenance action should be performed in accordance with established maintenance standards.

All catch basins and inlets should be inspected at least once every 2 years and cleaned if the inspections indicate a need to do so. Per the prior NPDES Phase II Permit requirements, all catch basins should have been inspected by August 1, 2019. The decant water generated from catch basin and pipe cleaning must be disposed of properly.

STAFF TRAINING

As discussed previously in this chapter, the City must develop and implement an ongoing training program for City employees whose construction and O&M job functions may impact stormwater quality. This program should address the importance of protecting water quality, O&M standards, inspection procedures, BMP selection, preventing impact to water quality, and procedures for reporting water quality concerns.

The City should ensure that the staff is well trained on techniques and procedures to inspect and maintain best management stormwater practices as outlined in the NPDES Phase II Permit requirements. At a minimum, staff should be educated on how to

maintain catch basins, detention ponds and control structures, bioswales/ditches, and any other best management practices implemented within the City. Staff should also be knowledgeable in identifying pollutant sources and in understanding pollutant control measures, spill response procedures, and environmentally acceptable material handling practices. Ecology's website (http://www.ecy.wa.gov/programs/wq/stormwater/municipal/IDDEresources.html) provides numerous resources to assist with this. There are also a number of IDDE training videos available on the internet. The City Engineer should be designated as responsible for setting up training for new employees regarding these issues. Renewal training for all employees on a biannual basis is recommended as well.

Personnel should also be well trained on erosion and sediment control issues so they can properly investigate and advise contractors regarding problem areas during construction. Appropriate staff members should be certified through a Construction Site Erosion and Sediment Control Certification Course as offered by numerous organizations. Refer to Ecology's website for a list of organizations (http://www.ecy.wa.gov/programs/wq/stormwater/cescl.html). Erosion and sediment control certification for staff members should be renewed every 3 years.

ENFORCEMENT

Staffing levels must be sufficient to respond to stormwater complaints, and provide periodic inspection of private stormwater treatment facilities such as oil/water separators and detention facilities. City staff should document the hours spent onsite inspections, together with the frequency of inspection. From these records and the records of time spent responding to complaints, an understanding of the adequacy of the current staffing level can be gained.

PUBLIC EDUCATION AND OUTREACH

An important element of a stormwater management plan is public education and outreach. The involvement of the public is necessary to insure the overall success of the stormwater management program. For the public to be motivated to participate in stormwater management, it must first be aware of existing stormwater and surface water problems, the public's role in creating these problems, and actions to avoid and correct them.

The public must also be aware of how their normal activities affect stormwater quality and quantity. Most citizens believe that stormwater management is someone else's problem. In order to educate the public, issues with local relevance must be identified and programs must be designed to address them. Resources for education materials to inform citizens about these topics include:

- The Washington Stormwater Center: http://www.wastormwatercenter.org/coordination

- EPA's NPS Outreach Toolbox: https://cfpub.epa.gov/npstbx/index.html

- Puget Sound Starts Here Library: http://pugetsoundstorm.weebly.com/library.html and http://www.psp.wa.gov/econet_PSSH.php#2

BEST MANAGEMENT PRACTICES (BMPS)

In most communities, a major source of stormwater contamination comes from sources that are lumped together and called nonpoint pollution. Nonpoint pollution sources can generally be defined as "pollution that does not have a single point of discharge." Nonpoint pollution discharges can be divided into commercial and residential categories.

The treatment of stormwater runoff prior to discharge to surface water or prevention of nonpoint pollution in stormwater should be accomplished by using BMPs. BMPs are defined as physical, structural, and/or managerial practices, which when used singly or in combination, prevent or reduce pollution of water.

The Stormwater Management Manual for Western Washington contains BMPs for urban land uses. Best Management Practices can be placed into two general groups: source control BMPs, and runoff treatment BMPs. The former group includes those BMPs that keep pollutants from coming in contact with stormwater; the latter group consists of methods for treating stormwater, once it is polluted. Source control BMPs are preferred as they are generally less expensive and frequently are more effective.

BMPs and general strategies for their use are listed below in order of preference:

1. **Alter the Activity:** The preferred option is to alter any practice that may contaminate surface water or groundwater by either not producing the pollutant to begin with or by controlling it in such a way as to keep it out of the environment. An example would be recycling used oil rather than dumping it down a storm drain.

2. **Enclose the Activity:** If the practice cannot be altered, it should be enclosed in a building. Enclosure accomplishes two things. It keeps rain from coming into contact with the activity and since drains inside a building must discharge to sanitary or process wastewater sewers or a dead-end sump, any contamination of runoff is avoided.

3. **Cover the Activity:** Placing the activity inside a building may be infeasible or prohibitively expensive. A less expensive structure with only a roof may be effective although it may not keep out all precipitation. Internal drains must be connected to the sanitary sewer to collect water

used to wash down the area as well as any rain that may enter along the perimeter.

4. **Segregate the Activity:** Segregating an activity that generates more pollutants than other activities may lower the cost of enclosure or covering to a reasonable level.

   If the segregated activity cannot be covered, it may be possible in certain situations to connect the area to the public sanitary sewer, subject to approval. Drains may also be connected to a businesses' own process wastewater system if the business operates independently of the local authority.

5. **Discharge Stormwater to the Process Wastewater Treatment System:** Many industries have their own process wastewater treatment system with final disposal directly to the receiving water. In these cases, stormwater from areas of significant pollution sources can be plumbed to the process treatment system as long as its capacity is not exceeded.

6. **Discharge Small, High-Frequency Storms to Public Sanitary Sewer:** This BMP would be limited to those few outside activities that contribute unusually high concentrations of pollutants and/or pollutants of unusual concern. Staff should consider the effects of allowing this discharge into the new membrane bioreactor wastewater treatment facility. Limited entry of these few special cases may not overtax the public sanitary sewer. It should be noted that the City recently completed the construction of a new membrane bioreactor (MBR) waste water treatment plant which may affect allowance discharges to sanitary sewer.

   The entry of stormwater to the sanitary or combined sewer can be limited to the small high-frequency storms that carry off the majority of pollutants over time. Storm flows in excess of the hydraulic capacity of the sanitary or combined sewer would be discharged to the storm drain. It should be noted here that the City recently completed the construction of a new membrane bioreactor (MBR) waste water treatment plant which may affect allowance discharges to sanitary sewer.

7. **Discharge Small, High-Frequency Storms to a Dead-End Sump:** This BMP would be limited to those few activities that contribute unusually high concentrations of pollutants and/or pollutants of unusual concern. This option would be used when discharge into a sanitary sewer or process wastewater treatment is not available or feasible. This option requires the capacity to pump out the sump regularly and to dispose of the waste in an appropriate manner.

8. **Treat the Stormwater with a Stormwater Treatment BMP:** The treatment of stormwater is the least-preferred option for several reasons. Source control BMPs keep the pollutants completely away from stormwater. In contrast, stormwater treatment devices are not 100 percent effective. In fact, a highly effective BMP is considered successful if 80 percent of the pollutants are removed. Even after treatment, freshwater criteria may not be met for some areas.

Given the above strategies for use of BMPs, the Ecology Manual provides a menu of BMPs for many types of pollutant sources. Certain projects may trigger "Minimum Requirement No. 3" (Source Control of Pollution) which would require the applicant to implement various source control measures on the project. These may include structural or operational BMPs.

The Manual provides five treatment menus including a basic, oil control, enhanced, and phosphorous treatment menu. However, as noted earlier, source control BMPs are preferred over treatment BMPs, if feasible.

Detailed water quality BMP operations and maintenance procedures as described in the Ecology Stormwater Manual can be found in Appendix E.

PHASE II NPDES PERMIT RELATED ACTIVITIES

The National Pollutant Discharge Elimination System (NPDES) Permit is a federal permit that regulates stormwater and wastewater discharges to waters of the State. While it is a federal permit, the regulatory authority was delegated to the Washington State Department of Ecology (Ecology). In response, Ecology developed and issued the Western Washington Phase II Municipal Stormwater Permit. The Permit was issued by Ecology on January 17, 2007, and was reissued in 2012 and 2019. In general, numerous permit requirements remained similar to past permits including the following requirements:

- Prepare an annual Stormwater Management Plan (SWMP).
- Provide public education and outreach with evaluation of behavior change.
- Provide public involvement and participation including posting the SWMP and Annual Report.
- Continue ongoing mapping of the stormwater system (i.e., MS4) for all known City owned outfalls and discharge points.
- Provide inspections, documentation, training and code/enforcement related to illicit discharges and connections. Field screen 12 percent of the MS4 each year.
- Review development plans and provide erosion control related inspections.
- Provide operation and maintenance on stormwater facilities including conducting annual inspections of both private and public flow control and

water quality facilities. Catch basins shall be inspected every 2 years and cleaned as necessary.
- Opt in towards funding the regional monitoring program.
- Prepare and submit an annual report by March 31st of each year.

New elements of the NPDES Phase II permit include the following:

- **Stormwater Planning:** Describe how water quality is being implemented in other codes and planning documents within the City, including land use planning; prepare a Stormwater Management Action Plan which includes delineating basins based upon a watershed approach and prioritizing these basins. Within one basin, potential retrofit opportunities will be documented with the intent that these opportunities may be constructed during the next permit cycle (2024-2029).

- **Source Control Program:** Implement a program to inspect public and private commercial and industrial properties and educate/enforce as necessary to ensure the businesses are implementing best management practices. Initial stages of the program include creating an inventory of businesses to inspect with latter stages of the program involving inspection of 20 percent of these businesses per year.

A preliminary sample schedule pertaining to the requirements within the 2019 NPDES Phase II Permit is provided in Appendix G.

Ecology has indicated that it may conduct future audits which will be performed by Ecology Staff. These audits may focus on any aspect of the municipal Phase II permit elements; however, Ecology noted that they will audit mostly on either construction related inspections, IDDE and/or municipal operation and maintenance items. The audit may include a record review of particular items and then an in-person review by Ecology staff. An example of information requested by cities for the record review is shown in Table 5-3.

TABLE 5-3

Sample Phase II Audit Items Requested by Ecology

Topic	Items Requested
Common Elements	• Organizational chart showing who is responsible for review of stormwater programs • Map of stormwater features (per Special Condition S5.C3. in the permit)
IDDE	• Copy of local ordinance to prohibit illicit discharges • Description of IDDE field screening protocol • Description of procedures used to characterize, trace, and eliminate illicit discharges/spills. • Copy of stormwater hotline and records of complaints of illicit discharges • Documentation of investigations and responses to illicit discharge connections/spills • Summary of IDDE related staff training
Municipal O&M	• Documentation of inspection and maintenance records for treatment and flow control facilities • Checklists used for these inspections. • Documentation of practices, policies, and procedures employed to reduce stormwater impacts • Copy of SWPPPs for storage yards/heavy equipment maintenance areas owned and operated by the City • Records of O&M trainings conducted for employees

The City should prepare for an audit by reviewing these items and possibly interacting with other cities that have been through an audit to discover lessons learned from past experience.

CHAPTER 6

CAPITAL IMPROVEMENT PLAN

INTRODUCTION

The City of Oak Harbor's Stormwater Capital Improvement Plan is presented in this section. The recommended projects include elements to control both the quantity and quality of stormwater runoff.

The Capital Improvement Plan (CIP) was developed based on input from several sources. Sources included City staff, who identified storm drainage problems, the City's 2006 Comprehensive Stormwater Drainage Plan (2006 Comp Plan), and the hydraulic/hydrologic model. In addition, the DOE's 2019 NPDES Phase II Permit requires basin analysis, basin prioritization, and programming for stormwater basin treatment and/or flow control retrofits. Currently, these retrofits are to be implemented in the permit Cycle starting 2024. This newer requirement changes the nature of the CIP list to include studies and examination of basins in preparation of the future retrofits. It should also be noted that two third party environmental groups have filed a lawsuit against the Department of Ecology to force the basin retrofit implementation into the 2019-2024 permit period. As of the writing of this Plan, this lawsuit is unresolved. Should the plaintiff prevail, the basin retrofit schedule will be accelerated.

Other stormwater capital improvement projects may arise in the future that are not identified as part of the City's CIP presented in this chapter. Such projects may be deemed necessary for remedying an emergency situation, assessing growth in other areas accommodating improvements proposed by other agencies or land development, or addressing unforeseen problems with the City's storm drainage system. Due to budgetary constraints and/or addressing growth scenarios that differ from those modeled in this Plan, the construction of these projects may require changes in the proposed completion date for projects in the CIP. When new information becomes available, the City retains the flexibility to reschedule, add to, or delete proposed projects and to expand or reduce the scope of the projects, as best determined by the City. Each capital improvement project should be re-evaluated to consider the most recent relevant planning efforts as the proposed project date approaches.

CAPITAL IMPROVEMENT PROJECTS

The compilation of this Comprehensive Stormwater Plan included a review of the outstanding projects from the 2006 Comp Plan. In the 2006 Comp Plan, there were 20 capital improvement projects (CIPs) identified. Of those 20 CIPs, six have been completed. An assessment of the remaining CIPs was made with City staff. The projects that carried over from the previous 2006 Comp Plan, along with newly identified problem areas (as identified by City staff, modeling efforts, and NPDES Permit driven retrofit

projects) are presented further herein.

Each project cost estimate includes an additional 20 percent construction contingency, 25 percent for design, engineering and permitting and an 8.7 percent sales tax. All project costs are based on 2019 dollars with no adjustments made for inflation in future years. Detailed cost estimates are provided in Appendix H.

The naming convention uses the initials of the drainage basin that the projects fall within, along with an identification number. Within the description, the City's pipe identification number and the identification number provided within the hydraulic model are both listed in parenthesis.

It should be noted that some projects may take lengthy coordination with other agencies for permitting purposes. Permit acquisition should be considered within the project's overall schedule.

UPPER DRY CREEK PROJECTS

UDC-1: Stormwater Pipe Replacement (North Oak Harbor Street)

(Beyond 2027 or as funds are available)

Replace stormwater pipes along North Oak Harbor Street as shown in Table 6-1 and Figure 6-2 to provide capacity under future conditions.

TABLE 6-1

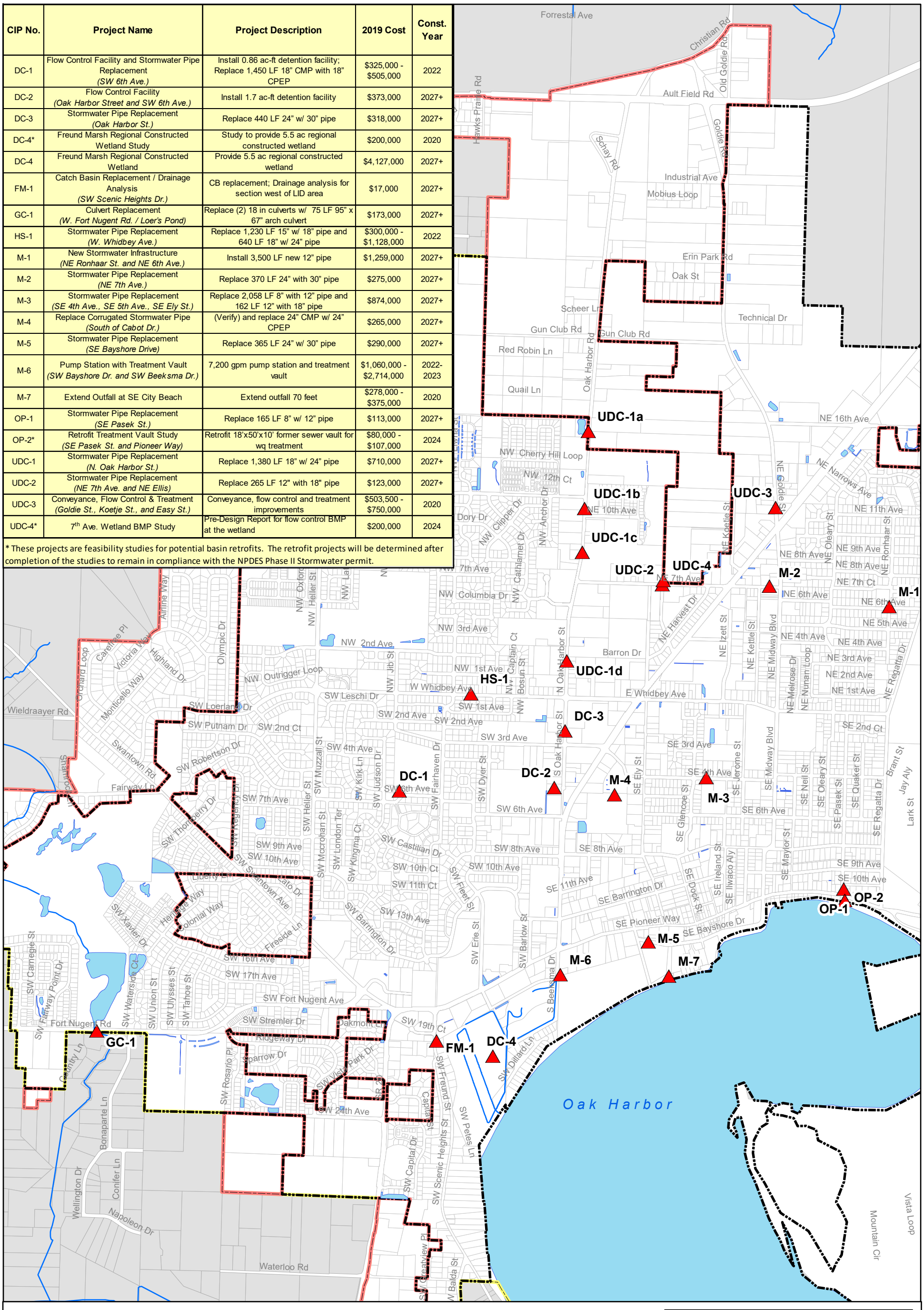
Stormwater Pipe Replacements (North Oak Harbor Street)

Location	GIS Pipe ID No.(s)	Model Pipe No.(s)	Total Pipe Length (LF)	Existing Size (in)	New Pipe Size (in)
North of NW Crosby Avenue	2408, -	L_C192	200	18	24
South of NW Crosby Avenue	1574, 1575	L_C4	406	18	24
Between NE 10th Avenue and NE 7th Avenue	1581, -	L_C6	352	18	24
North of East Whidbey Avenue	-	L_C10	422	18	24

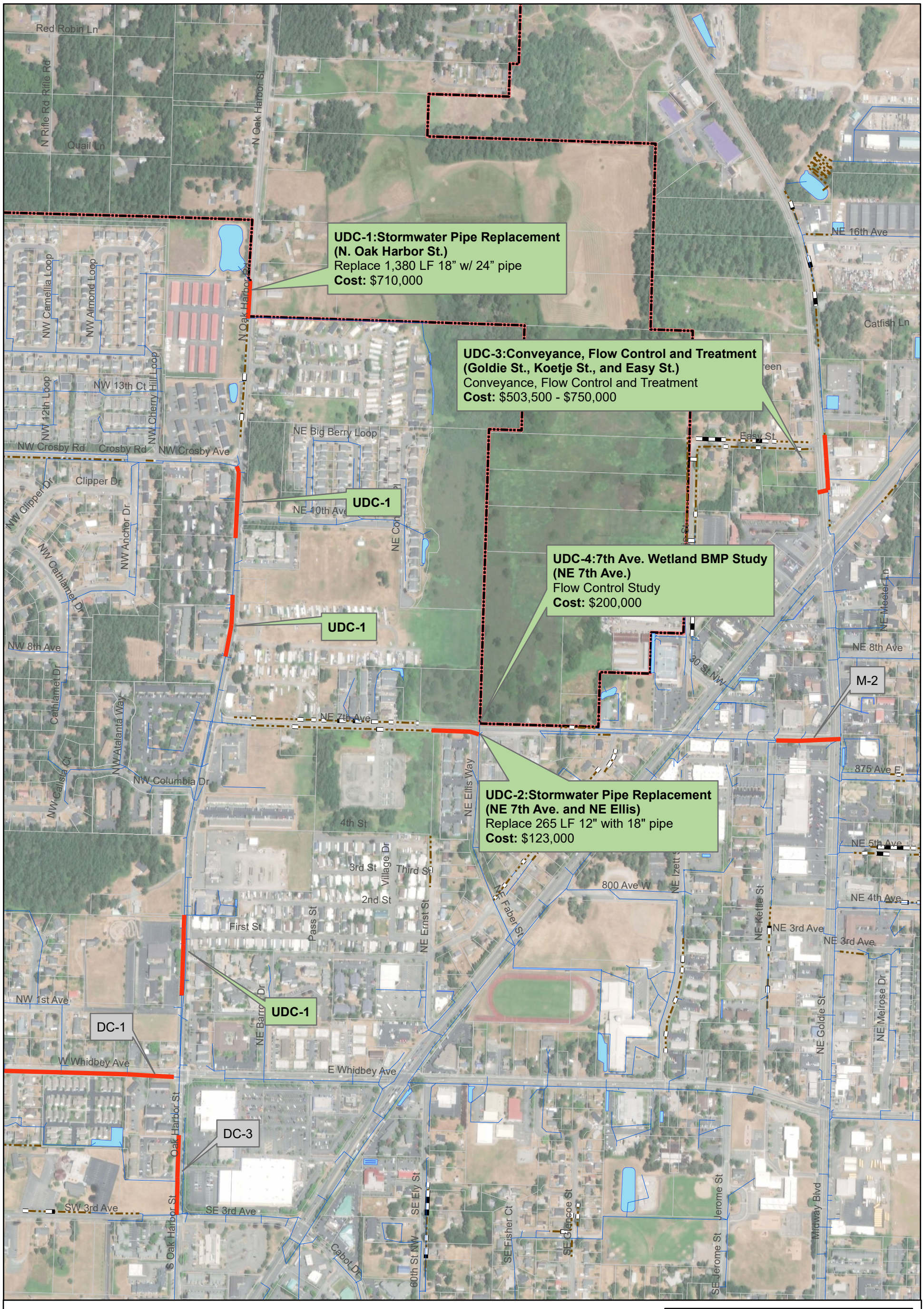
Estimated Project Cost: $710,000

CIP No.	Project Name	Project Description	2019 Cost	Const. Year
DC-1	Flow Control Facility and Stormwater Pipe Replacement *(SW 6th Ave.)*	Install 0.86 ac-ft detention facility; Replace 1,450 LF 18" CMP with 18" CPEP	$325,000 - $505,000	2022
DC-2	Flow Control Facility *(Oak Harbor Street and SW 6th Ave.)*	Install 1.7 ac-ft detention facility	$373,000	2027+
DC-3	Stormwater Pipe Replacement *(Oak Harbor St.)*	Replace 440 LF 24" w/ 30" pipe	$318,000	2027+
DC-4*	Freund Marsh Regional Constructed Wetland Study	Study to provide 5.5 ac regional constructed wetland	$200,000	2020
DC-4	Freund Marsh Regional Constructed Wetland	Provide 5.5 ac regional constructed wetland	$4,127,000	2027+
FM-1	Catch Basin Replacement / Drainage Analysis *(SW Scenic Heights Dr.)*	CB replacement; Drainage analysis for section west of LID area	$17,000	2027+
GC-1	Culvert Replacement *(W. Fort Nugent Rd. / Loer's Pond)*	Replace (2) 18 in culverts w/ 75 LF 95" x 67" arch culvert	$173,000	2027+
HS-1	Stormwater Pipe Replacement *(W. Whidbey Ave.)*	Replace 1,230 LF 15" w/ 18" pipe and 640 LF 18" w/ 24" pipe	$300,000 - $1,128,000	2022
M-1	New Stormwater Infrastructure *(NE Ronhaar St. and NE 6th Ave.)*	Install 3,500 LF new 12" pipe	$1,259,000	2027+
M-2	Stormwater Pipe Replacement *(NE 7th Ave.)*	Replace 370 LF 24" with 30" pipe	$275,000	2027+
M-3	Stormwater Pipe Replacement *(SE 4th Ave., SE 5th Ave., SE Ely St.)*	Replace 2,058 LF 8" with 12" pipe and 162 LF 12" with 18" pipe	$874,000	2027+
M-4	Replace Corrugated Stormwater Pipe *(South of Cabot Dr.)*	(Verify) and replace 24" CMP w/ 24" CPEP	$265,000	2027+
M-5	Stormwater Pipe Replacement *(SE Bayshore Drive)*	Replace 365 LF 24" w/ 30" pipe	$290,000	2027+
M-6	Pump Station with Treatment Vault *(SW Bayshore Dr. and SW Beeksma Dr.)*	7,200 gpm pump station and treatment vault	$1,060,000 - $2,714,000	2022-2023
M-7	Extend Outfall at SE City Beach	Extend outfall 70 feet	$278,000 - $375,000	2020
OP-1	Stormwater Pipe Replacement *(SE Pasek St.)*	Replace 165 LF 8" w/ 12" pipe	$113,000	2027+
OP-2*	Retrofit Treatment Vault Study *(SE Pasek St. and Pioneer Way)*	Retrofit 18'x50'x10' former sewer vault for wq treatment	$80,000 - $107,000	2024
UDC-1	Stormwater Pipe Replacement *(N. Oak Harbor St.)*	Replace 1,380 LF 18" w/ 24" pipe	$710,000	2027+
UDC-2	Stormwater Pipe Replacement *(NE 7th Ave. and NE Ellis)*	Replace 265 LF 12" with 18" pipe	$123,000	2027+
UDC-3	Conveyance, Flow Control & Treatment *(Goldie St., Koetje St., and Easy St.)*	Conveyance, flow control and treatment improvements	$503,500 - $750,000	2020
UDC-4*	7th Ave. Wetland BMP Study	Pre-Design Report for flow control BMP at the wetland	$200,000	2024

* These projects are feasibility studies for potential basin retrofits. The retrofit projects will be determined after completion of the studies to remain in compliance with the NPDES Phase II Stormwater permit.



M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\6-1 CIPs.mxd



LEGEND:

- System Deficiencies
- Storm Drains
- Culverts
- Ditches
- Streams
- Water Bodies
- Parcels
- City Limits
- Incorporated UGA
- Joint Planning Area

N

0 500 1,000
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
UPPER DRY CREEK CIPs
FIGURE 6-2

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\6-2 Upper Dry Creek.mxd

UDC-2: Stormwater Pipe Replacement (NE 7th Avenue and NE Ellis)
(Beyond 2027 or as funds are available)

Replace stormwater pipes at NE 7th Avenue and NE Ellis as shown in Table 6-2 and Figure 6-2 at a minimum constant slope of 0.3 percent to provide capacity under both existing and future conditions.

TABLE 6-2

Stormwater Pipe Replacements (NE 7th Avenue and NE Ellis)

Location	GIS Pipe ID No.(s)	Model Pipe No.(s)	Total Pipe Length (LF)	Existing Size (in)	New Pipe Size (in)
NE 7th Avenue and NE Ellis	1568, 1569	L_261, L_262	265	12	18

Estimated Project Cost: $123,000

UDC-3: Conveyance, Flow Control and Treatment Improvements in the Vicinity of Goldie Street, Koetje Street, and Easy Street
(2020)

This project would improve the drainage conveyance system and flow control between NE Goldie Street and NE Koetje Street near NE Easy Street and provide treatment of stormwater before it enters the wetland on Koetje Street (see Figure 6-2). The project may require acquisition of easements.

Estimated Project Cost: $503,500

UDC-4: 7th Avenue Wetland BMP Study
(2024)

This project involves conducting a feasibility study for potentially providing a flow control BMP in the vicinity of NE 7th Avenue and NE Ellis Way.

Estimated Project Cost: $200,000

MIDWAY PROJECTS

M-1: New Stormwater Infrastructure (NE Ronhaar Street and NE 6th Avenue)
(Beyond 2027 or as funds are available)

To alleviate uncontrolled runoff along the shoulders of NE 6th Avenue and NE Ronhaar Street, install 12-inch storm pipe along approximately 1,500 feet of NE 6th Avenue and 2,000 feet of NE Ronhaar Street (see Figure 6-3).

Estimated Project Cost: $1,259,000

M-2: Stormwater Pipe Replacement (NE 7th Avenue)
(Beyond 2027 or as funds are available)

Replace stormwater pipes at NE 7th Avenue as shown in Table 6-3 and Figure 6-3 to provide capacity under both existing and future conditions.

TABLE 6-3

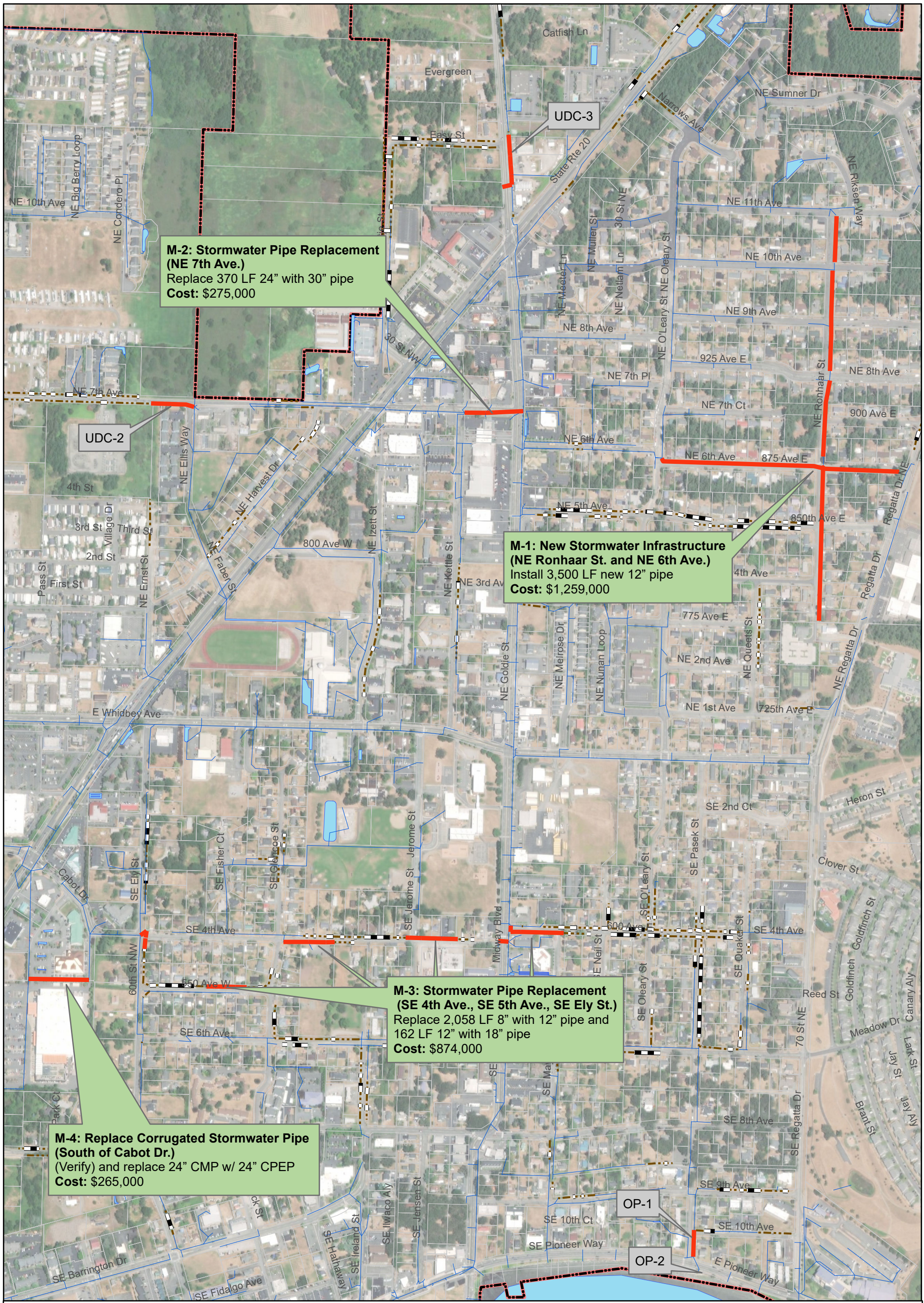
Stormwater Pipe Replacements (NE 7th Avenue)

Location	GIS Pipe ID No.(s)	Model Pipe No.(s)	Total Pipe Length (LF)	Existing Size (in)	New Pipe Size (in)
NE 7th Avenue, between NE Kettle Street and NE Midway Boulevard	2184, 2186	L_C165	370	24	30

Estimated Project Cost: $275,000

M-3: Stormwater Pipe Replacement (SE 4th Avenue, SE 5th Avenue, SE Ely Street)
(Beyond 2027 or as funds are available)

Replace stormwater pipes as shown in Table 6-4 and Figure 6-3 to provide capacity under future conditions. Upgrades to these pipes are considered less critical and, therefore, it is recommended that upgrades take place during a road resurfacing project to minimize costs.



M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\6-2 Midway(North).mxd

TABLE 6-4

Stormwater Pipe Replacements (SE 4th Avenue, SE 5th Avenue, SE Ely Street)

GIS Pipe ID No.(s)	Model Pipe No.(s)	Total Pipe Length (LF)	Existing Size (in)	New Pipe Size (in)
2460, 1795, 1796, 1797	L_C151	355	8	12
1804, 1803, 1800	L_C153	308	8	12
1778, 1779, 1780, 1781,	L_C155	244	8	12
-	L_C156	248	8	12
1790	L_C157	162	12	18
-	L_C158	227	8	12
1733, 1734, Unidentified	L_C159	676	8	12

Estimated Project Cost: $874,000

M-4: Replace Corrugated Stormwater Pipe (South of Cabot Drive)
(Beyond 2027 or as funds are available)

Verify if the existing 24-inch section of pipe to the north of Home Depot, south of Cabot Drive is CMP and replace with a smooth lined, 24-inch diameter corrugated polyethylene (CPEP) pipe (see Table 6-5 and Figure 6-3).

TABLE 6-5

Stormwater Pipe Replacements (South of Cabot Drive)

Location	GIS Pipe ID No.(s)	Model Pipe No.(s)	Total Pipe Length (LF)	Existing Size/ Material (in)	New Pipe Size/ Material (in)
South of Cabot Drive *(North of Home Depot)*	1965	L_C148	365	24/CMP	24/CPEP

Estimated Project Cost: $265,000

M-5: Stormwater Pipe Replacement (SE Bayshore Drive)
(Beyond 2027 or as funds are available)

Replace stormwater pipes along SE Bayshore Drive as shown in Table 6-6 and Figure 6-4 to provide capacity under existing and future conditions.

TABLE 6-6

Stormwater Pipe Replacements (SE Bayshore Drive)

Location	GIS Pipe ID No.(s)	Model Pipe No.(s)	Total Pipe Length (LF)	Existing Size (in)	New Pipe Size (in)
SE Bayshore Drive	47, 48	L_C96	365	24	30

Estimated Project Cost: $290,000

M-6: Pump Station with Treatment Vault (SW Bayshore Drive and SW Beeksma Drive)
(Design: 2020; Construction: 2022/2023)

Install a pump station near the intersection of SW Bayshore Drive and SW Beeksma Drive (see Figures 6-4 and 6-5). A valve would be installed in a new manhole where during a large storm, the valve would manually be closed and flows would be directed to a sediment/trash collection facility. From there, flows would enter a new pump station. The pump station would then pump flows through a new section of force main to another new manhole located just downstream of the first, utilizing the existing 42-inch storm drain from that point on as a force main. This project includes approximately 50 feet of pipe from the first new manhole to the pump station, a 7,200 gpm pump (at 20 feet total dynamic head), and 50 feet of 22-inch HDPE force main from the pump station back to the existing 42-inch pipe (into the second new manhole). The three catch basin lids downstream of the pump station would be converted to solid lids to maintain pressure to the outfall. New catch basins with duckbill valves (or similar) would be inserted next to the three solid lid (water-tight) catch basins to ensure that local drainage can enter the system while the 42-inch pipe leading to the outfall can remain under pressure. Additionally, a treatment vault just prior to the first new manhole can be installed to treat flow prior to being discharged to the Harbor. The vault could also be used as a potential area for collecting debris and/or oil prior to entering the pump station. The costs on this project may vary if a smaller discharge pipe can be utilized.

Estimated Project Cost: $1,060,000 – $2,714,000

M-7: Extend Outfall at SE City Beach
(2020)

Extend the outfall (*GIS Id: 113, Model ID: L_C89*) at SE City Beach further into the bay approximately 70 feet and install a duck bill type tidegate (see Figure 6-4). The costs on this project may vary due to the type of pipe material utilized.

Estimated Project Cost: $278,000 – $375,000



LEGEND:

- System Deficiencies
- Storm Drains
- Culverts
- Ditches
- Streams
- Water Bodies
- Parcels
- City Limits
- Incorporated UGA
- Joint Planning Area

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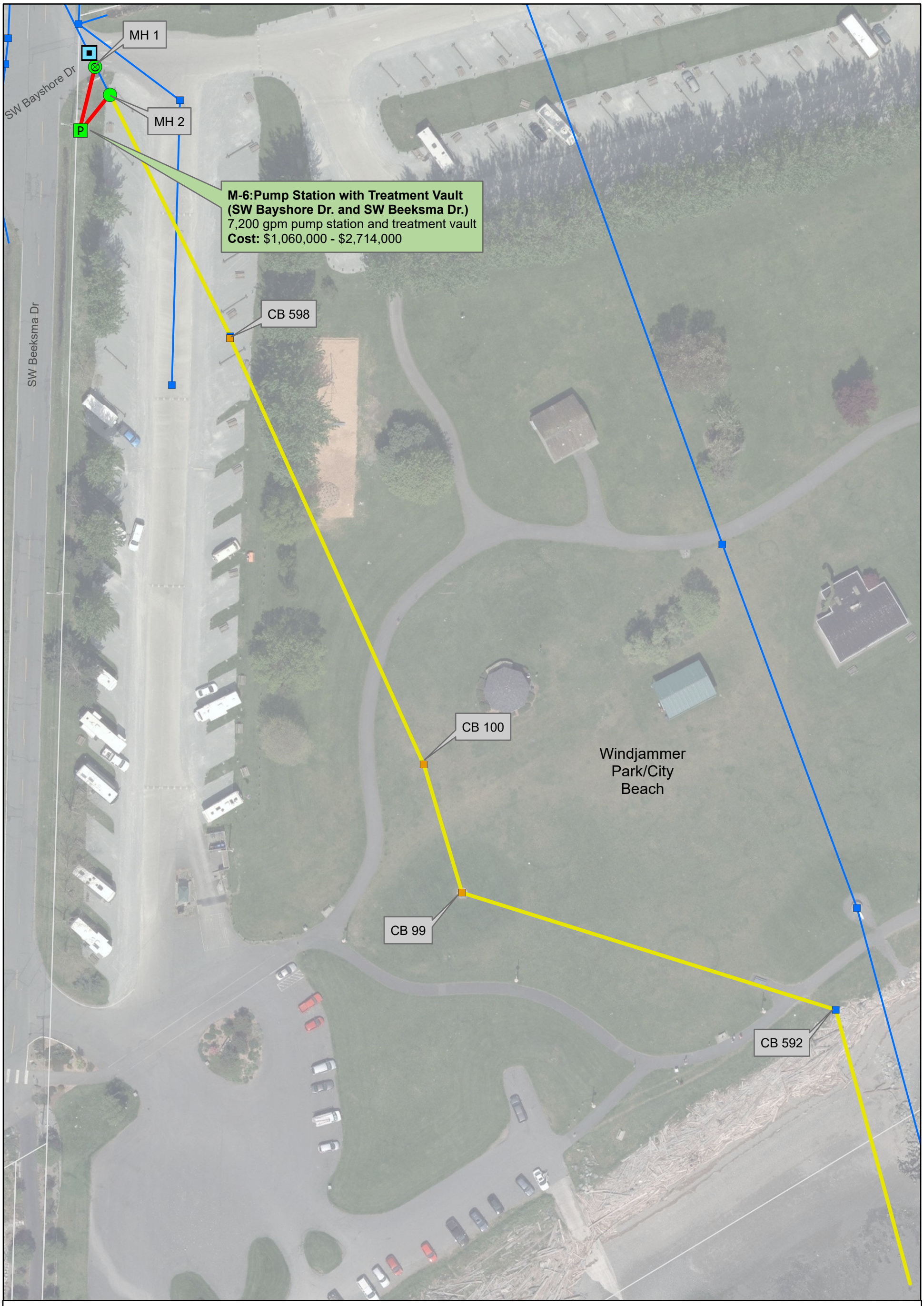
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
MIDWAY (SOUTH) CIPS
FIGURE 6-4

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\6-3 Midway(South).mxd



LEGEND:

- New Force Main
- Existing Pipe used as Force Main
- Storm Drains
- Treatment Vault
- New Pump Station
- New Valve
- New Manholes
- Catchbasins to be Sealed
- Catchbasins

N

0 60 120 Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
MIDWAY (CITY BEACH) CIPS
FIGURE 6-5

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\6-4 Pump Station.mxd

HIGH SCHOOL BASIN PROJECTS

HS-1: Stormwater Pipe Replacement (West Whidbey Avenue)
(2021/2022)

Replace stormwater pipes along West Whidbey Avenue as shown in Table 6-7 and Figure 6-6 to provide capacity under existing and future conditions. To mitigate downstream effects of these upgrades, it is recommended that this be completed along with the DC-2 and DC-3 projects. The cost of this project may vary depending upon the extent of efforts made to replace the existing pipes.

TABLE 6-7

Stormwater Pipe Replacements (West Whidbey Avenue)

Location	GIS Pipe ID No.(s)	Model Pipe No.(s)	Total Pipe Length (LF)	Existing Size (in)	New Pipe Size (in)
West Whidbey Avenue, East of NW Fairhaven Drive	1670, 1673, 1675, 1678	L_C32 L_C33	1,230	15	18
West Whidbey Avenue	1681, 1683	L_C34	640	18	24

Estimated Project Cost: $300,000 – $1,128,000

OAK PRAIRIE PROJECTS

OP-1: Stormwater Pipe Replacement (SE Pasek Street)
(Beyond 2027 or as funds are available)

Replace stormwater pipes along SE Pasek Street as shown in Table 6-8 and Figure 6-7 to provide capacity under existing and future conditions.

TABLE 6-8

Stormwater Pipe Replacements (SE Pasek Street)

Location	GIS Pipe ID No.(s)	Model Pipe No.(s)	Total Pipe Length (LF)	Existing Size (in)	New Pipe Size (in)
SE Pasek Street (Between SE 10th Avenue and SE Pioneer Way)	177	L_C115	165	8	12

Estimated Project Cost: $113,000

OP-2: Study to Retrofit Treatment Vault (SE Pasek Street and Pioneer Way)
(2024)

Provide a study to determine if runoff can be diverted to a former sewer pump station overflow vault located at SE Pasek Street and Pioneer Way (see Figure 6-7). This vault is approximately 18-feet wide x 50-feet long x 10-feet deep with a concrete lid that was replaced in 2019. The vault will be retrofitted with baffles, treatment cartridges or treatment media. The cost of this project may vary depending upon the types of materials utilized.

Estimated Project Cost: $80,000 – $107,000

DRY CREEK PROJECTS

DC-1: Flow Control Facility and Stormwater Pipe Replacement (SW 6th Avenue)
(2021/2022)

To alleviate existing flooding along SW 6th Avenue, east of SW Judson Drive, a detention pond or vault would be installed in conjunction with replacement of existing stormwater pipes as shown in Table 6-9 and Figure 6-8. The necessary detention volume needed to alleviate flooding during a 25-year storm is 0.86 acre feet. This equates to 6,243 sf area (or approximately 111' x 111') with an active depth of 3 feet and a flow control structure with a 6-inch orifice. The City owns a parcel adjacent to the intersection of SW 6th Avenue and SW Harrier Street which spans both the north and south sides of the road. This site can be used to house the flow control facility; however, it is important that the facility be lined or enclosed as there are concerns of water infiltrating along a well on the property north of the road (currently capped) and contaminating the aquifer. The cost of the project may vary due to the need for a liner and/or the need to replace only portions of the existing stormwater pipe.

HS-1: Stormwater Pipe Replacement (W. Whidbey Ave.)
Replace 1,230 LF 15” w/ 18” pipe and 640 LF 18” w/ 24” pipe
Cost: $300,000 - $1,128,000

UDC-1
DC-1
DC-2
DC-3

NW 7th Ave
NW 7th Ct
Cathlamet Dr
NW Atalanta Way
NE 7th Ave
NW Fairhaven Dr
Favorite St
NW Ebb Tide Ct
NW Ensign Dr
NW Columbia Dr
Columbia Dr
NW Calista Ct
NW 3rd Ave 825 Ave W
NW 2nd Ave
800 Ave W
NW Delta Ct
NW Captain Ct
NW 1st Ave
N Oak Harbor St
First St
NW Bosun St
W Whidbey Ave
E Whidbey Ave
SW Festival Ct
SW Cruise St
SW 1st Ave
SW 25th Ave
SW 2nd Ave
650th Ave W
SW 3rd Ave
SE 3rd Ave
600 Ave W
SW 4th Ave
SW Erie Cir
Erie Cir
SW Fairhaven Dr
SW Dyer St
S Oak Harbor St
State Rte 20
SW 6th Ave
SW 6th Ave 6th Ave
Erie St
SW Harrier Cir
SW Erie St

LEGEND:

- System Deficiencies
- Potential Solutions
- Storm Drains
- Culverts
- Ditches
- Streams
- Water Bodies
- Parcels
- City Limits
- Incorporated UGA
- Joint Planning Area

N

0 300 600
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
HIGH SCHOOL BASIN CIPS
FIGURE 6-6

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\6-5 Highschool.mxd



M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\6-6 OakPrairie.mxd

DC-3:Stormwater Pipe Replacement (Oak Harbor St.)
Replace 440 LF 24” w/ 30” pipe
Cost: $318,000

DC-2: Flow Control Facility (Oak Harbor Street and SW 6th Ave.)
Install 1.7 ac-ft detention facility
Cost: $373,000

DC-1: Flow Control Facility and Stormwater Pipe Replacement (SW 6th Ave.)
Install 0.86 ac-ft detention facility;
Replace 1,450 LF 18” CMP with 18” CPEP
Cost: $325,000 - $505,000

DC-4: Freund Marsh Regional Constructed Wetland
Provide 5.5 ac regional constructed wetland
Cost: $4,127,000

M-4

M-6

FM-1

Oak Harbor

LEGEND:

- System Deficiencies
- Potential Solutions
- Storm Drains
- Ditches
- Culverts
- Water Bodies
- Parcels
- City Limits
- Incorporated UGA
- Joint Planning Area

N

0 500 1,000
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
DRY CREEK CIPS
FIGURE 6-8

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\6-7 DryCreek.mxd

TABLE 6-9

Stormwater Pipe Replacements (SW 6th Avenue)

Location	GIS Pipe ID No.(s)	Model Pipe No.(s)	Total Pipe Length (LF)	Existing Size/ Material (in)	New Pipe Size/ Material (in)
SW 6th Avenue	596, 601, 603, 609, 611, 613, 615, 620, 624, 627	L_C44 L_C43	1,450	18/CMP(1)	18/CPEP

(1) Existing pipe is assumed to CMP. Pipe material shall be verified prior to design.

Estimated Project Cost: $325,000 – $505,000

DC-2: Flow Control Facility (Oak Harbor Street and SW 6th Avenue)
(Beyond 2027 or as funds are available)

A flow control facility would be installed to alleviate flooding near the intersection of SR 20 and SW 6th Avenue (see Figure 6-8). A specific location has not been specified yet one option includes locating the facility in the open space west of the South Oak Harbor Street cul-de-sac owned by the Southern Baptist Church. An easement would need to be purchased to accommodate the facility. The flow control facility would provide a detention volume of 1.7 acre feet, which equates to a vault approximately 245' x 50' with an active depth of 6 feet and a 16-inch orifice.

Estimated Project Cost: $373,000

DC-3: Stormwater Pipe Replacement (Oak Harbor Street)
(Beyond 2027 or as funds are available)

Replace stormwater pipes along Oak Harbor Street as shown in Table 6-10 and Figure 6-8 to provide capacity under future conditions.

TABLE 6-10

Stormwater Pipe Replacements (Oak Harbor Street)

Location	GIS Pipe ID No.(s)	Model Pipe No.(s)	Total Pipe Length (LF)	Existing Size (in)	New Pipe Size (in)
Oak Harbor Street	681, 682, 689, 692	L_C13	440	24	30

Estimated Project Cost: $318,000

DC-4: Freund Marsh Regional Constructed Wetland
(Feasibility Study 2020)

Provide a 5.5 acre regional, constructed wetland in the Freund Marsh area (see Figure 6-8) to provide treatment prior to entering the bay while also alleviating the flooded region on SW Beeksma Drive. The constructed wetland would have a 9-foot deep presettling cell to deposit sediments followed by a wetland cell consisting of plants to help with the biological uptake of pollutants. The wetland cell would consist of a shallower depth of 1.5 feet. Due to the high cost, it is suggested the City seek grant opportunities for this project which would allow sooner construction of the facility than shown within this Plan.

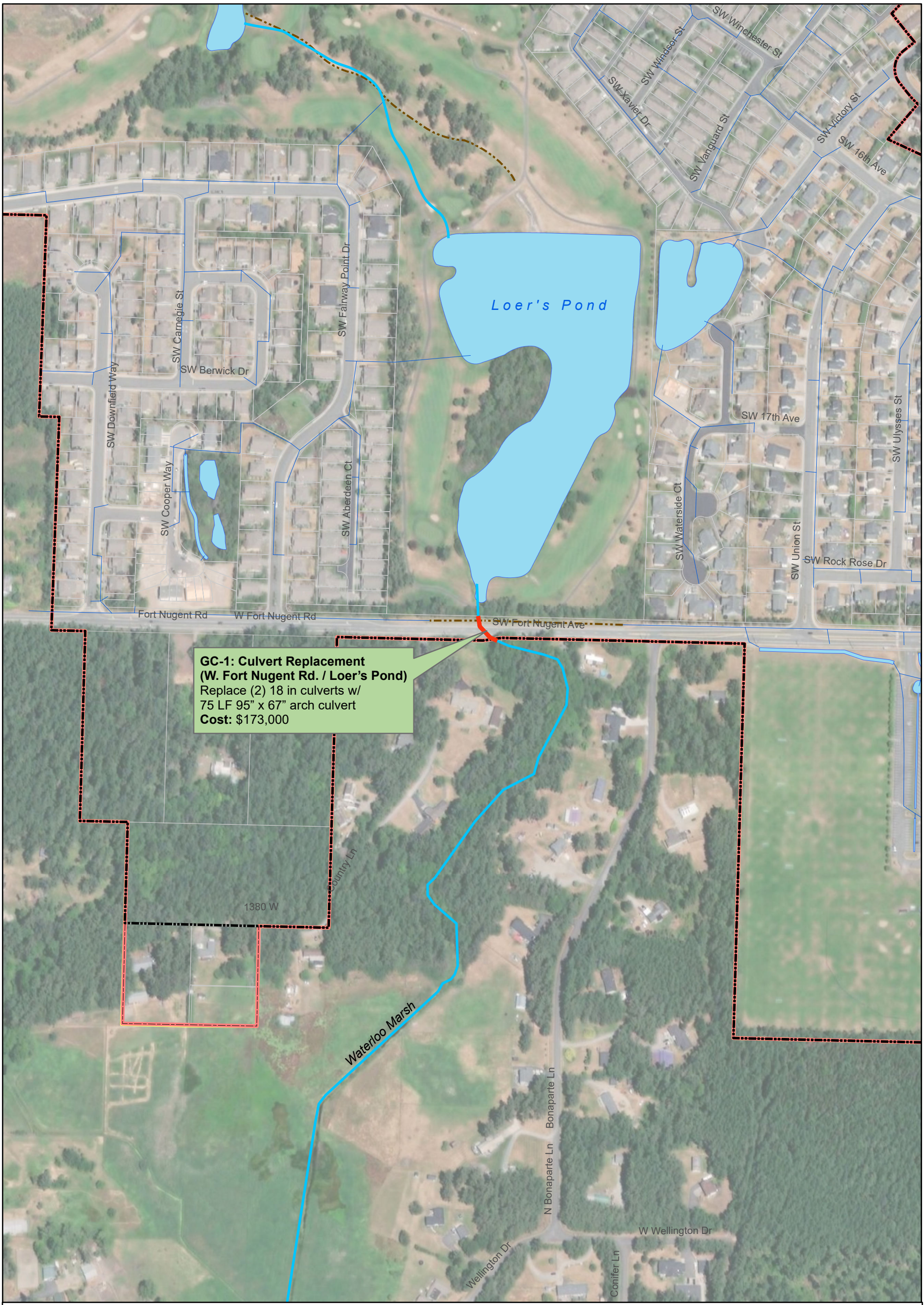
Estimated Project Cost: $200,000 (Predesign Report); $4,127,000 (Construction)

GOLF COURSE PROJECTS

GC-1: Culvert Replacement (West Fort Nugent Road/Loer's Pond)
(Beyond 2027 or as funds are available)

Replace two existing 18-inch CMP pipes crossing West Fort Nugent Road (see Figure 6-9), conveying water from Waterloo Marsh to Loer's Pond, with a 75 linear foot arch culvert with a bottom width of 95 inches, a height of 67 inches, and a bed slope of 2.4 percent

Estimated Project Cost: $173,000



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FREUND MARSH PROJECTS

FM-1: Catch Basin Replacement/Drainage Analysis
(Beyond 2027 or as funds are available)

Install a Type 1 catch basin west of the pervious concrete parking lot for the Scenic Heights Trailhead on SW Scenic Heights Street (see Figure 6-10). This project also includes a drainage analysis to determine the best alternative to directing street runoff away from the pervious pavement area.

Estimated Project Cost: $17,000

RETROFIT PROJECTS

RET-1: Future Retrofit Project
(2027)

This project involves the construction of a future retrofit project as mandated by the current NPDES Phase II Municipal Stormwater Permit. The retrofit will be a construction project determined upon the results of basin examination, prioritization, and the retrofit studies performed as OP-2, DC-4, and UDC-4

Estimated Project Cost: $1,065,000

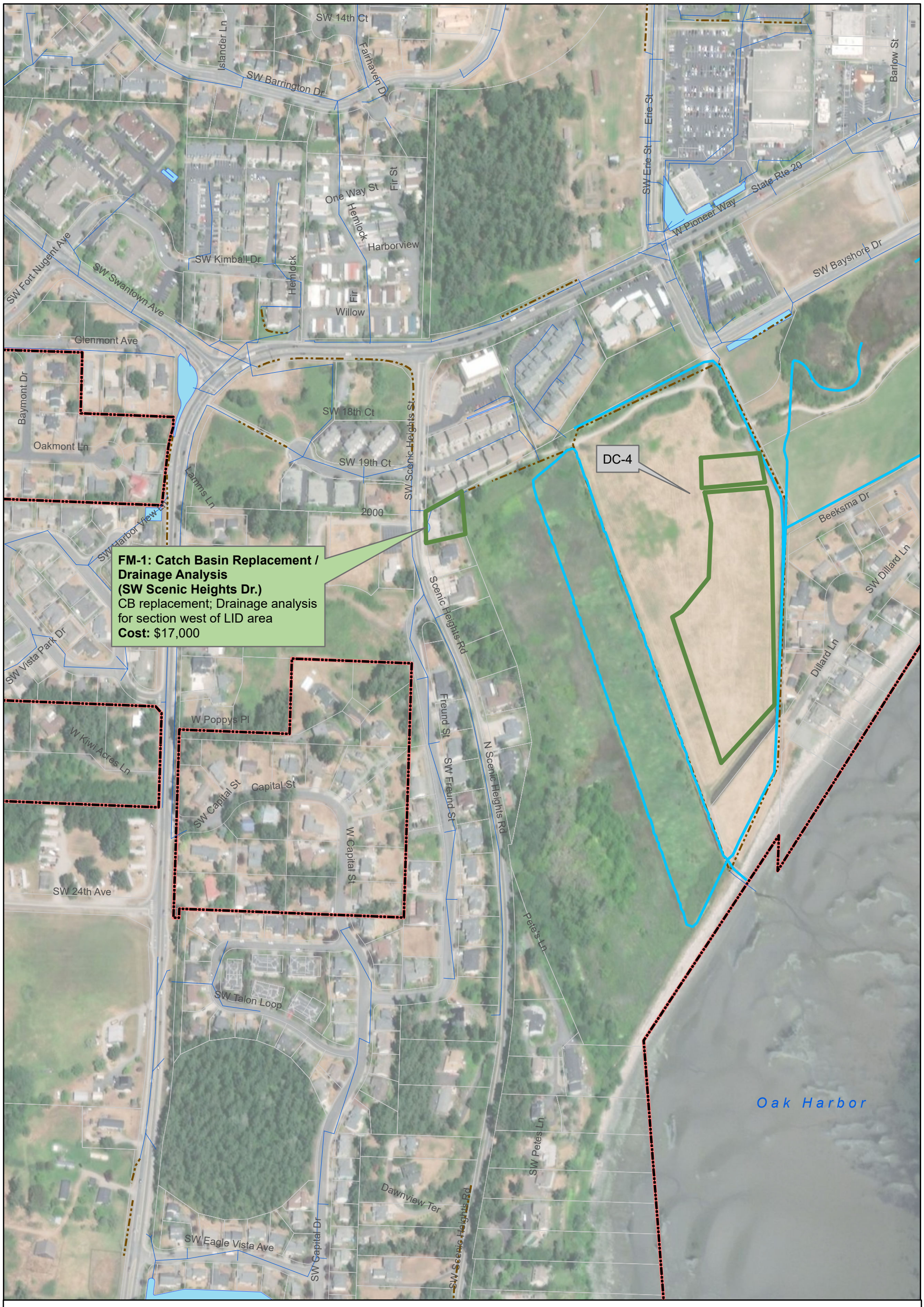
CAPITAL IMPROVEMENT PLAN

Based upon City staff prioritization and based upon financial feasibility, the projects chosen to be completed through 2027 are shown in Table 6-11. Other stormwater related issues may arise in the future and will need to be addressed at that time. This Stormwater Management Plan shall be updated to incorporate these changes as well as any modifications related to development or regulatory requirements.

TABLE 6-11

Capital Improvement Plan (2020 to 2027)

CIP No.	Project Name	Project Description	2019 Cost	Year Planned
DC-1	Flow Control Facility and Stormwater Pipe Replacement (SW 6th Avenue)	Install 0.86 ac-ft detention facility; Replace 1,450 LF 18-inch CMP with 18-inch CPEP	$325,000	2021/2022
HS-1	Stormwater Pipe Replacement (West Whidbey Avenue)	Replace 1,230 LF 15-inch w/18-inch pipe and 640 LF 18-inch w/24-inch pipe	$300,000	2021/2022
M-6	Pump Station with Treatment Vault (SW Bayshore Drive and SW Beeksma Drive)	7,200 gpm pump station and treatment vault	$1,060,000	2020, 2022/2023
M-7	Extend Outfall at SE City Beach	Extend outfall 70 feet	$375,000	2020
UDC-3	Conveyance, Flow Control and Treatment (Goldie Street, Koetje Street, and Easy Street)	Conveyance, flow control and treatment improvements	$750,000	2020
DC-4	Freund Marsh Regional Constructed Wetland Feasibility Study	Pre-design report for 5.5 ac regional constructed wetland	$200,000	2020
OP-2	Retrofit Treatment Vault (SE Pasek Street and Pioneer Way) Feasibility Study	Retrofit 18' x 50' x 10' former sewer vault for wq treatment	$80,000	2024
UDC-4	7th Ave. Wetland BMP Study (7th Avenue) Feasibility Study	Feasibility study for flow control BMP at the wetland	$200,000	2024
RET-1	Future Retrofit Project	Placeholder for future retrofit project as required by NPDES Phase II permit	$1,065,000	2027
Total CIP Costs (2020-2027):			**$4,355,000**	



LEGEND:

- System Deficiencies
- Potential Solutions
- Storm Drains
- Culverts
- Ditches
- Streams
- Water Bodies
- Parcels
- City Limits
- Incorporated UGA
- Joint Planning Area

N

0 300 600
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN
FREUND MARSH CIPS
FIGURE 6-10

Gray & Osborne, Inc.

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CHAPTER 7

FINANCIAL ANALYSIS

FINANCIAL PLAN

The financial resources available to the City to fund the operation, maintenance and capital improvements include service charges, grants and loans. This chapter provides a summary of additional potential funding sources.

The City has formed a stormwater utility to fund ongoing operation, maintenance, and capital improvements. Provided herein is a 6-year and 20-year budget forecast and rate recommendation required to fund the planned stormwater program.

Capital project expenditures are estimated to range from approximately $175,000 to $1 million per year within the 6-year planning period as shown in Table 7-5. The cost estimates provided within this Plan are planning level cost estimates which may result in estimates that are either higher or lower than resulting costs at the time of construction. Detailed construction costs will be prepared upon final completion of design plans. The estimated annual expenditure for the stormwater utility operations, not including capital projects, is $1.78 million in 2020. The City's proposed stormwater-related revenues are adequate to support the planned operational expenses and capital improvements over the proposed 6-year planning period. As discussed further in this Chapter, the proposed rate increases described in the City's Draft 2019 Rate Study (Appendix F) cannot cover these larger projects within the 20-year planning horizon. It is recommended that either rates be reanalyzed at a later date or the City pursue grant or loan opportunities for these larger projects. It should be noted that although this Plan is based upon the Draft 2019 Rate Study, the delay in adoption of this Study at the time of this Plan requires assumptions to be made. These assumptions include when implementations of rate increases would occur and therefore, some of the figures within this financial analysis are slightly different than the Draft Rate Study. The rates that the City Council will ultimately adopt will be the controlling values for future financial stormwater analyses.

CURRENT CHARGES AND CONNECTIONS

The City of Oak Harbor stormwater utility formation and rate structure is codified in Oak Harbor Municipal Code Chapter 12.10 and 12.40. The current stormwater service charges are shown in Table 7-1 and are billed on a monthly schedule. One Equivalent Residential Unit (ERU) corresponds to 3,300 square feet of hard surface area for non-single-family properties per OHMC 12.40.030. Therefore, for non-single-family residential parcels, the monthly stormwater service charge would be $14.22 for every 3,300 square feet of hard surface area that exists within that parcel. The total number of ERUs in the City will be used to determine the monthly service charge required to support the O&M program and planned capital improvements. Based on billing records,

the City currently has 10,966 ERUs. It should be noted that the City currently does not have a service connection fee.

TABLE 7-1

Stormwater Utility Monthly Billing Charges

Parcel Type	No. ERUs	Monthly Rate
Single-Family Residential	1	$14.22
Non-Single-Family Residential	1 per 3,300 SF hard surface	$14.22 x No. of ERUs

Per OHMC 12.40.065, the City also allows for a 10 percent reduction in the stormwater rate for new or remodeled commercial properties that have an adequately sized rainwater harvesting system.

The monthly service charge is levied by the City upon all developed property within the City's boundary. The stormwater service charge funds operations, improvements, and maintenance to address drainage problems within the City. The funding also allows the City to legally operate and maintain a storm drainage system and comply with regulations regarding the collection, storage, treatment, and discharge of stormwater runoff into the natural environment.

SERVICE CHARGE DETERMINATION

The 6-year and 20-year financial analysis assumes the capital improvement projects from Table 7-4 are funded from monthly service rates. As an alternative, low interest loans or grants may be used when necessary as described later in this chapter. Use of low interest loans may be financially favorable to self-financing as long as the interest costs of the loans are less than the interest that can be earned from reserve funds.

The budget forecast assumptions for this Plan are included in Table 7-2. The assumptions and beginning balances were based upon a Draft 2019 Rate Study that focused on funding from 2019 to 2039.

TABLE 7-2

Financial Forecast Assumptions

Item	Assumption
Number of ERUs in 2019	10,966[(1)(2)]
Growth (Single-Family and Non-Single-Family)	0.5%[(1)]
Labor Costs Inflation	3.5%[(1)]
Medical Benefits Inflation	6.0%[(1)]
Other Benefits Inflation	4.5%[(1)]
General Costs Inflation	2.5%–3%[(1)]
Construction Costs Inflation	3.5%
Interest Income	0.5%–1.0%[(3)]
Annual "Spot Storm Repair" Increase	5.0%
Annual "Overlay Related Storm Upgrade" Increase	3.0%
Annual "Infrastructure Replacement Program" Increase	3.0%

(1) From 2019 Draft Rate Study for the period of 2019 to 2039.

(2) ERUs were determined by dividing the rate revenue collected in 2019 (i.e., $1,947,084) by 12 months worth of the monthly stormwater rate of $14.22.

(3) Interest income was based upon the average of the beginning and ending balance for the year. This average value was multiplied by an assumed interest income rate which included 0.5 percent for 2020 to 2021, 0.6 percent in 2022, 0.7 percent in 2023, 0.8 percent in 2024, 0.9 percent in 2025, and 1 percent for 2026 to 2039.

In addition to the items listed above, it should be noted that per the 2019 Draft Rate Study, the beginning fund balance is estimated to be $2,254,712 in 2020.

PRELIMINARY RATE ANALYSIS

Tables 7-5 and 7-6 present a cash-based rate analysis based on the 2019 Draft Rate Study and recommended project financing. Table 7-5 shows the 10-year financial analysis (2020 to 2029) whereas Table 7-6 shows the remainder of the 20-year financial analysis (2030 to 2039). The financial analyses are provided for preliminary planning purposes. The City intends to finalize the stormwater rate study in 2020 which will adjust the monthly service rates and financing strategies as they relate to the City's long-term goals of providing quality stormwater related service to the community.

The City's Draft 2019 Rate Study recommended increases in the stormwater service charges by the amounts shown within Table 7-3.

TABLE 7-3

Preliminary Monthly Rate Increases

	2020	2021	2022	2023	2024	2025
Monthly Service Rate(1)	$14.79	$15.38	$16.00	$16.32	$16.64	$16.97

(1) Per City's Draft 2019 Rate Study. A 2 percent increase in rates is assumed for 2026 through 2039.

Within the 2019 Draft Rate Study, placeholders were provided for future unidentified capital projects. Beginning in 2021, the Study allocated $105,000 to $525,000 per year to be dedicated toward future projects.

The larger projects including the Freund Marsh Regional Constructed Wetland (DC-4) and the new stormwater infrastructure at NE Ronhaar Street and NE 6th Avenue (M-1) were projected beyond 2027. A projected increase in rates of 2 percent from 2030 to 2038 appears to be inadequate to cover the costs of these larger projects within the 20-year planning period. As one consideration, it was calculated that an annual rate increase of 6 percent between 2030 and 2036 and an annual rate increase of 7 percent between 2037 and 2039 would be necessary in order to provide adequate cash-based funding for three of the larger projects (DC-3, DC-4, M-1) near the end of the 20-year planning period. Alternatively, the City could obtain a loan to do the Freund Marsh Regional Constructed Wetland (DC-4) in 2022 however, to pay the annual loan payments, rates would have to increase as shown in Table 7-4. At a 1.5 percent interest rate, loan payments would range from approximately $240,000 to $300,000 per year for the next 20 years. As another alternative, this project would be susceptible to grants funded by the Department of Ecology as numerous grant funds are provided for water quality treatment projects such as the Freund Marsh wetland project.

TABLE 7-4

Rate Increases Necessary for a Freund Marsh Wetland Loan in 2022

Year	Percent Increase	Year	Percent Increase	Year	Percent Increase	Year	Percent Increase
2020	3.5%	2025	10%	2030	3.0%	2035	0.0%
2021	3.5%	2026	0.0%	2031	0.0%	2036	0.0%
2022	5.0%	2027	0.0%	2032	0.0%	2037	3.0%
2023	7.0%	2028	0.0%	2033	3.0%	2038	3.0%
2024	9.0%	2029	3.0%	2034	3.0%	2039	0.0%

TABLE 7-5

10-Year Financial Forecast Analysis (2020-2029)

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
1	**BEGINNING FUND 404 BALANCES**	**$1,832,331**	**$1,025,496**	**$1,208,600**	**$506,217**	**$635,611**	**$748,447**	**$1,024,536**	**$1,243,643**	**$868,425**	**$742,400**
	REVENUES:										
2	ERUs	11,346	11,866	12,369	12,657	12,950	13,248	13,551	13,860	14,174	14,493
3	ERU Monthly Service Rate	$14.79	$15.38	$16.00	$16.32	$16.64	$16.98	$17.32	$17.66	$18.02	$18.38
	Annual Rate Increase	*4.0%*	*4.0%*	*4.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
4	**Stormwater Rate Revenues**	**$2,013,657**	**$2,105,925**	**$2,195,175**	**$2,246,329**	**$2,298,359**	**$2,351,280**	**$2,405,111**	**$2,459,870**	**$2,515,573**	**$2,572,238**
5	Investment Interest	$2,525	$5,585	$7,679	$6,953	$8,915	$11,780	$15,565	$13,234	$10,728	$12,428
6	Miscellaneous Revenue	$13,300	$13,367	$13,433	$13,501	$13,568	$13,636	$13,704	$13,772	$13,841	$13,911
7	**Total Revenues:**	**$2,029,482**	**$2,124,877**	**$2,216,287**	**$2,266,783**	**$2,320,842**	**$2,376,696**	**$2,434,380**	**$2,486,876**	**$2,540,142**	**$2,598,577**
	EXPENSES										
	Operating Expenditures										
8	Debt Service	$60,343	$60,196	$60,049	$59,903	$59,756	$59,610	$59,464	$59,317	$59,171	$59,024
9	O&M Expenses	$734,085	$800,135	$829,048	$859,211	$890,680	$848,518	$882,790	$918,562	$955,907	$994,899
10	O&M Interfund Charges	$845,916	$654,740	$882,136	$720,102	$728,656	$627,819	$647,612	$668,056	$999,174	$710,987
11	City Utility Tax	$116,778	$117,362	$117,949	$118,539	$119,131	$119,727	$120,326	$120,927	$121,532	$122,140
12	State Utility Tax	$29,195	$29,341	$29,487	$29,635	$29,783	$29,932	$30,081	$30,232	$30,383	$30,535
13	**Total Operating Expenditures**	**$1,786,317**	**$1,661,773**	**$1,918,669**	**$1,787,389**	**$1,828,006**	**$1,685,607**	**$1,740,273**	**$1,797,094**	**$2,166,167**	**$1,917,586**
14	*Revenues Over (Under) Operating Expenditures*	*$243,165*	*$463,104*	*$297,618*	*$479,394*	*$492,836*	*$691,089*	*$694,107*	*$689,782*	*$373,975*	*$680,991*
	Capital Expenditures – Capital Improvement Projects										
15	**UDC-3:** Conveyance, Flow Control & Treatment *(Goldie Street, Koetje Street, and Easy Street)*	$400,000									
16	**M-7:** Extend Outfall at SE City Beach	$250,000									
17	**M-6:** Pump Station with Treatment Vault *(SW Bayshore Drive and SW Beeksma Drive)*	$200,000		$550,000	$310,000						
18	**DC-1:** Flow Control Facility and Stormwater Pipe Replacement *(SW 6th Avenue)*		$75,000	$250,000							

TABLE 7-5 – (continued)

10-Year Financial Forecast Analysis (2020-2029)

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
19	**HS-1:** Stormwater Pipe Replacement *(West Whidbey Avenue)*		$100,000	$200,000							
20	**OP-2:** Retrofit Treatment Vault *(SE Pasek Street and Pioneer Way)*					$80,000					
21	**DC-4:** Freund Marsh Regional Constructed Wetland	$200,000									
22	**RET-1:** Future Retrofit Project								$1,065,000		
23	**UDC-4:** 7th Avenue Wetland BMP Study *(NE 7th Avenue)*					$200,000					
24	**Future Unidentified Capital Projects**		$105,000		$40,000	$100,000	$415,000	$475,000		$500,000	$525,000
25	**Total CIP Project Costs:**	**$1,050,000**	**$280,000**	**$1,000,000**	**$350,000**	**$380,000**	**$415,000**	**$475,000**	**$1,065,000**	**$500,000**	**$525,000**
26	**TOTAL EXPENDITURES**	**$2,836,317**	**$1,941,773**	**$2,918,669**	**$2,137,389**	**$2,208,006**	**$2,100,607**	**$2,215,273**	**$2,862,094**	**$2,666,167**	**$2,442,586**
27	System Devl Charge Fund Balance	$422,381	$422,381	$422,381	$422,381	$422,381	$422,381	$422,381	$422,381	$422,381	$422,381
28	**ENDING FUND BALANCES:**	**$1,447,877**	**$1,630,981**	**$928,598**	**$1,057,992**	**$1,170,828**	**$1,446,917**	**$1,666,024**	**$1,290,806**	**$1,164,781**	**$1,320,773**
29	*Necessary Operating Reserve - 15% of Oper. Exp.*	*$237,000*	*$218,231*	*$256,678*	*$236,897*	*$242,900*	*$221,451*	*$229,560*	*$237,993*	*$293,262*	*$255,883*

TABLE 7-6

20-Year Financial Forecast Analysis (2030-2039)

		2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
1	**BEGINNING FUND 404 BALANCES**	**$898,392**	**$1,049,766**	**$1,194,914**	**$1,390,992**	**$1,577,727**	**$1,753,164**	**$1,915,215**	**$2,061,659**	**$2,190,128**	**$2,298,376**
	REVENUES:										
2	ERUs	14,818	15,148	15,485	15,827	16,175	16,529	16,889	17,256	17,629	18,008
3	ERU Monthly Service Rate	$18.74	$19.12	$19.50	$19.89	$20.29	$20.69	$21.11	$21.53	$21.96	$22.40
	Annual Rate Increase	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
4	**Stormwater Rate Revenues**	**$2,629,886**	**$2,688,533**	**$2,748,200**	**$2,808,907**	**$2,870,672**	**$2,933,517**	**$2,997,462**	**$3,062,529**	**$3,128,739**	**$3,196,114**
5	Investment Interest	$13,964	$15,447	$17,153	$19,067	$20,878	$22,565	$24,108	$25,482	$26,664	$27,628
6	Miscellaneous Revenue	$13,980	$14,050	$14,121	$14,191	$14,262	$14,333	$14,405	$14,477	$14,549	$14,623
7	**Total Revenues:**	**$2,657,830**	**$2,718,030**	**$2,779,474**	**$2,842,165**	**$2,905,812**	**$2,970,415**	**$3,035,975**	**$3,102,488**	**$3,169,952**	**$3,238,365**
	EXPENSES										
	Operating Expenditures										
8	Debt Service	$58,878	$58,731	$0	$0	$0	$0	$0	$0	$0	$0
9	O&M Expenses	$1,035,618	$1,078,145	$1,122,569	$1,168,980	$1,217,475	$1,268,156	$1,321,128	$1,376,504	$1,434,403	$1,494,947
10	O&M Interfund Charges	$733,522	$756,801	$780,851	$805,698	$831,371	$857,896	$885,304	$913,625	$942,891	$973,134
11	City Utility Tax	$122,750	$123,364	$123,981	$124,601	$125,224	$125,850	$126,479	$127,112	$127,474	$128,386
12	State Utility Tax	$30,688	$30,841	$30,995	$31,150	$31,306	$31,462	$31,620	$31,778	$31,937	$32,096
13	**Total Operating Expenditures**	**$1,981,456**	**$2,047,882**	**$2,058,396**	**$2,130,429**	**$2,205,376**	**$2,283,363**	**$2,364,531**	**$2,449,019**	**$2,536,705**	**$2,628,563**
14	*Revenues Over (Under) Operating Expenditures*	*$676,374*	*$670,148*	*$721,078*	*$711,736*	*$700,436*	*$687,052*	*$671,444*	*$653,469*	*$633,247*	*$609,802*
	Capital Expenditures – Capital Improvement Projects										
15	**UDC-3:** Conveyance, Flow Control and Treatment *(Goldie Street, Koetje Street, and Easy Street)*										
16	**M-7:** Extend Outfall at SE City Beach										
17	**M-6:** Pump Station with Treatment Vault *(SW Bayshore Drive and SW Beeksma Drive)*										

TABLE 7-6 – (continued)

20-Year Financial Forecast Analysis (2030-2039)

		2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
18	**DC-1:** Flow Control Facility and Stormwater Pipe Replacement *(SW 6th Avenue)*										
19	**HS-1:** Stormwater Pipe Replacement *(West Whidbey Avenue)*										
20	**OP-2:** Retrofit Treatment Vault *(SE Pasek Street and Pioneer Way)*										
21	**DC-4:** Freund Marsh Regional Constructed Wetland										
22	**RET-1:** Future Retrofit Project										
23	**UDC-4:** 7th Avenue Wetland BMP Study (NE 7th Avenue)										
24	**Future Unidentified Capital Projects**	$525,000	$525,000	$525,000	$525,000	$525,000	$525,000	$525,000	$525,000	$525,000	$525,000
25	**Total CIP Project Costs:**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**
26	**TOTAL EXPENDITURES**	**$2,506,456**	**$2,572,882**	**$2,583,396**	**$2,655,429**	**$2,730,376**	**$2,808,363**	**$2,889,531**	**$2,974,019**	**$3,061,705**	**$3,153,563**
27	System Devl Charge Fund Balance	$422,381	$422,381	$422,381	$422,381	$422,381	$422,381	$422,381	$422,381	$422,381	$422,381
28	**ENDING FUND BALANCES:**	**$1,472,147**	**$1,617,295**	**$1,813,373**	**$2,000,108**	**$2,175,545**	**$2,337,596**	**$2,484,040**	**$2,612,509**	**$2,720,757**	**$2,805,558**
29	*Necessary Operating Reserve - 15% of Oper. Exp.*	*$265,371*	*$275,242*	*$285,513*	*$296,202*	*$307,327*	*$318,908*	*$330,965*	*$343,519*	*$356,594*	*$370,212*

FUNDING ALTERNATIVES

SERVICE CONNECTION CHARGE

To fund future projects, the City may want to install a service connection charge. RCW 35.92.025, which authorizes cities and towns to charge for connecting to their system, requires that the service connection charge be an equitable share of the cost of the existing system. The maximum connection charge allowed is calculated by dividing the cost of the existing utility assets by the number of existing customers or ERUs. The City may want to calculate the allowed service connection charge in future financial analyses in order to determine the financial ceiling of imposing connection charges.

GRANT AND LOAN PROGRAMS

Grants and loans can be used to fund capital improvement projects, but cannot be used to fund operation and maintenance. Within the State of Washington, there are several grant and loan funds available for capital improvements. Among these are the Public Works Trust Fund (PWTF), Centennial Clean Water Fund (CCWF), and the State Revolving Fund (SRF). The various grant and loan programs are briefly described below for reference.

Public Works Trust Fund

This program is a revolving fund loan designed to help local governments finance needed public works projects through low-interest loans and technical assistance. It was established by the Washington State Legislature in 1985 and is administered by the Public Works Board. The State offers emergency, pre-construction (i.e., design) and construction loans. Although loan repayments and tax revenue streams that fund the program will continue to be deposited in the fund, it is uncertain what level of funding may be available through the program in the near future.

Department of Ecology Water Quality Combined Funding Program

The Department of Ecology administers several loan and grant programs that can be used to fund the following:

- Stormwater capital improvements including stormwater system retrofits;
- Low-impact development projects;
- Inventories of stormwater sources;
- Public education and communication;
- Review and preparation of stormwater regulations;
- Mapping;
- Source control activities; and
- Establishing and refining stormwater utilities.

The funding programs include the following:

- **Clean Water Act Section 319 Grant program:** Federal and State funds used for nonpoint source pollution control projects.

- **Centennial Clean Water Program Grant program:** State funds that provide grants for water quality infrastructure and nonpoint source pollution projects such as stream restoration and buffers, on-site septic repair and replacement, as well as education and outreach.

- **Clean Water State Revolving Fund Loan program:** Federal and State funds that provide low-interest and forgivable principal loan funding for nonpoint source pollution control projects and eligible "green" projects.

- **Stormwater Financial Assistance Grant Program:** State funds that provides grants for stormwater projects aimed to reduce impacts from existing infrastructure and to enhance existing stormwater projects.

- **Stormwater Capacity Grants Program:** State funds awarded to Phase I and Phase II NPDES Permittees for activities and equipment necessary for permit implementation. Historically, these non-competitive grants have ranged from $25,000 to $50,000 a year.

With the exception of the Stormwater Capacity Grants, a common application is available for funding from the Ecology-administered programs. The programs are competitive and the majority of the funding available is in the form of low-interest loans or grants with matching requirements.

DEBT FINANCING

Two forms of debt financing are available for capital improvements including general obligation (G.O.) bonds and revenue bonds. G.O. bonds are backed by the "full faith and credit of the City" and are paid for through property tax levies. These bonds require voter approval before they can be implemented. A less common means of financing capital improvements associated with stormwater projects is through the use of revenue bonds. The City, like other municipalities, is capable of issuing tax-exempt bonds. The principal and interest of such bonds are repaid from revenue generated from a utility, such as a water, sewer, or stormwater utility. This type of funding may be offered without voter approval. However, in order to qualify to sell revenue bonds, the City must establish that its net operating income is equal to or greater than its debt coverage factor, typically 1.25 at a minimum (but 2.0 is preferred), multiplied by the annual principal and interest due for all outstanding bonded indebtedness.

APPENDIX A

NOAA TIDAL INFORMATION

Datums - NOAA Tides & Curre

https://tidesandcurrents.noaa.gov/datums.html?id=9447952

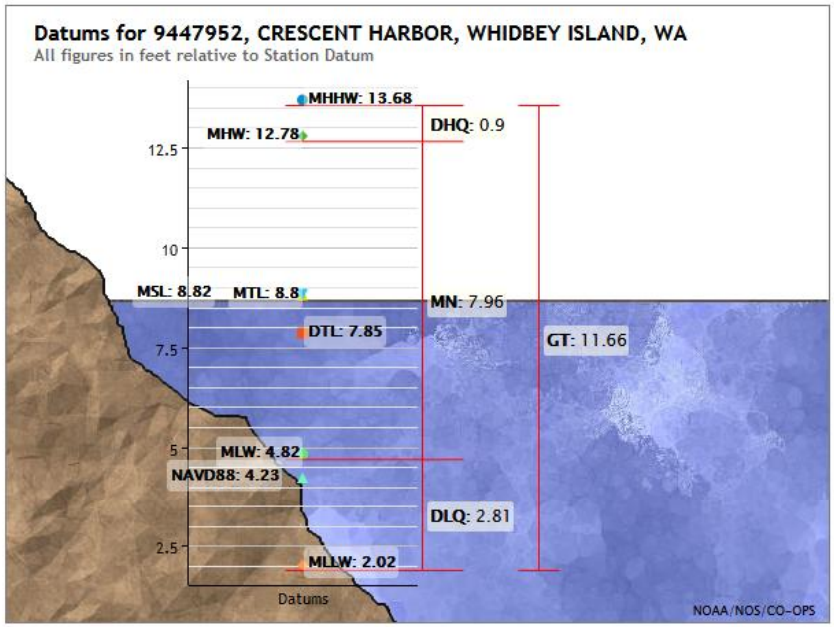
G&O | Personal | A-L | M-Z | Google | Rhapsody | Google Maps | join.me – Free Screen ... | Dictionary.com | SecureAccess Washin... | 2014 SWMMWW Man...

Elevations on Mean Lower Low Water

Station: 9447952, CRESCENT HARBOR, WHIDBEY ISLAND, WA
Status: Accepted (Jul 8 2004)
Units: Feet
Control Station: 9447130 Seattle, WA

T.M.: 120
Epoch: 1983-2001
Datum: MLLW

Datum	Value	Description
MHHW	11.66	Mean Higher-High Water
MHW	10.76	Mean High Water
MTL	6.78	Mean Tide Level
MSL	6.80	Mean Sea Level
DTL	5.83	Mean Diurnal Tide Level
MLW	2.80	Mean Low Water
MLLW	0.00	Mean Lower-Low Water
NAVD88	2.21	North American Vertical Datum of 1988
STND	-2.02	Station Datum
GT	11.66	Great Diurnal Range
MN	7.96	Mean Range of Tide
DHQ	0.90	Mean Diurnal High Water Inequality
DLQ	2.81	Mean Diurnal Low Water Inequality
HWI	0.47	Greenwich High Water Interval (in hours)
LWI	6.58	Greenwich Low Water Interval (in hours)
Max Tide		Highest Observed Tide
Max Tide Date & Time		Highest Observed Tide Date & Time
Min Tide		Lowest Observed Tide
Min Tide Date & Time		Lowest Observed Tide Date & Time
HAT		Highest Astronomical Tide
HAT Date & Time		HAT Date and Time
LAT		Lowest Astronomical Tide
LAT Date & Time		LAT Date and Time



Showing datums for

9447952 CRESCENT HARB...

Datum

STND

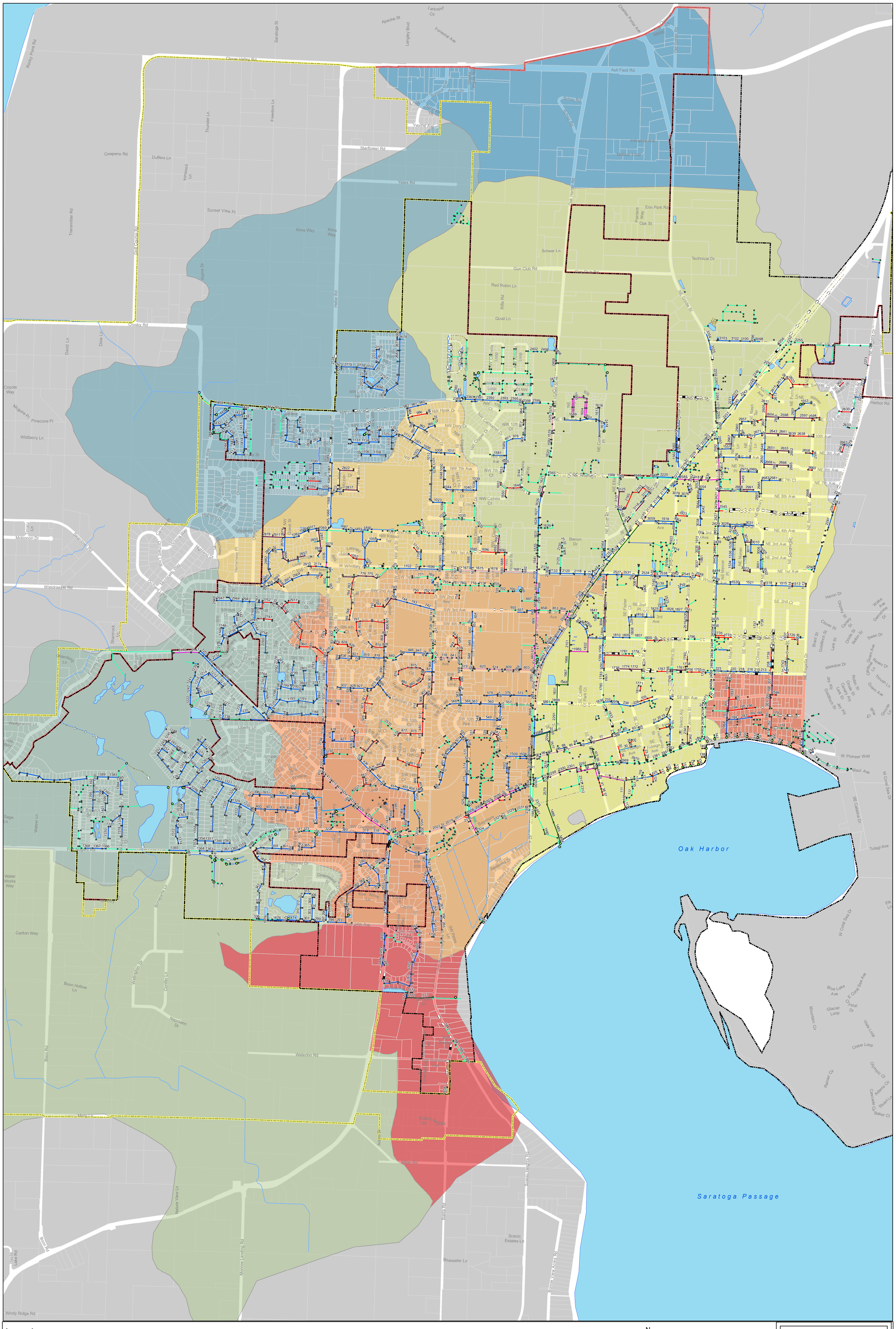
Data Units ◉ Feet ○ Meters

Epoch ◉ Present (1983-2001) ○ Superseded (1960-1978)

Submit

APPENDIX B

STORMWATER BASE MAP



Legend

Storm Pipe

Diameter

2" 3" 4" 6" 8" 10" 12" 15" 18" 24" 30" 36" 42" Unknown

Streams
Catch Basin
Culverts
Ditches
Water Bodies
City Limits
UGA
Joint Planning Area
Parcels

Ault Field Basin
Northwest Basin
Golf Course Basin
Waterloo Marsh Basin
Upper Dry Creek Basin
Midway Basin
High School Basin
Dry Creek Basin
Freund Marsh Basin
Oak Prairie Basin
Eagle Vista Basin

N

0 2,000 4,000
Feet

CITY OF OAK HARBOR

COMPREHENSIVE STORMWATER MANAGEMENT PLAN

STORMWATER BASEMAP

Gray & Osborne, Inc.

M:\Oak Harbor\16625.00 Storm Comp Plan\GIS\Base Map Large.mxd

APPENDIX C

MODEL BACKGROUND INFORMATION AND RESULTS

City of Oak Harbor
Background Information for XPStorm Hydraulic Stormwater Model

Subbasin Model No.	Area (ac)	Node	%imp existing	%imp future	Width (ft)	Average Basin Slope (ft/ft)	CN	Average Basin Slope (%)	Adjusted Hortons Roughness	Flow Length (ft)
0	35.99	J190	35%	69%	850	0.0660	69	6.595	0.0218	1680
1	94.57	J187	26%	72%	1900	0.0759	69	7.589	0.0396	2390
2	60.61	J176	38%	49%	1160	0.0745	69	7.453	0.0320	2220
3	44.46	J182	1%	55%	1100	0.0887	69	8.868	0.0450	1996
4	32.53	STOR7	24%	43%	890	0.0659	69	6.586	0.0257	2570
5	49.44	J182	28%	42%	840	0.0883	69	8.828	0.0392	2780
6	26.74	J181	46%	54%	650	0.0503	69	5.034	0.0275	1660
7	63.66	STOR8	22%	41%	1300	0.0828	69	8.281	0.0251	2628
8	49.12	J193	16%	78%	1600	0.0758	69	7.576	0.0376	1410
9	142.68	J201	4%	15%	2150	0.0574	74	5.743	0.0450	3280
10	33.44	J185	23%	68%	900	0.0596	80	5.964	0.0165	1020
11	76.98	STOR5	25%	50%	1450	0.0847	72	8.474	0.0197	2970
12	26.11	J179	29%	42%	980	0.0627	69	6.275	0.0185	1190
13	147.53	OUT14	6%	17%	2000	0.0881	74	8.810	0.0450	3215
14	43.39	J24	27%	32%	1200	0.0616	69	6.161	0.0150	2590
15	10.35	J171	24%	69%	600	0.0685	69	6.846	0.0395	1100
16	11.15	J199	21%	36%	250	0.0851	69	8.512	0.0336	1390
17	42.06	J160	27%	30%	1300	0.0620	69	6.199	0.0150	1220
18	21.81	J19	35%	59%	600	0.0829	69	8.288	0.0150	530
19	50.23	J34	28%	29%	780	0.0459	69	4.588	0.0150	1510
20	35.54	STOR4	33%	54%	960	0.0467	71	4.667	0.0150	1050
21	30.23	OUT12	27%	30%	800	0.0461	69	4.611	0.0150	1000
22	31.48	J33	30%	30%	850	0.0336	69	3.358	0.0251	1730
23	48.15	J15	25%	45%	1040	0.0775	70	7.751	0.0300	1460
24	31.27	J31	29%	30%	830	0.0606	69	6.061	0.0150	1300
25	24.93	J121	33%	37%	810	0.0420	69	4.204	0.0348	1700
26	11.77	J120	40%	59%	390	0.0463	69	4.632	0.0150	1400
27	38.65	J205	30%	31%	1080	0.0935	70	9.351	0.0300	3340
28	33.32	J12	33%	41%	310	0.0587	69	5.867	0.0150	2835
29	19.80	J118	65%	72%	670	0.0395	70	3.953	0.0150	1250
30	13.18	J137	24%	29%	450	0.0409	69	4.088	0.0359	1150
31	13.58	J139	30%	31%	520	0.0465	69	4.649	0.0305	930
32	22.12	J146	31%	34%	875	0.0549	69	5.486	0.0286	1770
33	14.82	J11	9%	35%	370	0.0407	69	4.075	0.0150	2000
34	13.77	J132	55%	74%	460	0.0571	73	5.706	0.0150	1500

City of Oak Harbor
Background Information for XPStorm Hydraulic Stormwater Model

Subbasin Model No.	Area (ac)	Node	%imp existing	%imp future	Width (ft)	Average Basin Slope (ft/ft)	CN	Average Basin Slope (%)	Adjusted Hortons Roughness	Flow Length (ft)
35	18.59	J133	30%	30%	875	0.0439	69	4.391	0.0307	1720
36	45.46	J206	6%	31%	1300	0.0794	69	7.944	0.0213	1530
37	21.17	J42	34%	34%	700	0.0649	69	6.491	0.015	760
38	34.33	J41	26%	42%	1080	0.0456	72	4.557	0.028125	1440
39	10.06	J10	41%	41%	390	0.0563	81	5.627	0.015	1490
40	34.76	STOR6	58%	70%	1050	0.0373	79	3.730	0.015	1890
41	23.04	J142	26%	37%	750	0.0356	69	3.556	0.015	1410
42	23.76	J140	32%	39%	620	0.0415	69	4.152	0.015	1243
43	49.28	STOR10	28%	30%	1100	0.0702	69	7.018	0.015	2090
44	11.46	J103	35%	47%	520	0.0329	69	3.289	0.015	1010
45	9.16	J104	28%	29%	500	0.0508	69	5.083	0.015	940
46	120.97	J207	15%	19%	1680	0.0746	69	7.457	0.029597701	2610
47	110.29	STOR10	5%	5%	2000	0.0199	79	1.988	0.045	2100
48	39.33	J64	33%	35%	730	0.0651	69	6.515	0.015	2920
49	12.19	STOR10	26%	31%	540	0.0934	70	9.336	0.022425743	1010
50	27.61	J43	28%	31%	630	0.0743	69	7.427	0.021106195	1130
51	14.85	J46	28%	31%	610	0.1350	69	13.497	0.023064516	930
52	29.34	J45	37%	37%	800	0.0568	80	5.677	0.015	1470
53	12.53	J114	29%	39%	420	0.0565	69	5.647	0.025909091	1320
54	13.91	J100	20%	48%	300	0.0857	69	8.570	0.015	1380
55	9.28	J99	31%	45%	250	0.0708	69	7.079	0.015	1520
56	7.31	J126	40%	52%	340	0.0436	69	4.359	0.015	1330
57	14.82	J130	34%	60%	350	0.0525	69	5.245	0.015	1420
58	13.09	J112	31%	43%	300	0.0852	69	8.525	0.015	1190
59	6.94	J95	29%	58%	380	0.0914	69	9.141	0.015	950
60	27.49	J127	34%	64%	690	0.0649	77	6.491	0.015	1700
61	25.19	J5	54%	56%	720	0.0592	84	5.923	0.015	1680
62	29.92	J67	28%	31%	850	0.0799	69	7.994	0.015	1460
63	29.42	J195	26%	30%	730	0.0564	69	5.642	0.018425197	2540
64	7.22	J110	30%	70%	760	0.1228	67	12.276	0.0375	400
65	64.40	STOR10	26%	31%	1100	0.0601	74	6.010	0.015	1173
66	40.81	J78	21%	46%	900	0.1570	72	15.703	0.015	1430
67	14.56	J98	41%	72%	890	0.0868	69	8.679	0.015	650
68	70.50	J208	21%	21%	1350	0.0831	70	8.313	0.015	2400
69	14.64	J90	27%	55%	370	0.0411	75	4.114	0.015	1355

Subbasin Model No.	Area (ac)	Node	%imp existing	%imp future	Width (ft)	Average Basin Slope (ft/ft)	CN	Average Basin Slope (%)	Adjusted Hortons Roughness	Flow Length (ft)
70	12.22	J93	26%	59%	1200	0.0729	63	7.294	0.015	460
71	15.41	J77	72%	76%	540	0.0627	84	6.267	0.015	1420
72	14.67	J92	55%	61%	400	0.0310	78	3.096	0.025	1420
73	30.30	J92	38%	47%	880	0.0173	76	1.734	0.015	2110
74	13.87	J47	65%	65%	650	0.0396	82	3.960	0.015	1510
75	13.24	J88	39%	68%	840	0.0472	72	4.718	0.015	710
76	17.99	STOR9	24%	29%	500	0.0800	72	8.002	0.015	1250
77	32.94	J68	30%	42%	1050	0.0835	69	8.353	0.015	2400
78	37.85	STOR9	27%	30%	1300	0.0820	69	8.203	0.015	1700
79	10.48	J75	31%	65%	480	0.1038	69	10.381	0.018	1220
80	121.51	STOR9	21%	21%	880	0.0594	70	5.936	0.015	4260
81	7.76	J75	45%	64%	350	0.0989	69	9.890	0.020	1000
82	7.08	J53	37%	66%	370	0.1279	69	12.793	0.018	900
83	86.50	STOR3	11%	22%	2100	0.0583	76	5.832	0.038	1800
84	7.53	J58	28%	58%	380	0.0529	69	5.286	0.015	1040
85	9.28	J86	10%	27%	1750	0.0628	49	6.282	0.045	140
86	47.37	J212	17%	29%	1200	0.0681	69	6.810	0.015	2460
87	60.96	J213	17%	30%	1450	0.0405	71	4.053	0.027	2000
88	49.74		1%	33%	1070	0.0636	72	6.3602867	0.045	2630
89	11.29	J83	31%	34%	1000	0.2563	68	25.628	0.045	440
90	258.25	J201	21%	21%	2100	0.0847	71	8.469	0.045	5900
91	96.35	J194	7%	81%	2170	0.0993	69	9.930	0.015	2680
92	31.23	J186	35%	84%	1820	0.0700	69	7.003	0.032	680
93	63.61	STOR4	11%	11%	1160	0.0000	84	0.001	0.045	2950
94	30.30	J173	46%	76%	950	0.0725	69	7.251	0.015	2160
95	9.90	J169	31%	52%	330	0.0795	69	7.948	0.028	1210
96	15.67	STOR4	29%	31%	420	0.0193	73	1.935	0.018	440
97	21.44	J157	41%	41%	860	0.0678	69	6.780	0.015	1380
98	10.69	J165	50%	67%	380	0.0546	69	5.456	0.015	685
99	8.54	J167	60%	60%	370	0.0622	69	6.224	0.015	770
100	21.74	J123	37%	60%	390	0.0605	69	6.051	0.026	1710
101	29.81	J161	31%	32%	670	0.0628	69	6.278	0.015	2600
102	9.62	J170	52%	61%	460	0.0492	69	4.923	0.015	1250
103	70.16	J124	32%	49%	1790	0.0296	79	2.957	0.015	1830
104	12.27	J155	56%	65%	270	0.0571	69	5.709	0.015	390

City of Oak Harbor
Background Information for XPStorm Hydraulic Stormwater Model

Subbasin Model No.	Area (ac)	Node	%imp existing	%imp future	Width (ft)	Average Basin Slope (ft/ft)	CN	Average Basin Slope (%)	Adjusted Hortons Roughness	Flow Length (ft)
105	24.69	J162	32%	32%	520	0.0577	69	5.773	0.015	2380
106	11.54	J163	41%	48%	540	0.0578	69	5.778	0.015	1010
107	19.47	J151	27%	40%	410	0.0468	69	4.683	0.015	2160
108	31.56	Storagesite3	26%	37%	690	0.0762	69	7.618	0.028	2500
109	44.88	J72	23%	39%	830	0.1508	69	15.080	0.039	1390
110	29.17	J189	30%	37%	940	0.0830	69	8.302	0.015	2370
111	26.45	J85	21%	34%	1070	0.0707	73	7.070	0.045	1650
112	37.98	J84	7%	32%	2500	0.0879	70	8.794	0.015	3000
113	15.04	J83	32%	34%	1290	0.1461	69	14.608	0.015	800
114	125.70	J199	24%	38%	2490	0.0782	69	7.824	0.015	3300
115	16.13	J39	28%	29%	570	0.0356	69	3.559	0.015	1140
116	33.25	STOR11	29%	29%	1070	0.0573	69	5.731	0.015	1630
117	28.66	J37	25%	30%	880	0.0581	69	5.806	0.015	2240
118	26.50	J32	7%	30%	690	0.0530	69	5.298	0.015	1640
119	31.67	J163	25%	30%	810	0.0517	69	5.166	0.015	2890
120	6.38	J163	11%	19%	190	0.0560	69	5.597	0.015	1440
121	30.28	J215	26%	30%	840	0.0955	69	9.548	0.015	2800
122	14.81	STOR12	25%	31%	800	0.1297	69	12.968	0.015	1360
123	13.50	J148	30%	37%	380	0.0558	69	5.576	0.017	1970
124	16.39	J36	30%	30%	660	0.0945	69	9.449	0.015	1850
125	42.37	J43	28%	30%	990	0.0740	69	7.402	0.018	2690
126	18.25	J206	30%	31%	410	0.0750	69	7.495	0.018	1410
127	24.40	J150	29%	34%	940	0.0542	69	5.417	0.015	1970
128	15.17	J66	28%	29%	630	0.0607	69	6.068	0.019	1390
129	41.91	J44	26%	30%	940	0.0682	69	6.817	0.015	1680
130	11.47	J109	28%	35%	570	0.0681	69	6.811	0.015	1330
131	13.43	J107	28%	35%	640	0.0947	69	9.469	0.015	1420
132	9.82	J105	26%	58%	670	0.1320	67	13.198	0.015	730
133	357.42	Node244	20%	75%	5120	0.0898	69	8.984	0.015	4400
134	1161.18	J210	7%	15%	3530	0.0529	73	5.2851686	0.045	10646
135	140.60	Out4	13%	20%	2790	0.1203	73	12.0271292	0.018	3810
138	76.50	J85	4%	15%	1300	0.0636	72	6.360	0.045	2630

Pipe Input Data

Conduit Name	Upstream Node	Downstream Node	Upstream Ground Elev. (ft)	Downstream Ground Elev. (ft)	Upstream Invert Elev. (ft)	Downstream Invert Elev. (ft)	Length (ft)	Slope	Conduit Class	Area (sq ft)	Manning Coef.	Width (ft)	Depth (ft)	Depth Slopes	Side c-factor
L_C1	J24	J23	140.57	131.60	139.57	130.60	134	0.0669	Trapezoid	6.00	0.035	1.00	2.00	1	1
L_C2	J23	J22	131.60	116.00	130.60	114.25	256	0.0610	Circular	0.79	0.013	1.00	1.00		
L_C3	J22	J21	116.00	108.72	114.25	107.22	122	0.0597	Circular	1.23	0.013	1.25	1.25		
L_C4	J21	J20	108.72	108.13	107.22	106.63	406	0.0014	Circular	1.77	0.013	1.50	1.50		
L_C5	J20	J19	108.13	106.71	106.63	105.21	339	0.0042	Circular	1.77	0.013	1.50	1.50		
L_C6	J19	J18	106.71	105.81	105.21	104.31	352	0.0026	Circular	1.77	0.013	1.50	1.50		
L_C7	J18	J17	105.81	101.04	104.31	99.20	339	0.0282	Circular	1.77	0.013	1.50	1.50		
L_C8	J17	J16	101.04	94.30	99.20	92.30	393	0.0180	Circular	0.55	0.013	0.83	0.83		
L_C9	J16	J15	94.30	88.76	92.30	87.26	672	0.0082	Circular	0.79	0.013	1.00	1.00		
L_C10	J15	J14	88.76	84.85	87.26	83.85	422	0.0093	Circular	1.77	0.013	1.50	1.50		
L_C11	J14	J13	84.85	78.48	83.85	77.48	456	0.0140	Circular	3.14	0.013	2.00	2.00		
L_C12	J13	J12	78.48	69.14	77.48	68.14	340	0.0275	Circular	3.14	0.013	2.00	2.00		
L_C13	J12	J11	69.14	65.59	68.14	64.59	411	0.0086	Circular	3.14	0.013	2.00	2.00		
L_C14	J11	J10	65.59	46.46	64.59	42.46	862	0.0257	Circular	3.14	0.013	2.00	2.00		
L_C15	J10	J9	46.46	43.99	42.46	40.69	335	0.0068	Circular	3.14	0.013	2.00	2.00		
L_C16	J9	J8	43.99	40.92	40.69	36.80	487	0.0080	Circular	4.91	0.013	2.50	2.50		
L_C17	J8	J7	40.92	40.31	36.80	36.01	168	0.0047	Circular	4.91	0.013	2.50	2.50		
L_C18	J7	J6	40.31	34.34	36.01	24.14	635	0.0187	Circular	4.91	0.013	2.50	2.50		
L_C20	J5	J4	25.47	13.75	13.13	5.95	480	0.0150	Circular	9.62	0.013	3.50	3.50		
L_C21	J4	J3	13.75	9.36	5.95	5.83	334	0.0004	Circular	9.62	0.024	3.50	3.50		
L_C22	J3	J2	9.36	8.76	5.83	5.72	375	0.0003	Circular	9.62	0.024	3.50	3.50		
L_C26	J26	J27	100.00	72.25	93.25	70.00	712	0.0392	Circular	3.97	0.013	2.25	2.25		
L_C27	J27	J28	72.25	64.25	70.00	62.65	737	0.0149	Circular	3.97	0.013	2.25	2.25		
L_C28	J28	J29	64.25	65.00	62.65	65.00	58	0.0017	Circular	4.91	0.013	2.50	2.50		
L_C29	J17	J26	101.04	100.00	99.20	93.25	57	0.0218	Circular	1.77	0.013	1.50	1.50		
L_C30	J34	J33	160.88	150.49	159.13	148.74	685	0.0152	Circular	1.23	0.024	1.25	1.25		
L_C31	J33	J32	150.49	121.96	148.74	118.22	635	0.0481	Circular	0.79	0.024	1.00	1.00		
L_C32	J32	J31	121.96	113.32	118.22	109.04	614	0.0154	Circular	1.23	0.024	1.25	1.25		
L_C33	J31	J30	113.32	92.70	109.04	89.53	631	0.0309	Circular	1.77	0.024	1.50	1.50		
L_C34	J30	J13	92.70	78.48	89.53	77.48	634	0.0198	Circular	1.77	0.024	1.50	1.50		
L_C35	J40	J39	189.09	169.18	185.09	167.43	873	0.0205	Circular	0.79	0.013	1.00	1.00		
L_C36	J39	J38	169.18	164.20	167.43	162.20	1,019	0.0049	Circular	0.79	0.013	1.00	1.00		
L_C37	J38	J37	164.20	163.17	162.20	161.17	444	0.0023	Circular	0.79	0.013	1.00	1.00		
L_C38	J37	J36	163.17	155.40	161.17	153.40	457	0.0170	Circular	0.79	0.013	1.00	1.00		
L_C39	J36	J35	155.40	130.99	153.40	128.99	738	0.0331	Circular	0.79	0.013	1.00	1.00		
L_C40	J35	J32	130.99	121.96	128.99	118.22	346	0.0319	Circular	0.79	0.013	1.00	1.00		
L_C41	J44	J43	163.31	112.02	161.31	110.52	1,050	0.0488	Circular	0.79	0.013	1.00	1.00		
L_C42	J43	J42	112.02	84.70	110.52	82.53	715	0.0391	Circular	1.77	0.013	1.50	1.50		
L_C43	J42	J41	84.70	64.91	82.53	63.17	617	0.0314	Circular	1.77	0.024	1.50	1.50		
L_C44	J41	J9	64.91	43.99	63.17	40.69	832	0.0282	Circular	1.77	0.024	1.50	1.50		
L_C45	J46	J45	59.25	43.41	57.25	41.66	788	0.0201	Circular	0.79	0.013	1.00	1.00		
L_C46	J45	J7	43.41	40.31	41.66	36.01	678	0.0102	Circular	1.23	0.013	1.25	1.25		

Pipe Input Data

Conduit Name	Upstream Node	Downstream Node	Upstream Ground Elev. (ft)	Downstream Ground Elev. (ft)	Upstream Invert Elev. (ft)	Downstream Invert Elev. (ft)	Length (ft)	Slope	Conduit Class	Area (sq ft)	Manning Coef.	Width (ft)	Depth (ft)	Depth Slopes	Side c-factor
L_C47	J55	J54	111.03	106.51	104.41	103.31	221	0.0050	Circular	1.77	0.013	1.50	1.50		
L_C48	J54	J53	106.51	83.44	103.31	80.73	387	0.0584	Circular	1.77	0.013	1.50	1.50		
L_C49	J53	J52	83.44	74.49	80.73	71.24	207	0.0458	Circular	1.77	0.013	1.50	1.50		
L_C50	J52	J51	74.49	39.69	71.24	36.32	552	0.0633	Circular	1.77	0.013	1.50	1.50		
L_C51	J51	J50	39.69	23.35	36.32	20.83	308	0.0503	Circular	1.77	0.013	1.50	1.50		
L_C53	J49	J48	14.85	13.31	12.18	10.31	192	0.0097	Circular	3.14	0.013	2.00	2.00		
L_C54	J48	J47	13.31	12.32	10.31	7.54	472	0.0059	Circular	3.14	0.013	2.00	2.00		
L_C55	J47	J4	12.32	13.75	7.54	5.95	362	0.0085	Circular	3.14	0.024	2.00	2.00		
L_C56	J66	J65	215.00	196.45	213.00	194.45	945	0.0196	Circular	0.79	0.013	1.00	1.00		
L_C57	J65	J64	196.45	166.96	194.45	164.96	800	0.0369	Circular	0.79	0.013	1.00	1.00		
L_C58	J64	J63	166.96	148.41	164.96	144.36	647	0.0326	Circular	0.79	0.013	1.00	1.00		
L_C59	J63	J62	148.41	139.92	144.36	137.42	282	0.0247	Circular	1.77	0.013	1.50	1.50		
L_C60	J62	J61	139.92	134.51	137.42	131.31	328	0.0201	Circular	1.77	0.013	1.50	1.50		
L_C61	J61	J60	134.51	132.38	131.31	127.64	125	0.0293	Circular	3.14	0.013	2.00	2.00		
L_C62	J60	J59	132.38	125.83	127.64	120.38	403	0.0180	Circular	3.14	0.013	2.00	2.00		
L_C63	J59	J58	125.83	118.03	120.38	115.58	275	0.0175	Circular	3.14	0.013	2.00	2.00		
L_C64	J58	J57	118.03	111.08	115.58	110.08	332	0.0165	Circular	3.14	0.013	2.00	2.00		
L_C65	J57	J56	111.08	111.76	110.08	105.76	61	0.0711	Circular	3.14	0.013	2.00	2.00		
L_C66	J56	Storagesite3	111.76	112.91	105.76	110.91	55	0.0154	Circular	3.14	0.013	2.00	2.00		
L_C68	J63	J67	148.41	139.00	144.36	137.00	171	0.0482	Circular	0.79	0.013	1.00	1.00		
L_C69	J67	Stor2	139.00	128.00	137.00	122.00	457	0.0328	Circular	3.14	0.013	2.00	2.00		
L_C70	J68	Stor2	132.96	128.00	128.96	122.00	264	0.0263	Circular	3.14	0.013	2.00	2.00		
L_C71	J68	J60	132.96	132.38	128.96	127.64	179	0.0074	Circular	0.79	0.013	1.00	1.00		
L_C72	J75	J74	108.35	89.77	106.35	88.77	221	0.0841	Circular	0.79	0.024	1.00	1.00		
L_C73	J74	J73	89.77	62.38	88.77	60.38	495	0.0553	Circular	0.79	0.024	1.00	1.00		
L_C74	J73	J72	62.38	33.97	60.38	32.22	385	0.0738	Circular	0.79	0.024	1.00	1.00		
L_C75	J72	J71	33.97	26.25	32.22	26.25	88	0.0875	Circular	1.23	0.024	1.25	1.25		
L_C76	J71	J70	26.25	14.79	26.25	14.79	548	0.0337	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C77	J70	Stor3	14.79	13.79	14.79	13.79	676	0.0015	Trapezoid	140.00	0.035	4.00	10.00	1	1
L_C78	Stor3	J69	13.79	13.69	13.79	13.69	805	0.0001	Trapezoid	140.00	0.035	4.00	10.00	1	1
L_C79	J69	Out1	13.69	8.50	13.69	5.09	90	0.0178	Circular	7.07	0.013	3.00	3.00		
L_C80	J78	J77	37.32	23.00	35.32	13.42	412	0.0556	Circular	0.79	0.013	1.00	1.00		
L_C81	Node245	J76	24.50	15.21	12.39	14.79	415	0.0045	Circular	3.14	0.013	2.00	2.00		
L_C82	J76	J70	15.21	14.79	14.79	14.79	557	0.0000	Trapezoid	140.00	0.035	4.00	10.00	1	1
L_C83	J2	Node246	8.76	5.95	5.72	5.50	849	0.0003	Circular	9.62	0.024	3.50	3.50		
L_C84	J6	J81	34.34	35.30	24.14	22.75	390	0.0064	Circular	4.91	0.013	2.50	2.50		
L_C85	J217	J82	35.30	34.27	22.75	19.00	397	0.0094	Circular	9.62	0.013	3.50	3.50		
L_C86	J82	J5	34.27	25.47	19.00	13.13	421	0.0139	Circular	9.62	0.013	3.50	3.50		
L_C87	J81	J80	35.30	28.45	22.75	12.74	407	0.0244	Circular	9.62	0.013	3.50	3.50		
L_C88	J80	J79	28.45	20.38	12.74	3.97	995	0.0088	Circular	9.62	0.013	3.50	3.50		
L_C89	J79	Out3	20.38	10.00	3.97	3.64	824	0.0004	Circular	9.62	0.013	3.50	3.50		
L_C91	J84	J83	130.63	97.34	129.63	97.34	550	0.0605	Circular	1.23	0.013	1.25	1.25		

Pipe Input Data

Conduit Name	Upstream Node	Downstream Node	Upstream Ground Elev. (ft)	Downstream Ground Elev. (ft)	Upstream Invert Elev. (ft)	Downstream Invert Elev. (ft)	Length (ft)	Slope	Conduit Class	Area (sq ft)	Manning Coef.	Width (ft)	Depth (ft)	Depth Slopes	Side c-factor
L_C92	J83	Out4	97.34	10.00	97.34	3.00	500	0.1887	Trapezoid	18.00	0.045	3.00	3.00	1	1
L_C93	J86	Out5	15.00	10.00	6.50	1.50	60	0.0833	Circular	1.77	0.013	1.50	1.50		
L_C94	J92	J91	11.57	13.13	8.07	7.88	345	0.0006	Circular	3.14	0.013	2.00	2.00		
L_C95	J91	J90	13.13	10.33	7.88	7.00	157	0.0056	Circular	3.14	0.013	2.00	2.00		
L_C96	J90	J89	10.33	11.23	7.00	7.70	409	0.0020	Circular	3.14	0.013	2.00	2.00		
L_C97	J89	J88	11.23	12.16	7.70	7.50	167	0.0012	Circular	9.62	0.013	3.50	3.50		
L_C98	J88	J87	12.16	12.34	7.50	5.50	451	0.0044	Circular	9.62	0.013	3.50	3.50		
L_C99	J87	Out6	12.34	10.00	5.50	3.50	123	0.0163	Circular	9.62	0.013	3.50	3.50		
L_C100	J93	Out7	14.96	10.00	12.96	1.00	199	0.0601	Circular	0.79	0.013	1.00	1.00		
L_C101	J98	J97	27.07	26.72	23.00	21.65	285	0.0047	Circular	2.41	0.013	1.75	1.75		
L_C102	J97	J96	26.72	26.58	21.65	20.83	189	0.0043	Circular	1.23	0.013	1.25	1.25		
L_C103	J96	J95	26.58	25.86	20.83	20.24	394	0.0021	Circular	2.41	0.013	1.75	1.75		
L_C104	J95	J94	25.86	25.62	20.24	18.67	331	0.0047	Circular	3.14	0.024	2.00	2.00		
L_C105	J94	Out8	25.62	10.00	18.67	2.00	115	0.1450	Circular	3.14	0.024	2.00	2.00		
L_C106	J99	J96	43.48	26.58	33.48	20.83	204	0.0658	Circular	0.79	0.013	1.00	1.00		
L_C107	J104	J103	95.03	92.39	93.03	87.64	637	0.0089	Circular	0.79	0.013	1.00	1.00		
L_C108	J103	J102	92.39	85.77	87.64	79.42	356	0.0238	Circular	1.23	0.013	1.25	1.25		
L_C109	J102	J101	85.77	79.80	79.42	75.75	318	0.0115	Circular	1.77	0.013	1.50	1.50		
L_C110	J101	J100	79.80	58.46	75.75	54.41	322	0.0656	Circular	1.23	0.013	1.25	1.25		
L_C111	J100	J94	58.46	25.62	54.41	18.67	401	0.0910	Circular	1.23	0.013	1.25	1.25		
L_C112	J109	J108	109.94	83.39	107.78	81.22	429	0.0619	Circular	0.55	0.013	0.83	0.83		
L_C113	J108	J107	83.39	55.43	81.22	53.43	407	0.0687	Circular	0.55	0.013	0.83	0.83		
L_C114	J107	J106	55.43	32.73	53.43	30.73	242	0.0939	Circular	0.79	0.024	1.00	1.00		
L_C115	J106	J105	32.73	18.06	30.73	16.06	156	0.0939	Circular	0.35	0.024	0.67	0.67		
L_C116	J105	Out9	18.06	10.00	16.06	1.00	126	0.1197	Circular	0.79	0.024	1.00	1.00		
L_C117	J110	Out10	18.57	10.00	16.57	1.00	92	0.1692	Circular	0.79	0.013	1.00	1.00		
L_C118	J114	J113	74.48	58.56	72.31	56.39	227	0.0703	Circular	0.55	0.013	0.83	0.83		
L_C119	J113	J112	58.56	46.19	56.39	44.19	199	0.0620	Circular	0.35	0.013	0.67	0.67		
L_C121	J112	J111	46.19	21.14	44.19	19.14	270	0.0929	Circular	0.79	0.024	1.00	1.00		
L_C122	J111	Out11	21.14	10.00	19.14	1.00	92	0.1971	Circular	0.79	0.024	1.00	1.00		
L_C124	J28	J124	64.25	65.76	62.65	60.16	619	0.0040	Circular	9.62	0.024	3.50	3.50		
L_C125	J124	J122	65.76	66.71	60.16	57.74	602	0.0040	Circular	9.62	0.024	3.50	3.50		
L_C126	J123	J122	73.78	66.71	73.78	57.74	495	0.0324	Circular	9.62	0.024	3.50	3.50		
L_C127	J122	J121	66.71	69.82	57.74	56.52	315	0.0039	Circular	9.62	0.013	3.50	3.50		
L_C128	J121	J120	69.82	68.26	56.52	54.08	612	0.0040	Circular	9.62	0.013	3.50	3.50		
L_C129	J120	J119	68.26	63.90	54.08	51.96	532	0.0040	Circular	9.62	0.013	3.50	3.50		
L_C130	J119	J118	63.90	55.55	51.96	46.91	532	0.0095	Circular	9.62	0.013	3.50	3.50		
L_C131	J118	J117	55.55	37.98	46.91	33.70	730	0.0181	Circular	9.62	0.013	3.50	3.50		
L_C132	J117	J116	37.98	36.38	33.70	30.00	630	0.0059	Circular	9.62	0.013	3.50	3.50		
L_C133	J116	J115	36.38	37.17	30.00	27.65	583	0.0040	Circular	9.62	0.013	3.50	3.50		
L_C134	J115	J81	37.17	35.30	27.65	22.75	556	0.0088	Circular	9.62	0.013	3.50	3.50		
L_C135	J126	J125	55.01	45.92	53.01	43.92	407	0.0223	Circular	0.79	0.013	1.00	1.00		

Pipe Input Data

Conduit Name	Upstream Node	Downstream Node	Upstream Ground Elev. (ft)	Downstream Ground Elev. (ft)	Upstream Invert Elev. (ft)	Downstream Invert Elev. (ft)	Length (ft)	Slope	Conduit Class	Area (sq ft)	Manning Coef.	Width (ft)	Depth (ft)	Depth Slopes	Side c-factor
L_C136	J125	J115	45.92	37.17	43.92	27.65	469	0.0400	Circular	0.79	0.013	1.00	1.00		
L_C137	J130	J129	46.47	26.50	44.31	24.50	308	0.0649	Circular	0.55	0.013	0.83	0.83		
L_C138	J129	J128	26.50	18.20	24.50	16.70	365	0.0227	Circular	0.79	0.013	1.00	1.00		
L_C139	J128	J127	18.20	18.08	16.70	15.33	486	0.0028	Circular	1.77	0.013	1.50	1.50		
L_C140	J127	J5	18.08	25.47	15.33	13.13	524	0.0080	Circular	1.77	0.013	1.50	1.50		
L_C141	J139	J138	96.61	88.95	94.61	86.95	419	0.0183	Circular	0.79	0.013	1.00	1.00		
L_C142	J138	J137	88.95	77.81	86.95	75.81	526	0.0212	Circular	0.79	0.013	1.00	1.00		
L_C143	J135	J136	71.81	70.57	69.81	68.57	387	0.0032	Circular	0.79	0.013	1.00	1.00		
L_C144	J135	J134	71.81	66.14	69.81	64.14	187	0.0304	Circular	0.79	0.024	1.00	1.00		
L_C145	J134	J133	66.14	53.48	64.14	51.73	362	0.0350	Circular	0.79	0.024	1.00	1.00		
L_C146	J133	J132	53.48	40.21	51.73	39.21	317	0.0419	Circular	1.23	0.024	1.25	1.25		
L_C147	J132	J131	40.21	40.60	39.21	34.00	311	0.0168	Circular	3.14	0.024	2.00	2.00		
L_C148	J131	J117	40.60	37.98	34.00	33.70	339	0.0053	Circular	3.14	0.024	2.00	2.00		
L_C149	J148	J147	127.23	105.16	125.23	103.16	645	0.0342	Circular	0.79	0.024	1.00	1.00		
L_C150	J147	J146	105.16	101.12	103.16	99.12	520	0.0078	Circular	0.79	0.024	1.00	1.00		
L_C151	J146	J145	101.12	92.34	99.12	90.01	549	0.0160	Circular	0.35	0.013	0.67	0.67		
L_C152	J145	J144	92.34	80.53	90.01	78.20	515	0.0229	Circular	0.35	0.013	0.67	0.67		
L_C153	J144	J143	80.53	78.09	78.20	75.76	277	0.0088	Circular	0.35	0.013	0.67	0.67		
L_C154	J143	J142	78.09	72.77	75.76	70.44	288	0.0185	Circular	0.35	0.013	0.67	0.67		
L_C155	J142	J141	72.77	64.72	70.44	62.38	362	0.0222	Circular	0.35	0.013	0.67	0.67		
L_C156	J141	J140	64.72	54.20	62.38	52.20	464	0.0227	Circular	0.35	0.013	0.67	0.67		
L_C157	J140	J133	54.20	53.48	52.20	51.73	317	0.0023	Circular	0.79	0.013	1.00	1.00		
L_C158	J150	J149	113.75	105.92	111.41	103.58	520	0.0150	Circular	0.35	0.013	0.67	0.67		
L_C159	J149	J146	105.92	101.12	103.58	99.12	387	0.0124	Circular	0.35	0.013	0.67	0.67		
L_C160	J151	J120	78.36	68.26	73.42	54.08	769	0.0283	Circular	0.79	0.013	1.00	1.00		
L_C161	J160	J159	148.74	113.74	146.74	111.74	672	0.0521	Circular	0.79	0.024	1.00	1.00		
L_C162	J159	J158	113.74	99.60	111.74	97.60	560	0.0253	Circular	0.79	0.024	1.00	1.00		
L_C163	J158	J157	99.60	104.00	97.60	93.00	413	0.0135	Circular	0.79	0.013	1.00	1.00		
L_C164	J157	J156	104.00	92.01	93.00	91.01	206	0.0097	Circular	3.14	0.013	2.00	2.00		
L_C165	J156	J155	92.01	92.01	91.01	89.26	368	0.0048	Circular	3.14	0.013	2.00	2.00		
L_C166	J155	J154	92.01	78.74	89.26	74.26	487	0.0318	Circular	3.14	0.013	2.00	2.00		
L_C167	J154	J153	78.74	73.38	74.26	70.54	346	0.0108	Circular	4.91	0.013	2.50	2.50		
L_C168	J153	J152	73.38	65.99	70.54	65.49	413	0.0122	Circular	4.91	0.013	2.50	2.50		
L_C169	J152	J28	65.99	64.25	65.49	62.65	342	0.0117	Circular	4.91	0.013	2.50	2.50		
L_C170	J163	J162	111.86	106.82	110.36	105.82	300	0.0168	Circular	1.77	0.024	1.50	1.50		
L_C171	J162	J161	106.82	104.66	105.82	103.66	390	0.0055	Circular	3.14	0.024	2.00	2.00		
L_C172	J161	J156	104.66	92.01	103.66	91.01	226	0.0559	Circular	3.14	0.024	2.00	2.00		
L_C173	J169	J168	100.66	91.02	98.66	89.02	357	0.0270	Circular	0.79	0.024	1.00	1.00		
L_C174	J168	J167	91.02	80.90	89.02	79.40	550	0.0184	Circular	0.79	0.024	1.00	1.00		
L_C175	J167	J166	80.90	70.77	79.40	69.27	329	0.0307	Circular	1.77	0.013	1.50	1.50		
L_C176	J166	J165	70.77	69.17	69.27	69.17	176	0.0091	Circular	1.77	0.013	1.50	1.50		
L_C177	J165	J164	69.17	66.00	69.17	66.00	526	0.0117	Trapezoid	15.00	0.035	2.00	3.00	1	1

Pipe Input Data

Conduit Name	Upstream Node	Downstream Node	Upstream Ground Elev. (ft)	Downstream Ground Elev. (ft)	Upstream Invert Elev. (ft)	Downstream Invert Elev. (ft)	Length (ft)	Slope	Conduit Class	Area (sq ft)	Manning Coef.	Width (ft)	Depth (ft)	Depth Slopes	Side c-factor
L_C178	J164	Stor4	66.00	65.00	66.00	65.00	571	0.0018	Trapezoid	54.00	0.035	3.00	6.00	1	1
L_C179	Stor4	J29	65.00	65.00	65.00	65.00	657	0.0000	Trapezoid	48.00	0.035	2.00	6.00	1	1
L_C180	J170	J166	82.12	70.77	80.12	69.27	617	0.0184	Circular	0.79	0.013	1.00	1.00		
L_C182	J175	J174	137.57	116.00	137.57	116.00	588	0.0367	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C183	J174	J173	116.00	97.95	116.00	97.95	537	0.0336	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C184	J173	J172	97.95	93.02	97.95	93.02	283	0.0174	Circular	1.23	0.013	1.25	1.25		
L_C185	J172	J171	93.02	70.00	93.02	70.00	702	0.0328	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C186	J171	J165	70.00	69.17	70.00	69.17	532	0.0016	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C187	J181	J180	176.36	159.00	174.86	158.50	462	0.0354	Circular	1.77	0.013	1.50	1.50		
L_C189	J179	J178	136.00	126.00	134.50	124.50	363	0.0275	Circular	1.77	0.013	1.50	1.50		
L_C190	J178	J177	126.00	115.76	124.50	114.26	392	0.0261	Circular	1.77	0.013	1.50	1.50		
L_C191	J177	J172	115.76	93.02	114.26	93.02	371	0.0613	Circular	1.23	0.013	1.25	1.25		
L_C192	J182	J183	106.00	106.00	106.00	103.50	200	0.0050	Circular	1.77	0.013	1.50	1.50		
L_C193	J183	J185	106.00	69.00	103.50	68.50	980	0.0357	Circular	1.77	0.013	1.50	1.50		
L_C194	J184	J185	82.20	69.00	79.20	68.50	543	0.0354	Trapezoid	54.00	0.035	3.00	6.00	1	1
L_C195	J185	Stor4	69.00	65.00	68.50	65.00	1,702	0.0006	Trapezoid	54.00	0.035	3.00	6.00	1	1
L_C196	J186	J187	101.00	95.00	101.00	95.00	1,081	0.0055	Trapezoid	54.00	0.045	3.00	6.00	1	1
L_C197	J187	J188	95.00	66.00	95.00	66.00	1,298	0.0223	Trapezoid	54.00	0.045	3.00	6.00	1	1
L_C198	J188	Stor4	66.00	65.00	66.00	65.00	2,386	0.0004	Trapezoid	54.00	0.035	3.00	6.00	1	1
L_C199	J189	Storagesite3	119.68	112.91	118.68	110.91	395	0.0197	Trapezoid	7.00	0.035	1.50	2.00	1	1
L_C200	J137	J136	77.81	70.57	75.81	68.57	371	0.0195	Circular	0.79	0.013	1.00	1.00		
L_C201	J190	J191	244.00	240.00	244.00	240.00	609	0.0066	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C202	J191	J176	240.00	236.00	240.00	236.00	816	0.0049	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C203	J176	J192	236.00	184.00	236.00	184.00	814	0.0639	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C204	J192	J193	184.00	66.00	184.00	66.00	900	0.1344	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C205	J193	Stor4	66.00	65.00	66.00	65.00	1,200	0.0008	Trapezoid	54.00	0.035	3.00	6.00	1	1
L_C206	J194	J187	236.00	95.00	236.00	95.00	962	0.1497	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C207	J195	J53	164.32	83.44	162.32	80.73	846	0.0970	Circular	0.79	0.013	1.00	1.00		
L_C208	J196	J74	107.90	89.77	101.90	88.77	224	0.0586	Circular	3.14	0.013	2.00	2.00		
L_C209	J199	J200	135.89	124.47	135.89	124.47	850	0.0134	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C210	J200	J201	124.47	111.00	124.47	111.00	250	0.0539	Circular	3.14	0.013	2.00	2.00		
L_C211	J201	Out13	111.00	112.00	111.00	105.00	650	0.0092	Trapezoid	18.00	0.035	3.00	3.00	1	1
L_C212	J203	J197	202.00	181.97	189.26	180.47	1,400	0.0066	Circular	0.79	0.013	1.00	1.00		
L_C213	J197	J198	181.97	180.00	180.47	180.00	50	0.0393	Circular	1.77	0.013	1.50	1.50		
L_C214	J198	J202	180.00	113.00	180.00	113.00	505	0.1327	Trapezoid	18.00	0.045	3.00	3.00	1	1
L_C215	J202	J201	113.00	111.00	113.00	111.00	400	0.0050	Trapezoid	18.00	0.045	3.00	3.00	1	1
L_C217	J205	J204	106.27	86.69	104.77	86.69	937	0.0230	Circular	1.77	0.013	1.50	1.50		
L_C218	J206	J205	141.90	106.27	140.40	104.77	904	0.0394	Circular	1.77	0.013	1.50	1.50		
L_C219	J213	J212	184.00	146.00	184.00	146.00	1,913	0.0199	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C220	J212	J211	146.00	123.00	146.00	123.00	430	0.0535	Trapezoid	15.00	0.035	2.00	3.00	1	1
L_C221	J211	J210	123.00	112.00	123.00	109.00	100	0.1400	Circular	1.77	0.013	1.50	1.50		
L_C222	Stor9	J210	112.50	112.00	109.50	109.00	75	0.0067	Circular	7.07	0.013	3.00	3.00		

Pipe Input Data

Conduit Name	Upstream Node	Downstream Node	Upstream Ground Elev. (ft)	Downstream Ground Elev. (ft)	Upstream Invert Elev. (ft)	Downstream Invert Elev. (ft)	Length (ft)	Slope	Conduit Class	Area (sq ft)	Manning Coef.	Width (ft)	Depth (ft)	Depth Slopes	Side c-factor
L_C223	Stor9	J209	112.50	112.00	109.50	109.00	75	0.0067	Circular	7.07	0.013	3.00	3.00		
L_C224	J214	J208	111.00	96.00	110.00	95.00	1,200	0.0125	Trapezoid	40.00	0.04	3.00	5.00	1	1
L_C225	J208	J207	96.00	94.00	95.00	93.00	996	0.0020	Trapezoid	40.00	0.04	3.00	5.00	1	1
L_C226	J207	J204	94.00	86.69	93.00	86.69	2,665	0.0024	Trapezoid	65.00	0.04	3.00	5.00	2	2
L_C227	J209	J214	112.00	111.00	109.00	110.00	126	0.0079	Circular	3.14	0.013	2.00	2.00		
L_C228	Stor11	J39	170.18	169.18	167.43	167.43	75	0.0000	Circular	1.23	0.013	1.25	1.25		
L_C229	J216	J215	199.00	189.09	188.00	187.09	400	0.0023	Circular	0.79	0.013	1.00	1.00		
L_C230	J215	J40	189.09	189.09	187.09	185.09	276	0.0072	Circular	0.79	0.013	1.00	1.00		
Link234	J77	Node249	23.00	22.98	13.42	13.02	13	0.0133	Circular	3.14	0.014	2.00	2.00		
Link235	Node246	Node247	5.95	13.34	5.50	4.98	33	0.0309	Circular	9.62	0.014	3.50	3.50		
Link236	Node247	Out2	13.34	6.50	4.98	4.14	33	0.0255	Circular	12.57	0.014	4.00	4.00		
Link237	Node249	Node245	22.98	24.50	13.02	12.39	20	0.0197	Circular	3.14	0.014	2.00	2.00		
Link238	Node251	Node249	20.45	22.98	20.45	13.02	2	0.0033	Circular	3.14	0.014	2.00	2.00		
Link239	Node248	Node249	23.60	22.98	20.35	13.02	12	0.2410	Circular	3.14	0.014	2.00	2.00		
Link240	J50	J49	23.35	14.85	20.83	12.18	398	0.0208	Circular	3.14	0.013	2.00	2.00		
Link242	Node252	J182	143.00	106.00	143.00	106.00	1,350	0.0274	Trapezoid	15.00	0.035	2.00	3.00	1	1
Link243	J26	Node270	100.00	90.48	93.25	90.48	160	0.0258	Circular	1.77	0.013	1.50	1.50		
Link244	Node270	Node269	90.48	87.84	90.48	87.62	67	0.0427	Natural	12.10	0.025	9.15	2.90		
Link245	Node269	Node268	87.84	84.18	87.62	84.18	94	0.0267	Natural	5.17	0.025	5.99	1.97		
Link246	Node268	Node267	84.18	83.14	84.18	82.30	60	0.0313	Natural	10.81	0.025	11.00	1.97		
Link247	Node267	Node266	83.14	82.08	82.30	80.74	32	0.0094	Circular	3.14	0.013	2.00	2.00		
Link248	Node266	Node265	82.08	81.38	80.74	80.67	30	0.0013	Natural	10.81	0.025	11.00	1.97		
Link249	Node265	Node264	81.38	79.41	80.67	79.41	92	0.0137	Natural	10.81	0.025	11.00	1.97		
Link250	Node264	Node263	79.41	77.59	79.41	77.29	103	0.0128	Natural	8.70	0.025	16.00	1.17		
Link251	Node263	Node262	77.59	75.92	77.29	75.91	69	0.0228	Natural	8.70	0.025	16.00	1.17		
Link252	Node262	Node261	75.92	74.41	75.91	74.41	49	0.0445	Natural	6.11	0.025	7.40	1.36		
Link253	Node261	Node260	74.41	72.26	74.41	70.98	85	0.0404	Natural	13.00	0.025	14.00	2.04		
Link254	Node260	Node259	72.26	71.34	70.98	71.22	41	0.0071	Circular	3.14	0.013	2.00	2.00		
Link255	Node259	Node258	71.34	70.26	71.22	70.26	37	0.0259	Natural	16.72	0.025	17.00	2.57		
Link256	Node258	Node257	70.26	68.45	70.26	68.45	57	0.0307	Natural	15.73	0.025	16.09	2.51		
Link257	Node257	Node256	68.45	67.45	68.45	66.73	34	0.0571	Natural	44.74	0.025	22.31	2.51		
Link258	Node256	Node255	67.45	65.26	66.73	65.26	69	0.0213	Natural	49.69	0.025	22.72	2.73		
Link259	Node255	Node254	65.26	63.99	65.26	63.92	61	0.0223	Natural	24.24	0.025	18.46	2.73		
Link260	Node254	Node253	63.99	63.55	63.92	63.55	18	0.0123	Natural	24.61	0.025	18.58	2.75		
Link261	Node271	Node253	63.69	63.55	62.19	63.55	204	0.0019	Circular	0.79	0.013	1.00	1.00		
Link262	Node271	J28	63.69	64.25	62.19	62.65	47	0.0466	Circular	0.79	0.013	1.00	1.00		
530.1	J85	J84	136.70	130.63	136.70	129.63	700	0.0101	Trapezoid	10.00	0.045	3.00	2.00	1	1
625.1	J180	J179	159.00	136.00	158.50	134.50	505	0.0322	Circular	1.77	0.013	1.50	1.50		

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Pipe Name	Capacity (cfs)	Velocity (ft/s)	Diameter (in)	Modeled Flow (cfs)	q/Q	Max Elev. Upstream (ft)	Max Elev. Downstream (ft)	Upstream Node	Freeboard at Upstream Node (ft)
L_C1	61.5	5.0	12	3.9	0.0636	139.57	130.60	J24	2.5
L_C2	8.8	10.4	12	3.9	0.4444	130.60	114.25	J23	2.5
L_C3	15.8	8.8	15	3.9	0.2476	114.25	107.22	J22	2.6
L_C4	4.0	2.8	18	3.8	0.9586	107.22	106.63	J21	1.9
L_C5	6.8	3.8	18	3.7	0.5506	106.63	105.21	J20	2.2
L_C6	5.3	3.3	18	4.2	0.7946	105.21	104.31	J19	2.0
L_C7	12.0	5.8	18	4.2	0.3508	104.31	99.20	J18	2.3
L_C8	2.9	5.6	10	1.9	0.6392	99.20	92.30	J17	2.5
L_C9	3.2	4.0	12	1.9	0.5741	92.30	87.26	J16	2.5
L_C10	10.1	5.6	18	6.0	0.5918	87.26	83.85	J15	2.1
L_C11	26.7	6.6	24	6.0	0.2237	83.85	77.48	J14	2.4
L_C12	37.5	9.9	24	13.3	0.3556	77.48	68.14	J13	2.2
L_C13	21.0	7.1	24	17.0	0.8056	68.14	64.59	J12	1.5
L_C14	36.2	10.4	24	17.2	0.4752	64.59	42.46	J11	2.0
L_C15	18.6	6.7	24	19.5	1.0448	42.46	40.69	J10	4.3
L_C16	36.7	8.1	30	29.5	0.8045	40.69	36.80	J9	4.1
L_C17	28.1	7.5	30	29.5	1.05	36.80	36.01	J8	4.7
L_C18	56.1	11.5	30	36.7	0.655	36.01	24.14	J7	5.3
L_C20	123.0	5.0	42	15.3	0.124	13.13	5.95	J5	14.8
L_C21	10.3	2.6	42	25.0	2.4248	5.95	5.83	J4	3.5
L_C22	9.3	2.2	42	21.4	2.2941	5.83	5.72	J3	0.0
L_C26	61.3	7.1	27	2.3	0.038	93.25	70.00	J26	2.7
L_C27	37.8	3.5	27	2.3	0.0609	70.00	62.65	J27	2.6
L_C28	3.2	-1.7	30	-6.0	-1.8949	62.65	65.00	J28	2.6
L_C29	11.1	5.0	18	2.3	0.21	99.20	93.25	J17	2.5
L_C30	4.3	3.5	15	4.0	0.9365	159.13	148.74	J34	1.7
L_C31	4.2	5.7	12	4.1	0.9796	148.74	118.22	J33	0.0
L_C32	4.3	4.5	15	5.5	1.2701	118.22	109.04	J32	0.0
L_C33	10.0	6.0	18	7.5	0.7502	109.04	89.53	J31	4.8
L_C34	8.0	4.6	18	7.4	0.9277	89.53	77.48	J30	3.3
L_C35	5.1	5.8	12	2.4	0.4775	185.09	167.43	J40	4.5
L_C36	2.5	3.5	12	2.5	0.9889	167.43	162.20	J39	1.2
L_C37	1.7	3.2	12	2.5	1.4338	162.20	161.17	J38	1.0
L_C38	4.6	6.6	12	4.5	0.9702	161.17	153.40	J37	2.2
L_C39	6.5	9.0	12	5.7	0.8757	153.40	128.99	J36	2.3
L_C40	6.4	7.1	12	5.6	0.8882	128.99	118.22	J35	0.2
L_C41	7.9	8.5	12	3.0	0.379	161.31	110.52	J44	2.6
L_C42	20.8	10.5	18	9.9	0.4752	110.52	82.53	J43	2.3
L_C43	10.1	6.2	18	10.3	1.0171	82.53	63.17	J42	0.0
L_C44	9.6	6.1	18	10.2	1.0616	63.17	40.69	J41	0.0
L_C45	5.1	4.4	12	1.3	0.2585	57.25	41.66	J46	2.7
L_C46	6.5	5.9	15	7.3	1.1246	41.66	36.01	J45	0.0
L_C47	7.4	4.6	18	5.7	0.767	104.41	103.31	J55	7.1
L_C48	25.4	11.2	18	5.7	0.2238	103.31	80.73	J54	4.2
L_C49	22.5	11.3	18	8.2	0.3639	80.73	71.24	J53	3.6
L_C50	26.4	13.1	18	8.2	0.3091	71.24	36.32	J52	4.2
L_C51	23.6	12.1	18	8.2	0.3465	36.32	20.83	J51	4.3

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L_C53	22.3	5.9	24	8.2	0.3654	12.18	10.31	J49	1.4
L_C54	17.3	4.8	24	8.1	0.4703	10.31	7.54	J48	0.1
L_C55	11.3	3.6	24	10.7	0.9459	7.54	5.95	J47	0.0
L_C56	5.0	5.1	12	1.4	0.286	213.00	194.45	J66	2.6
L_C57	6.8	6.3	12	1.4	0.2066	194.45	164.96	J65	2.7
L_C58	6.4	8.1	12	3.9	0.6089	164.96	144.36	J64	2.4
L_C59	16.5	7.4	18	3.8	0.228	144.36	137.42	J63	5.1
L_C60	14.9	6.5	18	3.8	0.2523	137.42	131.31	J62	3.4
L_C61	38.7	7.6	24	3.8	0.0971	131.31	127.64	J61	4.8
L_C62	30.4	6.8	24	4.1	0.1365	127.64	120.38	J60	6.2
L_C63	29.9	6.5	24	4.1	0.1384	120.38	115.58	J59	7.0
L_C64	29.1	6.2	24	4.9	0.1688	115.58	110.08	J58	3.8
L_C65	60.3	10.4	24	4.9	0.0815	110.08	105.76	J57	2.6
L_C66	28.1	5.2	24	-7.4	-0.2643	105.76	110.91	J56	6.5
L_C68	7.8	3.1	12	0.2	0.0198	144.36	137.00	J63	5.1
L_C69	41.0	3.9	24	2.1	0.0504	137.00	122.00	J67	3.7
L_C70	36.7	4.1	24	2.4	0.0641	128.96	122.00	J68	5.7
L_C71	3.1	3.1	12	0.8	0.253	128.96	127.64	J68	5.7
L_C72	5.6	6.5	12	2.1	0.384	106.35	88.77	J75	2.6
L_C73	4.5	5.5	12	2.1	0.4689	88.77	60.38	J74	2.5
L_C74	5.2	5.9	12	2.1	0.404	60.38	32.22	J73	2.6
L_C75	10.3	7.7	15	5.0	0.4789	32.22	26.25	J72	2.3
L_C76	148.4	3.3	24	4.9	0.0331	26.25	14.79	J71	2.5
L_C77	607.9	1.5	48	10.3	0.0169	14.79	13.79	J70	8.1
L_C78	176.2	1.3	48	19.8	0.1123	13.79	13.69	Stor3	7.2
L_C79	88.9	7.7	36	26.6	0.2989	13.69	5.09	J69	7.1
L_C80	8.4	7.4	12	2.0	0.2358	35.32	13.42	J78	2.7
L_C81	15.2	4.8	24	7.5	0.4904	12.39	14.79	Node245	14.2
L_C82	50.0	0.8	48	6.5	0.1299	14.79	14.79	J76	8.6
L_C83	8.9	1.9	42	18.2	2.0547	5.72	5.50	J2	0.0
L_C84	32.9	7.6	30	36.4	1.1069	24.14	22.75	J6	9.0
L_C85	97.8	1.4	42	0.1	0.0009	22.75	19.00	J217	16.0
L_C86	118.8	1.9	42	0.1	0.0007	19.00	13.13	J82	18.7
L_C87	157.0	12.7	42	80.1	0.5103	22.75	12.74	J81	12.7
L_C88	94.4	8.2	42	80.1	0.8483	12.74	3.97	J80	8.3
L_C89	20.1	8.2	42	80.1	3.9803	3.97	3.64	J79	6.4
L_C91	15.9	9.1	15	3.6	0.2235	129.63	97.34	J84	2.5
L_C92	348.4	4.7	36	4.2	0.0122	97.34	3.00	J83	2.8
L_C93	30.3	2.8	18	-0.3	-0.0083	6.50	1.50	J86	6.0
L_C94	5.4	3.6	24	11.4	2.1273	8.07	7.88	J92	0.0
L_C95	16.9	3.7	24	11.4	0.6753	7.88	7.00	J91	2.4
L_C96	10.0	4.1	24	13.1	1.3075	7.00	7.70	J90	0.0
L_C97	34.8	2.5	42	13.1	0.376	7.70	7.50	J89	2.1
L_C98	67.0	3.5	42	14.4	0.2142	7.50	5.50	J88	3.1
L_C99	128.3	5.8	42	-30.5	-0.2375	5.50	3.50	J87	3.3
L_C100	8.7	2.9	12	0.1	0.0068	12.96	1.00	J93	2.9
L_C101	10.9	2.5	21	0.7	0.0606	23.00	21.65	J98	5.5

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L_C102	4.2	2.3	15	0.7	0.1535	21.65	20.83	J97	6.5
L_C103	7.3	2.2	21	1.4	0.1855	20.83	20.24	J96	7.0
L_C104	8.4	1.9	24	1.6	0.1873	20.24	18.67	J95	7.0
L_C105	46.7	5.9	24	3.7	0.0797	18.67	2.00	J94	8.6
L_C106	9.1	5.6	12	0.8	0.0829	33.48	20.83	J99	10.8
L_C107	3.4	2.9	12	0.5	0.1519	93.03	87.64	J104	2.7
L_C108	10.0	5.8	15	1.7	0.1661	87.64	79.42	J103	5.7
L_C109	11.3	4.1	18	1.6	0.1463	79.42	75.75	J102	7.4
L_C110	16.5	8.5	15	1.6	0.0995	75.75	54.41	J101	5.3
L_C111	19.5	10.0	15	2.2	0.1121	54.41	18.67	J100	5.0
L_C112	5.4	7.0	10	0.8	0.1463	107.78	81.22	J109	2.8
L_C113	5.7	6.7	10	0.8	0.1381	81.22	53.43	J108	2.8
L_C114	5.9	6.1	12	1.6	0.2698	53.43	30.73	J107	2.7
L_C115	2.0	6.1	8	1.6	0.7935	30.73	16.06	J106	2.5
L_C116	6.7	5.1	12	1.7	0.2594	16.06	1.00	J105	2.6
L_C117	14.7	6.6	12	0.6	0.0432	16.57	1.00	J110	2.9
L_C118	5.8	8.4	10	1.3	0.2202	72.31	56.39	J114	2.7
L_C119	3.0	7.8	8	1.3	0.4234	56.39	44.19	J113	2.7
L_C121	5.9	6.4	12	2.1	0.3574	44.19	19.14	J112	2.6
L_C122	8.6	6.9	12	2.1	0.2454	19.14	1.00	J111	2.7
L_C124	33.0	2.8	42	11.0	0.3342	62.65	60.16	J28	2.6
L_C125	45.7	4.0	42	25.4	0.5567	60.16	57.74	J124	8.3
L_C126	103.5	1.9	42	3.0	0.0288	73.78	57.74	J123	3.1
L_C127	28.1	-2.9	42	-28.1	-1.0005	57.74	56.52	J122	12.7
L_C128	34.8	4.1	42	30.3	0.8718	56.52	54.08	J121	14.3
L_C129	61.2	6.4	42	32.9	0.5373	54.08	51.96	J120	13.5
L_C130	99.3	8.9	42	32.8	0.3309	51.96	46.91	J119	13.5
L_C131	136.1	11.1	42	36.5	0.2684	46.91	33.70	J118	10.8
L_C132	77.1	8.1	42	45.7	0.5928	33.70	30.00	J117	5.8
L_C133	63.9	7.2	42	45.9	0.7175	30.00	27.65	J116	7.6
L_C134	94.4	9.0	42	46.3	0.4904	27.65	22.75	J115	11.2
L_C135	5.3	4.8	12	0.9	0.1767	53.01	43.92	J126	2.7
L_C136	7.1	4.4	12	0.9	0.1312	43.92	27.65	J125	2.8
L_C137	5.6	8.4	10	1.5	0.2658	44.31	24.50	J130	2.7
L_C138	5.4	5.5	12	1.5	0.2738	24.50	16.70	J129	2.6
L_C139	5.6	2.4	18	1.4	0.255	16.70	15.33	J128	2.5
L_C140	9.4	5.6	18	6.4	0.6785	15.33	13.13	J127	3.3
L_C141	4.8	5.2	12	1.4	0.2859	94.61	86.95	J139	2.6
L_C142	5.2	5.3	12	1.4	0.2641	86.95	75.81	J138	2.7
L_C143	2.0	-2.4	12	-1.8	-0.8968	69.81	68.57	J135	2.5
L_C144	3.4	4.3	12	1.8	0.5367	69.81	64.14	J135	2.5
L_C145	3.6	4.2	12	1.8	0.5001	64.14	51.73	J134	2.5
L_C146	7.2	6.6	15	6.9	0.964	51.73	39.21	J133	2.0
L_C147	15.9	5.0	24	9.9	0.6226	39.21	34.00	J132	1.9
L_C148	8.9	3.2	24	9.6	1.08	34.00	33.70	J131	6.7
L_C149	3.6	3.8	12	1.4	0.3993	125.23	103.16	J148	2.6
L_C150	1.7	1.7	12	1.4	0.8054	103.16	99.12	J147	1.2

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L_C151	1.5	5.0	8	1.8	1.1603	99.12	90.01	J146	0.0
L_C152	1.8	5.6	8	1.7	0.9518	90.01	78.20	J145	0.5
L_C153	1.1	4.5	8	1.6	1.4121	78.20	75.76	J144	0.0
L_C154	1.6	5.2	8	1.5	0.9113	75.76	70.44	J143	0.3
L_C155	1.8	5.9	8	2.0	1.0856	70.44	62.38	J142	0.0
L_C156	1.8	5.6	8	2.0	1.0753	62.38	52.20	J141	0.0
L_C157	1.7	4.4	12	3.4	2.0294	52.20	51.73	J140	0.0
L_C158	1.5	4.6	8	1.5	1.0246	111.41	103.58	J150	0.0
L_C159	1.3	3.8	8	1.4	1.0115	103.58	99.12	J149	0.0
L_C160	6.0	5.5	12	1.8	0.294	73.42	54.08	J151	5.6
L_C161	4.4	5.6	12	2.6	0.5843	146.74	111.74	J160	2.5
L_C162	3.1	4.1	12	2.5	0.8236	111.74	97.60	J159	2.2
L_C163	4.1	5.4	12	2.5	0.6067	97.60	93.00	J158	2.4
L_C164	22.3	4.5	24	4.9	0.2185	93.00	91.01	J157	12.4
L_C165	15.6	5.7	24	14.7	0.9399	91.01	89.26	J156	1.4
L_C166	40.4	11.6	24	15.2	0.3765	89.26	74.26	J155	3.9
L_C167	42.6	7.9	30	15.2	0.3574	74.26	70.54	J154	5.9
L_C168	45.3	8.3	30	15.2	0.3355	70.54	65.49	J153	4.3
L_C169	44.3	7.8	30	15.2	0.3428	65.49	62.65	J152	2.0
L_C170	7.4	3.9	18	4.0	0.5391	110.36	105.82	J163	2.2
L_C171	9.1	3.0	24	6.7	0.7388	105.82	103.66	J162	1.6
L_C172	29.0	7.4	24	9.8	0.3395	103.66	91.01	J161	2.2
L_C173	3.2	3.6	12	1.1	0.3479	98.66	89.02	J169	2.6
L_C174	2.6	2.9	12	1.1	0.4082	89.02	79.40	J168	2.5
L_C175	18.4	6.0	18	2.0	0.111	79.40	69.27	J167	2.7
L_C176	10.0	4.6	18	3.7	0.3739	69.27	69.17	J166	2.3
L_C177	87.6	3.6	24	16.1	0.1837	69.17	66.00	J165	1.7
L_C178	186.2	2.2	36	15.9	0.0853	66.00	65.00	J164	4.3
L_C179	12.0	-1.3	24	-5.6	-0.4717	65.00	65.00	Stor4	5.4
L_C180	4.8	5.2	12	1.7	0.3535	80.12	69.27	J170	2.6
L_C182	154.8	2.0	24	0.6	0.0037	137.57	116.00	J175	2.9
L_C183	148.2	2.1	24	0.6	0.0038	116.00	97.95	J174	2.9
L_C184	8.5	7.2	15	5.2	0.6152	97.95	93.02	J173	2.3
L_C185	146.4	4.3	24	11.9	0.0813	93.02	70.00	J172	2.2
L_C186	31.9	1.8	24	12.2	0.3825	70.00	69.17	J171	1.2
L_C187	19.8	9.2	18	4.8	0.2432	174.86	158.50	J181	2.5
L_C189	17.4	9.2	18	7.0	0.4036	134.50	124.50	J179	2.3
L_C190	17.0	8.6	18	7.0	0.4145	124.50	114.26	J178	2.3
L_C191	16.0	12.0	15	7.0	0.44	114.26	93.02	J177	2.4
L_C192	12.0	5.8	18	5.0	0.4171	106.00	103.50	J182	2.2
L_C193	23.4	10.5	18	5.0	0.2142	103.50	68.50	J183	2.5
L_C194	152.1	3.1	36	5.0	0.0329	79.20	68.50	J184	2.5
L_C195	107.9	1.2	36	7.3	0.068	68.50	65.00	J185	4.5
L_C196	257.8	1.5	36	3.7	0.0145	101.00	95.00	J186	5.3
L_C197	517.4	3.2	36	11.6	0.0224	95.00	66.00	J187	5.2
L_C198	91.1	1.1	36	9.4	0.103	66.00	65.00	J188	4.1
L_C199	41.1	1.7	18	0.7	0.017	118.68	110.91	J189	2.8

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L_C200	5.0	5.1	12	2.2	0.4415	75.81	68.57	J137	2.5
L_C201	65.5	2.2	24	4.8	0.0733	244.00	240.00	J190	2.2
L_C202	56.6	1.9	24	4.4	0.0783	240.00	236.00	J191	2.2
L_C203	204.4	6.0	24	11.9	0.0584	236.00	184.00	J176	2.3
L_C204	296.5	6.2	24	11.9	0.0402	184.00	66.00	J192	2.5
L_C205	128.5	1.6	36	13.5	0.1049	66.00	65.00	J193	4.1
L_C206	312.8	3.8	24	2.0	0.0064	236.00	95.00	J194	2.8
L_C207	11.1	13.2	12	5.1	0.4619	162.32	80.73	J195	2.5
L_C208	54.8	0.0	24	0.0	0	101.90	88.77	J196	8.0
L_C209	93.7	3.1	24	10.1	0.1078	135.89	124.47	J199	1.9
L_C210	52.5	10.7	24	10.1	0.1922	124.47	111.00	J200	2.4
L_C211	99.1	3.8	36	31.7	0.3205	111.00	105.00	J201	1.2
L_C212	2.9	4.1	12	3.2	1.0926	189.26	180.47	J203	6.5
L_C213	20.8	7.6	18	3.2	0.1523	180.47	180.00	J197	2.6
L_C214	292.1	4.1	36	3.2	0.0108	180.00	113.00	J198	2.8
L_C215	56.7	1.3	36	3.2	0.0561	113.00	111.00	J202	2.3
L_C217	15.9	8.4	18	6.0	0.3772	104.77	86.69	J205	2.4
L_C218	20.9	6.7	18	2.2	0.1066	140.40	104.77	J206	2.7
L_C219	114.0	3.1	24	4.1	0.0357	184.00	146.00	J213	2.5
L_C220	187.0	4.6	24	6.1	0.0327	146.00	123.00	J212	2.5
L_C221	39.3	11.7	18	6.1	0.1557	123.00	109.00	J211	2.6
L_C222	54.5	-9.4	36	-51.0	-0.9367	109.50	109.00	Stor9	3.2
L_C223	54.5	6.3	36	32.3	0.5934	109.50	109.00	Stor9	3.2
L_C224	292.3	3.8	36	32.3	0.1105	110.00	95.00	J214	4.3
L_C225	117.1	2.1	36	32.8	0.2799	95.00	93.00	J208	3.3
L_C226	220.1	1.9	36	35.8	0.1628	93.00	86.69	J207	3.5
L_C227	20.1	10.4	24	32.3	1.6041	109.00	110.00	J209	2.8
L_C228	0.3	4.3	15	4.1	12.2552	167.43	167.43	Stor11	2.2
L_C229	1.7	1.8	12	0.5	0.3032	188.00	187.09	J216	11.6
L_C230	3.0	4.1	12	2.5	0.8147	187.09	185.09	J215	2.2
Link234	24.3	6.8	24	7.6	0.3136	13.42	13.02	J77	10.8
Link235	164.2	8.2	42	34.3	0.209	5.50	4.98	Node246	0.0
Link236	212.8	7.6	48	34.7	0.1629	4.98	4.14	Node247	4.4
Link237	29.5	7.9	24	7.6	0.2583	13.02	12.39	Node249	11.3
Link240	30.3	7.2	24	8.2	0.2696	20.83	12.18	J50	4.2
530.1	36.5	1.7	36	2.7	0.0737	136.70	129.63	J85	1.5
625.1	18.9	8.3	18	4.4	0.2348	158.50	134.50	J180	9.2

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L_C1	61.5	6.2	12	9.9	0.16	139.57	130.60	J24	2.2
L_C2	8.8	12.7	12	9.2	1.04	130.60	114.25	J23	0.9
L_C3	15.8	11.3	15	9.2	0.58	114.25	107.22	J22	2.2
L_C4	4.0	4.3	18	7.6	1.89	107.22	106.63	J21	0.0
L_C5	6.8	4.0	18	6.8	1.00	106.63	105.21	J20	0.8
L_C6	5.3	4.5	18	7.8	1.47	105.21	104.31	J19	0.7
L_C7	12.0	6.8	18	7.8	0.65	104.31	99.20	J18	2.1
L_C8	2.9	6.0	10	2.9	0.98	99.20	92.30	J17	2.3
L_C9	3.2	4.5	12	3.1	0.97	92.30	87.26	J16	1.5
L_C10	10.1	6.9	18	11.8	1.16	87.26	83.85	J15	0.0
L_C11	26.7	8.0	24	11.8	0.44	83.85	77.48	J14	2.1
L_C12	37.5	10.9	24	20.9	0.56	77.48	68.14	J13	1.9
L_C13	21.0	8.4	24	25.7	1.22	68.14	64.59	J12	0.0
L_C14	36.2	11.3	24	27.0	0.74	64.59	42.46	J11	1.6
L_C15	18.6	9.2	24	29.2	1.57	42.46	40.69	J10	0.0
L_C16	36.7	8.2	30	37.8	1.03	40.69	36.80	J9	0.8
L_C17	28.1	7.7	30	37.2	1.32	36.80	36.01	J8	0.9
L_C18	56.1	11.5	30	42.4	0.76	36.01	24.14	J7	1.4
L_C20	123.0	5.0	42	23.8	0.19	13.13	5.95	J5	14.0
L_C21	10.3	3.3	42	32.4	3.14	5.95	5.83	J4	2.4
L_C22	9.3	2.5	42	24.2	2.59	5.83	5.72	J3	0.0
L_C26	61.3	8.9	27	5.0	0.08	93.25	70.00	J26	2.6
L_C27	37.8	4.6	27	5.0	0.13	70.00	62.65	J27	2.5
L_C28	3.2	-3.3	30	-21.7	-6.82	62.65	65.00	J28	1.6
L_C29	11.1	6.5	18	5.0	0.45	99.20	93.25	J17	2.3
L_C30	4.3	3.5	15	4.3	1.00	159.13	148.74	J34	0.0
L_C31	4.2	5.6	12	4.2	0.99	148.74	118.22	J33	0.0
L_C32	4.3	4.8	15	6.0	1.37	118.22	109.04	J32	0.0
L_C33	10.0	6.2	18	10.1	1.01	109.04	89.53	J31	1.2
L_C34	8.0	5.2	18	9.2	1.14	89.53	77.48	J30	0.0
L_C35	5.1	6.9	12	4.5	0.88	185.09	167.43	J40	4.2
L_C36	2.5	3.8	12	3.0	1.22	167.43	162.20	J39	0.0
L_C37	1.7	4.0	12	3.2	1.85	162.20	161.17	J38	0.0
L_C38	4.6	6.7	12	5.3	1.15	161.17	153.40	J37	0.0
L_C39	6.5	9.0	12	6.6	1.01	153.40	128.99	J36	0.0
L_C40	6.4	7.1	12	5.7	0.89	128.99	118.22	J35	0.0
L_C41	7.9	10.9	12	7.7	0.98	161.31	110.52	J44	2.2
L_C42	20.8	12.9	18	20.5	0.99	110.52	82.53	J43	0.0
L_C43	10.1	6.2	18	10.4	1.03	82.53	63.17	J42	0.0
L_C44	9.6	6.1	18	10.5	1.10	63.17	40.69	J41	0.0
L_C45	5.1	6.2	12	3.2	0.64	57.25	41.66	J46	2.4
L_C46	6.5	6.0	15	7.4	1.14	41.66	36.01	J45	0.0
L_C47	7.4	6.6	18	11.1	1.49	104.41	103.31	J55	4.9
L_C48	25.4	13.5	18	11.1	0.44	103.31	80.73	J54	4.0
L_C49	22.5	13.4	18	16.6	0.74	80.73	71.24	J53	3.2
L_C50	26.4	15.6	18	16.6	0.63	71.24	36.32	J52	3.9
L_C51	23.6	14.4	18	16.6	0.70	36.32	20.83	J51	3.9
L_C53	22.3	6.4	24	16.3	0.73	12.18	10.31	J49	0.0
L_C54	17.3	5.0	24	14.1	0.81	10.31	7.54	J48	0.0

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L_C55	11.3	5.0	24	15.8	1.40	7.54	5.95	J47	0.0
L_C56	5.0	6.4	12	3.5	0.71	213.00	194.45	J66	2.3
L_C57	6.8	8.0	12	3.5	0.52	194.45	164.96	J65	2.5
L_C58	6.4	8.8	12	6.4	0.99	164.96	144.36	J64	0.0
L_C59	16.5	8.3	18	5.6	0.34	144.36	137.42	J63	5.0
L_C60	14.9	7.3	18	5.6	0.38	137.42	131.31	J62	3.3
L_C61	38.7	8.5	24	5.6	0.14	131.31	127.64	J61	4.7
L_C62	30.4	7.9	24	7.2	0.24	127.64	120.38	J60	6.1
L_C63	29.9	7.5	24	7.1	0.24	120.38	115.58	J59	6.8
L_C64	29.1	7.4	24	9.0	0.31	115.58	110.08	J58	3.6
L_C65	60.3	10.9	24	9.0	0.15	110.08	105.76	J57	2.5
L_C66	28.1	4.4	24	8.9	0.32	105.76	110.91	J56	5.3
L_C68	7.8	6.0	12	0.8	0.10	144.36	137.00	J63	5.0
L_C69	41.0	7.0	24	5.8	0.14	137.00	122.00	J67	3.5
L_C70	36.7	6.6	24	5.7	0.16	128.96	122.00	J68	5.5
L_C71	3.1	3.9	12	1.7	0.56	128.96	127.64	J68	5.5
L_C72	5.6	7.7	12	4.5	0.81	106.35	88.77	J75	2.3
L_C73	4.5	6.4	12	4.4	0.98	88.77	60.38	J74	2.2
L_C74	5.2	7.1	12	4.4	0.84	60.38	32.22	J73	2.3
L_C75	10.3	9.3	15	11.1	1.07	32.22	26.25	J72	0.0
L_C76	148.4	4.2	24	11.1	0.07	26.25	14.79	J71	2.2
L_C77	607.9	1.8	48	20.3	0.03	14.79	13.79	J70	7.1
L_C78	176.2	1.7	48	36.5	0.21	13.79	13.69	Stor3	6.2
L_C79	88.9	8.4	36	40.7	0.46	13.69	5.09	J69	6.1
L_C80	8.4	10.2	12	4.8	0.57	35.32	13.42	J78	2.5
L_C81	15.2	5.4	24	12.6	0.83	12.39	14.79	Node245	13.8
L_C82	50.0	0.9	48	11.4	0.23	14.79	14.79	J76	7.5
L_C83	8.9	2.4	42	23.5	2.65	5.72	5.50	J2	0.0
L_C84	32.9	8.5	30	42.4	1.29	24.14	22.75	J6	1.1
L_C85	97.8	1.9	42	0.2	0.00	22.75	19.00	J217	15.9
L_C86	118.8	1.9	42	0.2	0.00	19.00	13.13	J82	18.7
L_C87	157.0	14.1	42	99.8	0.64	22.75	12.74	J81	5.4
L_C88	94.4	10.1	42	99.8	1.06	12.74	3.97	J80	2.4
L_C89	20.1	10.1	42	99.8	4.96	3.97	3.64	J79	3.6
L_C91	15.9	12.2	15	11.7	0.74	129.63	97.34	J84	2.0
L_C92	348.4	5.6	36	13.4	0.04	97.34	3.00	J83	2.5
L_C93	30.3	4.3	18	-2.1	-0.07	6.50	1.50	J86	6.0
L_C94	5.4	4.1	24	13.2	2.45	8.07	7.88	J92	0.0
L_C95	16.9	4.2	24	13.2	0.78	7.88	7.00	J91	1.9
L_C96	10.0	4.5	24	14.3	1.43	7.00	7.70	J90	0.0
L_C97	34.8	2.9	42	14.3	0.41	7.70	7.50	J89	2.1
L_C98	67.0	4.0	42	16.1	0.24	7.50	5.50	J88	3.0
L_C99	128.3	6.1	42	-28.2	-0.22	5.50	3.50	J87	3.3
L_C100	8.7	3.4	12	0.3	0.04	12.96	1.00	J93	2.9
L_C101	10.9	3.0	21	1.3	0.12	23.00	21.65	J98	5.4
L_C102	4.2	2.7	15	1.3	0.31	21.65	20.83	J97	6.3
L_C103	7.3	2.7	21	3.0	0.40	20.83	20.24	J96	6.7
L_C104	8.4	2.4	24	3.5	0.42	20.24	18.67	J95	6.6
L_C105	46.7	8.5	24	8.8	0.19	18.67	2.00	J94	8.3

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L_C106	9.1	7.3	12	1.8	0.19	33.48	20.83	J99	10.7
L_C107	3.4	3.8	12	1.3	0.38	93.03	87.64	J104	2.6
L_C108	10.0	7.3	15	3.8	0.38	87.64	79.42	J103	5.5
L_C109	11.3	5.2	18	3.8	0.33	79.42	75.75	J102	7.2
L_C110	16.5	10.7	15	3.8	0.23	75.75	54.41	J101	5.2
L_C111	19.5	13.0	15	5.4	0.28	54.41	18.67	J100	4.9
L_C112	5.4	9.0	10	2.0	0.36	107.78	81.22	J109	2.7
L_C113	5.7	8.6	10	1.9	0.34	81.22	53.43	J108	2.7
L_C114	5.9	7.6	12	3.9	0.66	53.43	30.73	J107	2.4
L_C115	2.0	6.4	8	2.2	1.11	30.73	16.06	J106	0.0
L_C116	6.7	5.8	12	2.6	0.40	16.06	1.00	J105	2.5
L_C117	14.7	8.2	12	1.7	0.12	16.57	1.00	J110	2.8
L_C118	5.8	10.4	10	3.2	0.54	72.31	56.39	J114	2.6
L_C119	3.0	9.6	8	3.1	1.04	56.39	44.19	J113	2.4
L_C121	5.9	8.2	12	5.0	0.86	44.19	19.14	J112	2.3
L_C122	8.6	8.8	12	5.0	0.59	19.14	1.00	J111	2.4
L_C124	33.0	3.1	42	16.3	0.49	62.65	60.16	J28	1.6
L_C125	45.7	4.0	42	34.5	0.76	60.16	57.74	J124	5.8
L_C126	103.5	3.3	42	6.5	0.06	73.78	57.74	J123	2.9
L_C127	28.1	-4.2	42	-40.8	-1.45	57.74	56.52	J122	10.3
L_C128	34.8	4.7	42	44.8	1.29	56.52	54.08	J121	12.6
L_C129	61.2	7.4	42	52.1	0.85	54.08	51.96	J120	12.9
L_C130	99.3	10.5	42	53.1	0.54	51.96	46.91	J119	13.1
L_C131	136.1	12.3	42	61.1	0.45	46.91	33.70	J118	10.2
L_C132	77.1	8.6	42	70.0	0.91	33.70	30.00	J117	1.0
L_C133	63.9	7.4	42	59.3	0.93	30.00	27.65	J116	2.5
L_C134	94.4	9.1	42	61.0	0.65	27.65	22.75	J115	5.2
L_C135	5.3	5.8	12	1.9	0.36	53.01	43.92	J126	2.6
L_C136	7.1	6.3	12	1.9	0.27	43.92	27.65	J125	2.7
L_C137	5.6	10.4	10	3.3	0.59	44.31	24.50	J130	2.5
L_C138	5.4	6.7	12	3.3	0.61	24.50	16.70	J129	2.4
L_C139	5.6	2.7	18	3.6	0.65	16.70	15.33	J128	0.0
L_C140	9.4	6.6	18	11.7	1.25	15.33	13.13	J127	0.2
L_C141	4.8	6.6	12	3.4	0.70	94.61	86.95	J139	2.4
L_C142	5.2	6.3	12	3.4	0.65	86.95	75.81	J138	2.4
L_C143	2.0	-3.1	12	-2.4	-1.17	69.81	68.57	J135	2.4
L_C144	3.4	4.6	12	2.4	0.70	69.81	64.14	J135	2.4
L_C145	3.6	4.7	12	2.4	0.66	64.14	51.73	J134	2.4
L_C146	7.2	6.7	15	7.8	1.09	51.73	39.21	J133	0.0
L_C147	15.9	5.0	24	12.6	0.79	39.21	34.00	J132	0.0
L_C148	8.9	3.9	24	12.4	1.39	34.00	33.70	J131	1.7
L_C149	3.6	4.8	12	3.4	0.95	125.23	103.16	J148	2.2
L_C150	1.7	2.0	12	1.6	0.95	103.16	99.12	J147	0.0
L_C151	1.5	5.0	8	1.8	1.19	99.12	90.01	J146	0.0
L_C152	1.8	5.5	8	1.8	0.98	90.01	78.20	J145	0.0
L_C153	1.1	4.5	8	1.6	1.39	78.20	75.76	J144	0.0
L_C154	1.6	5.2	8	1.5	0.93	75.76	70.44	J143	0.0
L_C155	1.8	5.9	8	2.0	1.12	70.44	62.38	J142	0.0
L_C156	1.8	5.6	8	2.0	1.09	62.38	52.20	J141	0.0

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L_C157	1.7	4.7	12	3.7	2.20	52.20	51.73	J140	0.0
L_C158	1.5	4.5	8	1.6	1.06	111.41	103.58	J150	0.0
L_C159	1.3	3.7	8	1.3	0.99	103.58	99.12	J149	0.0
L_C160	6.0	7.9	12	4.5	0.75	73.42	54.08	J151	5.3
L_C161	4.4	6.2	12	4.5	1.02	146.74	111.74	J160	0.0
L_C162	3.1	4.3	12	3.3	1.08	111.74	97.60	J159	0.0
L_C163	4.1	5.8	12	3.3	0.80	97.60	93.00	J158	2.3
L_C164	22.3	4.7	24	8.2	0.37	93.00	91.01	J157	11.3
L_C165	15.6	7.0	24	21.2	1.36	91.01	89.26	J156	0.0
L_C166	40.4	12.7	24	21.8	0.54	89.26	74.26	J155	3.7
L_C167	42.6	8.6	30	21.8	0.51	74.26	70.54	J154	5.7
L_C168	45.3	9.1	30	21.8	0.48	70.54	65.49	J153	4.1
L_C169	44.3	8.4	30	21.8	0.49	65.49	62.65	J152	1.7
L_C170	7.4	4.3	18	7.4	1.00	110.36	105.82	J163	0.0
L_C171	9.1	3.8	24	11.5	1.26	105.82	103.66	J162	0.0
L_C172	29.0	9.0	24	19.0	0.65	103.66	91.01	J161	1.8
L_C173	3.2	4.4	12	2.6	0.82	98.66	89.02	J169	2.3
L_C174	2.6	3.3	12	2.3	0.89	89.02	79.40	J168	1.5
L_C175	18.4	7.1	18	4.1	0.22	79.40	69.27	J167	2.5
L_C176	10.0	5.1	18	7.1	0.71	69.27	69.17	J166	1.9
L_C177	87.6	4.4	24	32.9	0.38	69.17	66.00	J165	1.1
L_C178	186.2	2.9	36	32.7	0.18	66.00	65.00	J164	3.6
L_C179	12.0	-2.1	24	-20.6	-1.72	65.00	65.00	Stor4	4.9
L_C180	4.8	6.1	12	3.1	0.64	80.12	69.27	J170	2.4
L_C182	154.8	3.0	24	1.8	0.01	137.57	116.00	J175	2.7
L_C183	148.2	2.6	24	1.8	0.01	116.00	97.95	J174	2.7
L_C184	8.5	7.8	15	9.2	1.08	97.95	93.02	J173	1.1
L_C185	146.4	5.1	24	23.9	0.16	93.02	70.00	J172	1.8
L_C186	31.9	2.3	24	25.3	0.80	70.00	69.17	J171	0.4
L_C187	19.8	11.0	18	9.4	0.47	174.86	158.50	J181	2.3
L_C189	17.4	11.0	18	14.9	0.85	134.50	124.50	J179	1.9
L_C190	17.0	10.4	18	14.9	0.88	124.50	114.26	J178	1.9
L_C191	16.0	14.5	15	14.9	0.93	114.26	93.02	J177	2.1
L_C192	12.0	7.0	18	11.9	0.99	106.00	103.50	J182	0.0
L_C193	23.4	13.2	18	11.9	0.51	103.50	68.50	J183	2.2
L_C194	152.1	4.0	36	11.9	0.08	79.20	68.50	J184	2.2
L_C195	107.9	1.6	36	18.1	0.17	68.50	65.00	J185	3.7
L_C196	257.8	1.9	36	8.4	0.03	101.00	95.00	J186	4.9
L_C197	517.4	4.2	36	32.9	0.06	95.00	66.00	J187	4.5
L_C198	91.1	1.7	36	29.5	0.32	66.00	65.00	J188	2.9
L_C199	41.1	2.9	18	3.4	0.08	118.68	110.91	J189	2.4
L_C200	5.0	6.2	12	5.0	1.00	75.81	68.57	J137	0.0
L_C201	65.5	2.7	24	10.5	0.16	244.00	240.00	J190	1.8
L_C202	56.6	2.4	24	9.9	0.17	240.00	236.00	J191	1.7
L_C203	204.4	7.4	24	25.6	0.13	236.00	184.00	J176	1.9
L_C204	296.5	7.4	24	25.6	0.09	184.00	66.00	J192	2.2
L_C205	128.5	2.3	36	32.1	0.25	66.00	65.00	J193	3.3
L_C206	312.8	6.4	24	10.2	0.03	236.00	95.00	J194	2.5
L_C207	11.1	14.0	12	6.9	0.62	162.32	80.73	J195	2.4

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L_C208	54.8	0.0	24	0.0	0.00	101.90	88.77	J196	8.0
L_C209	93.7	4.1	24	28.2	0.30	135.89	124.47	J199	1.1
L_C210	52.5	15.6	24	28.2	0.54	124.47	111.00	J200	2.0
L_C211	99.1	4.9	36	79.1	0.80	111.00	105.00	J201	0.2
L_C212	2.9	4.3	12	3.3	1.14	189.26	180.47	J203	5.7
L_C213	20.8	7.7	18	3.3	0.16	180.47	180.00	J197	2.5
L_C214	292.1	4.1	36	3.3	0.01	180.00	113.00	J198	2.8
L_C215	56.7	1.3	36	3.4	0.06	113.00	111.00	J202	2.0
L_C217	15.9	10.3	18	17.1	1.07	104.77	86.69	J205	0.0
L_C218	20.9	10.4	18	9.5	0.46	140.40	104.77	J206	2.3
L_C219	114.0	4.2	24	11.9	0.10	184.00	146.00	J213	2.1
L_C220	187.0	6.4	24	19.3	0.10	146.00	123.00	J212	2.0
L_C221	39.3	20.0	18	19.3	0.49	123.00	109.00	J211	2.3
L_C222	54.5	-22.2	36	-150.3	-2.76	109.50	109.00	Stor9	0.0
L_C223	54.5	6.9	36	48.8	0.90	109.50	109.00	Stor9	0.0
L_C224	292.3	4.2	36	48.4	0.17	110.00	95.00	J214	3.9
L_C225	117.1	2.4	36	49.2	0.42	95.00	93.00	J208	2.7
L_C226	220.1	2.2	36	54.3	0.25	93.00	86.69	J207	3.0
L_C227	20.1	15.2	24	48.4	2.40	109.00	110.00	J209	0.0
L_C228	0.3	4.3	15	-5.2	-15.50	167.43	167.43	Stor11	0.0
L_C229	1.7	1.8	12	-0.9	-0.56	188.00	187.09	J216	9.7
L_C230	3.0	5.8	12	4.5	1.48	187.09	185.09	J215	0.0
Link234	24.3	7.8	24	12.9	0.53	13.42	13.02	J77	10.5
Link235	164.2	9.4	42	56.4	0.34	5.50	4.98	Node246	0.0
Link236	212.8	8.8	48	57.0	0.27	4.98	4.14	Node247	4.3
Link237	29.5	9.1	24	12.9	0.44	13.02	12.39	Node249	11.1
Link240	30.3	8.0	24	16.6	0.55	20.83	12.18	J50	3.7
530.1	36.5	2.5	36	9.2	0.25	136.70	129.63	J85	1.1
625.1	18.9	9.9	18	8.8	0.47	158.50	134.50	J180	9.0

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L_C1	61.5	10.2	24	4.9	0.08	138.15	129.17	J24	2.4
L_C2	8.8	11.2	12	4.9	0.56	129.17	113.48	J23	2.4
L_C3	15.8	12.9	15	4.9	0.31	113.48	107.06	J22	2.5
L_C4	4.0	2.3	18	4.8	1.20	107.06	106.08	J21	1.7
L_C5	6.8	3.8	18	4.7	0.69	106.08	105.05	J20	2.1
L_C6	5.3	3.0	18	5.7	1.06	105.05	103.39	J19	1.7
L_C7	17.6	10.0	18	5.6	0.32	103.39	93.82	J18	2.4
L_C8	2.9	5.4	10	0.0	0.00	91.30	91.30	J17	7.4
L_C9	3.2	4.1	12	0.0	0.00	91.30	86.99	J16	3.0
L_C10	10.1	5.7	18	9.1	0.89	86.99	82.65	J15	1.8
L_C11	26.7	8.5	24	9.0	0.34	82.65	76.41	J14	2.2
L_C12	37.5	11.9	24	16.6	0.44	76.41	68.05	J13	2.1
L_C13	21.0	6.7	24	21.7	1.03	68.05	63.77	J12	1.1
L_C14	36.2	11.5	24	23.4	0.65	63.77	44.53	J11	1.8
L_C15	18.6	5.9	24	25.8	1.38	44.53	40.33	J10	1.9
L_C16	36.7	7.5	30	35.5	0.97	40.33	36.96	J9	3.7
L_C17	28.1	5.7	30	35.1	1.25	36.96	35.84	J8	4.0
L_C18	56.1	11.4	30	40.4	0.72	35.84	30.49	J7	4.5
L_C20	123.0	12.8	42	19.4	0.16	10.88	10.62	J5	14.6
L_C21	10.3	1.1	42	28.3	2.74	10.62	9.92	J4	3.1
L_C22	9.3	1.0	42	23.1	2.47	9.92	9.52	J3	0.0
L_C28	17.0	3.5	30	7.8	0.46	60.63	60.66	J28	3.6
L_C29	15.5	8.8	18	5.6	0.36	93.62	92.35	J17	7.4
L_C30	4.3	3.5	15	4.2	0.97	160.42	150.96	J34	0.5
L_C31	4.2	5.4	12	4.1	0.98	150.96	124.54	J33	0.0
L_C32	4.3	3.5	15	5.6	1.29	124.54	108.52	J32	0.0
L_C33	10.0	5.7	18	7.7	0.77	108.52	89.34	J31	4.8
L_C34	8.0	4.5	18	7.6	0.95	89.34	76.41	J30	3.4
L_C35	5.1	6.5	12	2.9	0.57	184.64	168.35	J40	4.5
L_C36	2.5	3.2	12	2.5	1.02	168.35	163.27	J39	0.8
L_C37	1.7	2.2	12	2.5	1.48	163.27	161.32	J38	0.9
L_C38	4.6	5.9	12	5.0	1.07	161.32	153.25	J37	1.8
L_C39	6.5	8.2	12	6.2	0.95	153.25	131.04	J36	2.2
L_C40	6.4	8.1	12	5.7	0.90	131.04	124.54	J35	0.0
L_C41	7.9	10.0	12	3.6	0.46	160.79	109.81	J44	2.5
L_C42	20.8	11.8	18	11.3	0.55	109.81	84.83	J43	2.2
L_C43	10.1	5.7	18	10.2	1.01	84.83	65.78	J42	0.0
L_C44	9.6	5.4	18	10.2	1.07	65.78	40.33	J41	0.0
L_C45	5.1	6.4	12	1.5	0.29	56.62	42.36	J46	2.6
L_C46	6.5	5.3	15	6.6	1.01	42.36	35.84	J45	1.1
L_C47	7.4	4.2	18	6.2	0.84	104.02	102.32	J55	7.0
L_C48	25.4	14.4	18	6.2	0.25	102.32	79.86	J54	4.2
L_C49	22.5	12.7	18	7.7	0.34	79.86	70.29	J53	3.6
L_C50	26.4	15.0	18	7.7	0.29	70.29	35.41	J52	4.2
L_C51	23.6	13.3	18	7.7	0.33	35.41	19.92	J51	4.3
L_C53	22.3	7.1	24	7.9	0.35	13.43	13.22	J49	1.4
L_C54	17.3	5.5	24	8.0	0.46	13.22	12.68	J48	0.1

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L_C55	11.3	3.6	24	10.4	0.91	12.68	10.62	J47	0.0
L_C56	5.0	6.4	12	1.5	0.30	212.41	193.77	J66	2.6
L_C57	6.8	8.7	12	1.5	0.22	193.77	164.34	J65	2.7
L_C58	6.4	8.2	12	1.9	0.29	164.34	143.20	J64	2.6
L_C59	16.5	9.3	18	1.9	0.11	143.20	136.30	J63	5.2
L_C60	14.9	8.4	18	1.9	0.13	136.30	129.60	J62	3.6
L_C61	38.7	12.3	24	1.9	0.05	129.60	126.05	J61	4.9
L_C62	30.4	9.7	24	2.8	0.09	126.05	118.80	J60	6.3
L_C63	29.9	9.5	24	2.8	0.09	118.80	114.13	J59	7.0
L_C64	29.1	9.3	24	3.9	0.13	114.13	108.43	J58	3.9
L_C65	60.3	19.2	24	3.9	0.06	108.43	105.29	J57	2.7
L_C66	28.1	8.9	24	-7.4	-0.26	105.29	105.24	J56	6.5
L_C68	7.8	10.0	12	0.0	0.00	143.20	135.33	J63	5.2
L_C69	41.0	13.0	24	2.4	0.06	135.33	121.98	J67	3.7
L_C70	36.7	11.7	24	3.8	0.10	121.98	127.39	J68	5.6
L_C71	3.1	3.9	12	1.1	0.37	127.39	126.05	J68	5.6
L_C72	5.6	7.1	12	4.6	0.83	106.05	87.66	J75	2.3
L_C73	4.5	5.8	12	4.6	1.01	87.66	60.11	J74	2.1
L_C74	5.2	6.7	12	4.6	0.87	60.11	33.58	J73	2.3
L_C75	10.3	8.4	15	10.6	1.02	33.58	24.02	J72	0.4
L_C76	148.4	9.9	36	10.5	0.07	24.02	7.17	J71	2.2
L_C77	607.9	4.3	120	17.6	0.03	7.17	7.14	J70	7.6
L_C78	176.2	1.3	120	28.1	0.16	7.14	7.13	Stor3	6.7
L_C79	88.9	12.6	36	32.4	0.36	7.13	9.00	J69	6.6
L_C80	8.4	10.7	12	4.3	0.51	34.83	12.32	J78	2.5
L_C81	15.2	4.8	24	9.9	0.65	10.49	8.55	Node245	14.0
L_C82	50.0	0.0	120	8.7	0.17	7.18	7.17	J76	8.0
L_C83	8.9	0.9	42	19.1	2.15	9.52	8.90	J2	0.0
L_C84	32.9	6.7	30	40.2	1.23	30.49	27.31	J6	3.9
L_C85	97.8	10.2	42	0.2	0.00	19.35	15.59	J217	15.9
L_C86	118.8	12.3	42	0.2	0.00	15.59	10.88	J82	18.7
L_C87	157.0	16.3	42	93.0	0.59	27.31	23.93	J81	8.0
L_C88	94.4	9.8	42	93.0	0.98	23.93	15.76	J80	4.5
L_C89	20.1	2.1	42	93.0	4.62	15.76	9.00	J79	4.6
L_C91	15.9	13.0	15	10.2	0.64	128.50	94.78	J84	2.1
L_C92	348.4	19.4	108	11.1	0.03	94.78	9.00	J83	2.6
L_C93	30.3	17.2	18	-2.2	-0.07	9.00	9.00	J86	6.0
L_C94	5.4	1.7	24	11.5	2.14	11.76	10.90	J92	0.0
L_C95	16.9	5.4	24	11.5	0.68	10.90	10.51	J91	2.2
L_C96	10.0	3.2	24	13.5	1.35	10.51	9.17	J90	0.0
L_C97	34.8	3.6	42	13.5	0.39	9.17	9.14	J89	2.1
L_C98	67.0	7.0	42	15.8	0.24	9.14	9.02	J88	3.0
L_C99	128.3	13.3	42	-29.0	-0.23	9.02	9.00	J87	3.3
L_C100	8.7	11.1	12	0.5	0.06	12.12	9.00	J93	2.8
L_C101	10.9	4.5	21	1.5	0.14	21.69	20.42	J98	5.4
L_C102	4.2	3.5	15	1.5	0.35	20.42	19.83	J97	6.3
L_C103	7.3	3.0	21	2.7	0.36	19.83	19.19	J96	6.8

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Pipe Name	Capacity (cfs)	Velocity (ft/s)	Diameter (in)	Modeled Flow (cfs)	q/Q	Max Elev. Upstream (ft)	Max Elev. Downstream (ft)	Upstream Node	Freeboard at Upstream Node (ft)
L_C104	8.4	2.7	24	3.3	0.39	19.19	17.20	J95	6.7
L_C105	46.7	14.9	24	7.2	0.15	17.20	9.00	J94	8.4
L_C106	9.1	11.6	12	1.3	0.14	32.73	19.83	J99	10.8
L_C107	3.4	4.3	12	0.5	0.16	92.30	86.79	J104	2.7
L_C108	10.0	8.1	15	2.3	0.23	86.79	78.43	J103	5.6
L_C109	11.3	6.4	18	2.2	0.20	78.43	74.56	J102	7.3
L_C110	16.5	13.5	15	2.2	0.14	74.56	53.55	J101	5.2
L_C111	19.5	15.9	15	4.0	0.20	53.55	17.20	J100	4.9
L_C112	5.4	10.0	10	1.1	0.20	107.20	80.63	J109	2.8
L_C113	5.7	10.5	10	1.1	0.19	80.63	52.85	J108	2.8
L_C114	5.9	7.5	12	2.1	0.36	52.85	30.45	J107	2.6
L_C115	2.0	5.7	8	2.1	1.05	30.45	15.58	J106	2.3
L_C116	6.7	8.5	12	2.6	0.39	15.58	9.00	J105	2.5
L_C117	14.7	18.7	12	2.6	0.18	15.87	9.00	J110	2.7
L_C118	5.8	10.6	10	1.9	0.33	71.81	55.95	J114	2.7
L_C119	3.0	8.6	8	1.9	0.64	55.95	43.75	J113	2.6
L_C121	5.9	7.5	12	3.2	0.55	43.75	18.61	J112	2.4
L_C122	8.6	10.9	12	3.2	0.38	18.61	9.00	J111	2.5
L_C124	34.6	3.6	42	11.8	0.34	60.66	59.34	J28	3.6
L_C125	34.6	3.6	42	31.7	0.92	59.34	56.21	J124	6.4
L_C126	98.1	10.2	42	6.1	0.06	70.87	56.21	J123	2.9
L_C127	62.6	6.5	42	37.4	0.60	56.21	55.06	J122	10.5
L_C128	63.5	6.6	42	40.1	0.63	55.06	52.81	J121	14.8
L_C129	63.5	6.6	42	44.9	0.71	52.81	50.19	J120	15.5
L_C130	98.0	10.2	42	44.9	0.46	50.19	44.88	J119	13.7
L_C131	135.4	14.1	42	49.7	0.37	44.88	32.71	J118	10.7
L_C132	77.1	8.0	42	59.9	0.78	32.71	30.69	J117	5.3
L_C133	63.9	6.6	42	57.6	0.90	30.69	29.00	J116	5.7
L_C134	94.4	9.8	42	56.7	0.60	29.00	27.31	J115	8.2
L_C135	5.3	6.8	12	1.4	0.26	52.37	43.21	J126	2.6
L_C136	7.1	9.1	12	1.4	0.19	43.21	29.00	J125	2.7
L_C137	5.6	10.2	10	3.3	0.59	43.93	24.07	J130	2.5
L_C138	5.4	6.8	12	3.3	0.61	24.07	16.41	J129	2.4
L_C139	5.6	3.2	18	3.1	0.56	16.41	16.02	J128	1.8
L_C140	9.4	5.3	18	10.5	1.12	16.02	10.88	J127	2.1
L_C141	4.8	6.1	12	1.4	0.30	94.00	86.31	J139	2.6
L_C142	5.2	6.6	12	1.4	0.28	86.31	75.36	J138	2.6
L_C143	2.0	2.6	12	-1.9	-0.92	70.70	69.35	J135	2.5
L_C144	3.4	4.3	12	1.9	0.55	69.35	63.65	J135	2.5
L_C145	3.6	4.6	12	1.9	0.51	63.65	51.49	J134	2.5
L_C146	7.2	5.8	15	7.0	0.97	51.49	38.59	J133	2.0
L_C147	15.9	5.0	24	11.2	0.71	38.59	35.23	J132	1.6
L_C148	8.9	2.8	24	11.2	1.26	35.23	32.71	J131	5.4
L_C149	3.6	4.5	12	1.9	0.54	124.75	105.18	J148	2.5
L_C150	1.7	2.2	12	1.7	0.99	105.18	102.40	J147	0.0
L_C151	1.5	4.4	8	1.8	1.16	102.40	91.81	J146	0.0
L_C152	1.8	5.2	8	1.7	0.95	91.81	81.89	J145	0.5

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L_C153	1.1	3.2	8	1.5	1.30	81.89	78.02	J144	0.0
L_C154	1.6	4.7	8	1.5	0.90	78.02	73.94	J143	0.1
L_C155	1.8	5.2	8	2.0	1.10	73.94	64.76	J142	0.0
L_C156	1.8	5.2	8	2.0	1.08	64.76	54.33	J141	0.0
L_C157	1.7	2.2	12	3.5	2.04	54.33	51.49	J140	0.0
L_C158	1.5	4.2	8	1.5	1.03	113.89	106.04	J150	0.0
L_C159	1.3	3.9	8	1.4	1.02	106.04	102.40	J149	0.0
L_C160	6.0	7.6	12	3.0	0.50	72.92	52.81	J151	5.4
L_C161	4.4	5.6	12	3.0	0.67	146.34	111.62	J160	2.4
L_C162	3.1	3.9	12	2.9	0.94	111.62	97.21	J159	2.1
L_C163	4.1	5.3	12	2.9	0.69	97.21	91.68	J158	2.4
L_C164	22.3	7.1	24	5.2	0.23	91.68	90.81	J157	12.3
L_C165	15.6	5.0	24	16.2	1.04	90.81	88.16	J156	1.2
L_C166	40.4	12.9	24	16.9	0.42	88.16	72.87	J155	3.9
L_C167	42.6	8.7	30	16.9	0.40	72.87	69.09	J154	5.9
L_C168	45.3	9.2	30	16.9	0.37	69.09	64.06	J153	4.3
L_C169	44.3	9.0	30	16.9	0.38	64.06	60.66	J152	1.9
L_C170	7.4	4.2	18	5.2	0.70	109.78	105.39	J163	2.1
L_C171	9.1	2.9	24	7.9	0.87	105.39	102.52	J162	1.4
L_C172	29.0	9.2	24	11.1	0.38	102.52	90.81	J161	2.1
L_C173	3.2	4.0	12	2.3	0.72	98.29	88.90	J169	2.4
L_C174	2.6	3.3	12	2.2	0.84	88.90	78.32	J168	2.1
L_C175	18.4	10.4	18	3.2	0.17	78.32	68.62	J167	2.6
L_C176	10.0	5.7	18	5.3	0.53	68.62	67.90	J166	2.2
L_C177	87.6	5.8	36	28.1	0.32	67.90	62.21	J165	1.3
L_C178	186.2	3.4	72	27.9	0.15	62.21	60.27	J164	3.8
L_C179	12.0	0.0	72	-7.3	-0.61	60.27	60.63	Stor4	4.7
L_C180	4.8	6.2	12	2.2	0.45	79.58	68.62	J170	2.5
L_C182	154.8	10.3	36	1.2	0.01	134.78	113.22	J175	2.8
L_C183	148.2	9.9	36	1.2	0.01	113.22	97.61	J174	2.8
L_C184	8.5	6.9	15	9.9	1.16	97.61	91.11	J173	0.3
L_C185	146.4	9.8	36	19.6	0.13	91.11	69.42	J172	1.9
L_C186	31.9	2.1	36	22.3	0.70	69.42	67.90	J171	0.6
L_C187	19.8	11.2	18	6.1	0.31	173.94	157.57	J181	2.4
L_C189	17.4	9.9	18	9.8	0.56	133.81	123.87	J179	2.2
L_C190	17.0	9.6	18	9.9	0.58	123.87	113.47	J178	2.1
L_C191	16.0	13.0	15	9.8	0.62	113.47	91.11	J177	2.3
L_C192	7.4	4.2	18	17.4	2.34	108.58	103.09	J182	0.0
L_C193	19.9	11.2	18	17.4	0.87	103.09	68.09	J183	2.9
L_C195	107.9	2.0	72	23.6	0.22	62.62	60.27	J185	6.4
L_C196	257.8	4.8	72	14.3	0.06	96.42	91.35	J186	4.6
L_C197	517.4	9.6	72	74.4	0.14	91.35	64.31	J187	3.7
L_C198	91.1	1.7	72	67.5	0.74	64.31	60.27	J188	1.7
L_C199	41.1	5.9	24	3.5	0.08	117.26	109.40	J189	2.4
L_C200	5.0	6.3	12	2.5	0.50	75.36	70.70	J137	2.5
L_C201	65.5	4.4	36	12.8	0.19	242.33	238.50	J190	1.7
L_C202	56.6	3.8	36	12.1	0.21	238.50	234.07	J191	1.5

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L_C203	204.4	13.6	36	22.6	0.11	234.07	181.80	J176	1.9
L_C204	296.5	19.8	36	22.6	0.08	181.80	63.01	J192	2.2
L_C205	128.5	2.4	72	39.3	0.31	63.01	60.27	J193	3.0
L_C206	312.8	20.9	36	38.4	0.12	234.04	91.35	J194	2.0
L_C207	11.1	14.1	12	2.2	0.20	161.62	79.86	J195	2.7
L_C208	54.8	17.4	24	0.0	0.00	99.90	87.66	J196	8.0
L_C209	93.7	6.2	36	19.1	0.20	134.44	122.31	J199	1.5
L_C210	52.5	16.7	24	19.1	0.36	122.31	110.02	J200	2.2
L_C211	99.1	5.5	36	39.9	0.40	110.02	103.48	J201	1.0
L_C212	2.9	3.7	12	3.2	1.09	195.49	179.41	J203	6.5
L_C213	20.8	11.8	18	3.2	0.15	179.41	177.23	J197	2.6
L_C214	292.1	16.2	36	3.2	0.01	177.23	110.68	J198	2.8
L_C215	56.7	3.2	36	3.2	0.06	110.68	110.02	J202	2.3
L_C217	15.9	9.0	18	10.7	0.67	104.17	83.00	J205	2.1
L_C218	20.9	11.8	18	7.1	0.34	139.50	104.17	J206	2.4
L_C219	114.0	7.6	36	7.4	0.06	181.73	143.78	J213	2.3
L_C220	187.0	12.5	36	11.6	0.06	143.78	120.56	J212	2.2
L_C221	39.3	22.2	18	11.6	0.30	120.56	110.49	J211	2.4
L_C222	54.5	7.7	36	-87.2	-1.60	110.49	110.21	Stor9	2.3
L_C223	54.5	7.7	36	36.5	0.67	110.21	109.98	Stor9	2.3
L_C224	292.3	7.3	60	36.5	0.12	106.77	92.88	J214	4.2
L_C225	117.1	2.9	60	37.0	0.32	92.88	90.61	J208	3.1
L_C226	220.1	3.4	60	40.2	0.18	90.61	83.00	J207	3.4
L_C227	20.1	6.4	24	36.5	1.81	109.98	106.77	J209	2.0
L_C228	0.3	0.3	15	4.1	12.26	168.36	168.35	Stor11	1.8
L_C229	1.7	2.2	12	0.5	0.30	187.40	187.00	J216	11.6
L_C230	3.0	3.9	12	3.0	0.98	187.00	184.64	J215	2.1
Link234	24.3	7.7	24	10.1	0.42	12.32	11.92	J77	10.7
Link235	164.2	17.1	42	34.4	0.21	8.90	8.95	Node246	0.0
Link236	212.8	16.9	48	35.9	0.17	8.95	9.00	Node247	4.4
Link237	29.5	9.4	24	10.1	0.34	11.79	11.20	Node249	11.2
Link238	12.1	3.9	24	0.0	0.00	18.25	18.25	Node251	20.5
Link239	103.1	32.8	24	0.0	0.00	18.25	11.79	Node248	5.4
Link240	32.6	10.4	24	7.7	0.24	19.11	13.43	J50	4.2
Link242	133.9	8.9	67	21.1	0.16	141.19	108.58	Node252	1.8
Link243	16.9	9.6	18	5.6	0.33	92.35	88.55	J26	7.7
Link244	164.0	13.6	35	5.6	0.03	88.55	85.86	Node270	1.9
Link245	40.6	7.8	24	5.6	0.14	85.86	82.98	Node269	2.0
Link246	107.4	9.9	24	5.6	0.05	82.98	81.10	Node268	1.2
Link247	21.9	7.0	24	5.6	0.26	79.88	79.84	Node267	3.3
Link248	22.2	2.1	24	5.6	0.25	79.84	79.65	Node266	2.2
Link249	71.0	6.6	24	5.6	0.08	79.65	77.98	Node265	1.7
Link250	38.8	4.5	14	5.6	0.15	77.98	76.61	Node264	1.4
Link251	51.7	5.9	14	5.6	0.11	76.61	75.01	Node263	1.0
Link252	63.2	10.3	16	5.6	0.09	75.01	72.84	Node262	0.9
Link253	141.9	10.9	24	5.6	0.04	72.84	69.70	Node261	1.6
Link254	19.0	6.1	24	5.6	0.30	69.70	69.44	Node260	2.6

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Link255	152.3	9.1	31	5.6	0.04	69.44	68.53	Node259	1.9
Link256	154.8	9.8	30	5.6	0.04	68.53	66.21	Node258	1.7
Link257	996.3	22.3	30	5.6	0.01	66.21	64.33	Node257	2.2
Link258	715.6	14.4	33	5.6	0.01	64.33	63.98	Node256	3.1
Link259	250.3	10.3	33	-23.9	-0.10	63.98	63.82	Node255	1.3
Link260	190.1	7.7	33	-36.4	-0.19	63.82	63.79	Node254	0.2
Link261	1.6	2.0	12	-3.0	-1.95	63.79	61.69	Node271	2.0
Link262	7.7	9.8	12	3.0	0.39	61.69	60.66	Node271	2.0
530.1	36.5	3.7	24	8.0	0.22	135.57	128.50	J85	1.1
625.1	18.9	10.7	18	5.7	0.30	149.86	133.81	J180	9.1

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L_C1	61.5	11.2	12	11.2	0.18	139.57	130.60	J24	2.1
L_C2	8.8	9.5	12	9.5	1.08	130.60	114.25	J23	0.0
L_C3	15.8	9.5	15	9.5	0.60	114.25	107.22	J22	2.2
L_C4	4.0	7.5	18	7.5	1.87	107.22	106.63	J21	0.0
L_C5	6.8	6.9	18	6.9	1.01	106.63	105.21	J20	0.6
L_C6	5.3	8.4	18	8.4	1.57	105.21	104.31	J19	0.5
L_C7	12.0	8.4	18	8.4	0.70	104.31	99.20	J18	2.0
L_C8	2.9	2.9	10	2.9	0.98	99.20	92.30	J17	2.3
L_C9	3.2	2.8	12	2.8	0.85	92.30	87.26	J16	1.0
L_C10	10.1	12.6	18	12.6	1.25	87.26	83.85	J15	0.0
L_C11	26.7	12.6	24	12.6	0.47	83.85	77.48	J14	2.0
L_C12	37.5	21.8	24	21.8	0.58	77.48	68.14	J13	1.8
L_C13	21.0	26.6	24	26.6	1.27	68.14	64.59	J12	0.0
L_C14	36.2	29.9	24	29.9	0.82	64.59	42.46	J11	1.5
L_C15	18.6	29.4	24	29.4	1.58	42.46	40.69	J10	0.0
L_C16	36.7	39.6	30	39.6	1.08	40.69	36.80	J9	0.3
L_C17	28.1	39.8	30	39.8	1.42	36.80	36.01	J8	0.7
L_C18	56.1	43.4	30	43.4	0.77	36.01	24.14	J7	1.2
L_C20	123.0	25.1	42	25.1	0.20	13.13	5.95	J5	13.8
L_C21	10.3	33.2	42	33.2	3.21	5.95	5.83	J4	2.2
L_C22	9.3	25.3	42	25.3	2.71	5.83	5.72	J3	0.0
L_C26	61.3	5.6	27	5.6	0.09	93.25	70.00	J26	2.5
L_C27	37.8	5.6	27	5.6	0.15	70.00	62.65	J27	2.4
L_C28	3.2	-32.6	30	-32.6	-10.24	62.65	65.00	J28	1.1
L_C29	11.1	5.6	18	5.6	0.50	99.20	93.25	J17	2.3
L_C30	4.3	4.3	15	4.3	1.00	159.13	148.74	J34	0.0
L_C31	4.2	4.2	12	4.2	0.98	148.74	118.22	J33	0.0
L_C32	4.3	6.0	15	6.0	1.38	118.22	109.04	J32	0.0
L_C33	10.0	10.2	18	10.2	1.02	109.04	89.53	J31	0.8
L_C34	8.0	9.2	18	9.2	1.15	89.53	77.48	J30	0.0
L_C35	5.1	4.5	12	4.5	0.89	185.09	167.43	J40	4.2
L_C36	2.5	3.1	12	3.1	1.23	167.43	162.20	J39	0.0
L_C37	1.7	3.1	12	3.1	1.83	162.20	161.17	J38	0.0
L_C38	4.6	5.4	12	5.4	1.16	161.17	153.40	J37	0.0
L_C39	6.5	6.6	12	6.6	1.01	153.40	128.99	J36	0.0
L_C40	6.4	5.6	12	5.6	0.88	128.99	118.22	J35	0.0
L_C41	7.9	8.0	12	8.0	1.02	161.31	110.52	J44	0.0
L_C42	20.8	20.5	18	20.5	0.99	110.52	82.53	J43	0.0
L_C43	10.1	10.3	18	10.3	1.03	82.53	63.17	J42	0.0
L_C44	9.6	10.6	18	10.6	1.10	63.17	40.69	J41	0.0
L_C45	5.1	3.5	12	3.5	0.69	57.25	41.66	J46	2.4
L_C46	6.5	7.0	15	7.0	1.08	41.66	36.01	J45	0.0
L_C47	7.4	12.4	18	12.4	1.68	104.41	103.31	J55	4.2
L_C48	25.4	12.4	18	12.4	0.49	103.31	80.73	J54	4.0
L_C49	22.5	17.8	18	17.8	0.79	80.73	71.24	J53	3.2
L_C50	26.4	17.8	18	17.8	0.67	71.24	36.32	J52	3.9
L_C51	23.6	17.8	18	17.8	0.75	36.32	20.83	J51	3.9

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L_C53	22.3	17.6	24	17.6	0.79	12.18	10.31	J49	0.0
L_C54	17.3	14.6	24	14.6	0.84	10.31	7.54	J48	0.0
L_C55	11.3	16.5	24	16.5	1.45	7.54	5.95	J47	0.0
L_C56	5.0	3.6	12	3.6	0.73	213.00	194.45	J66	2.3
L_C57	6.8	3.6	12	3.6	0.53	194.45	164.96	J65	2.5
L_C58	6.4	6.0	12	6.0	0.93	164.96	144.36	J64	2.1
L_C59	16.5	5.3	18	5.3	0.32	144.36	137.42	J63	5.0
L_C60	14.9	5.3	18	5.3	0.36	137.42	131.31	J62	3.3
L_C61	38.7	5.3	24	5.3	0.14	131.31	127.64	J61	4.7
L_C62	30.4	7.1	24	7.1	0.23	127.64	120.38	J60	6.1
L_C63	29.9	7.1	24	7.1	0.24	120.38	115.58	J59	6.8
L_C64	29.1	9.0	24	9.0	0.31	115.58	110.08	J58	3.6
L_C65	60.3	9.0	24	9.0	0.15	110.08	105.76	J57	2.5
L_C66	28.1	9.0	24	9.0	0.32	105.76	110.91	J56	4.5
L_C68	7.8	0.7	12	0.7	0.08	144.36	137.00	J63	5.0
L_C69	41.0	5.9	24	5.9	0.14	137.00	122.00	J67	3.5
L_C70	36.7	7.7	24	7.7	0.21	128.96	122.00	J68	5.4
L_C71	3.1	2.2	12	2.2	0.70	128.96	127.64	J68	5.4
L_C72	5.6	5.7	12	5.7	1.01	106.35	88.77	J75	0.0
L_C73	4.5	4.8	12	4.8	1.06	88.77	60.38	J74	0.0
L_C74	5.2	4.8	12	4.8	0.91	60.38	32.22	J73	2.2
L_C75	10.3	11.6	15	11.6	1.12	32.22	26.25	J72	0.0
L_C76	148.4	11.6	24	11.6	0.08	26.25	14.79	J71	2.2
L_C77	607.9	23.2	48	23.2	0.04	14.79	13.79	J70	6.7
L_C78	176.2	42.7	48	42.7	0.24	13.79	13.69	Stor3	5.7
L_C79	88.9	46.0	36	46.0	0.52	13.69	5.09	J69	5.7
L_C80	8.4	7.8	12	7.8	0.93	35.32	13.42	J78	2.2
L_C81	15.2	15.7	24	15.7	1.03	12.39	14.79	Node245	13.5
L_C82	50.0	14.5	48	14.5	0.29	14.79	14.79	J76	7.1
L_C83	8.9	25.2	42	25.2	2.84	5.72	5.50	J2	0.0
L_C84	32.9	43.4	30	43.4	1.32	24.14	22.75	J6	0.9
L_C85	97.8	0.2	42	0.2	0.00	22.75	19.00	J217	15.9
L_C86	118.8	0.2	42	0.2	0.00	19.00	13.13	J82	18.7
L_C87	157.0	100.4	42	100.4	0.64	22.75	12.74	J81	5.1
L_C88	94.4	100.4	42	100.4	1.06	12.74	3.97	J80	2.2
L_C89	20.1	100.4	42	100.4	4.99	3.97	3.64	J79	3.6
L_C91	15.9	13.7	15	13.7	0.86	129.63	97.34	J84	0.0
L_C92	348.4	17.6	36	17.6	0.05	97.34	3.00	J83	2.4
L_C93	30.3	-2.1	18	-2.1	-0.07	6.50	1.50	J86	6.0
L_C94	5.4	13.2	24	13.2	2.46	8.07	7.88	J92	0.0
L_C95	16.9	13.2	24	13.2	0.78	7.88	7.00	J91	1.7
L_C96	10.0	15.1	24	15.1	1.51	7.00	7.70	J90	0.0
L_C97	34.8	15.1	42	15.1	0.43	7.70	7.50	J89	2.1
L_C98	67.0	18.1	42	18.1	0.27	7.50	5.50	J88	3.0
L_C99	128.3	-28.9	42	-28.9	-0.23	5.50	3.50	J87	3.3
L_C100	8.7	0.9	12	0.9	0.10	12.96	1.00	J93	2.8
L_C101	10.9	2.4	21	2.4	0.22	23.00	21.65	J98	5.3

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L_C102	4.2	2.3	15	2.3	0.55	21.65	20.83	J97	6.1
L_C103	7.3	4.6	21	4.6	0.63	20.83	20.24	J96	6.4
L_C104	8.4	5.7	24	5.7	0.68	20.24	18.67	J95	6.3
L_C105	46.7	13.4	24	13.4	0.29	18.67	2.00	J94	8.2
L_C106	9.1	2.4	12	2.4	0.27	33.48	20.83	J99	10.7
L_C107	3.4	1.3	12	1.3	0.39	93.03	87.64	J104	2.6
L_C108	10.0	4.6	15	4.6	0.46	87.64	79.42	J103	5.4
L_C109	11.3	4.5	18	4.5	0.40	79.42	75.75	J102	7.1
L_C110	16.5	4.5	15	4.5	0.27	75.75	54.41	J101	5.1
L_C111	19.5	7.8	15	7.8	0.40	54.41	18.67	J100	4.8
L_C112	5.4	2.3	10	2.3	0.43	107.78	81.22	J109	2.6
L_C113	5.7	2.3	10	2.3	0.40	81.22	53.43	J108	2.6
L_C114	5.9	4.7	12	4.7	0.79	53.43	30.73	J107	2.3
L_C115	2.0	2.2	8	2.2	1.12	30.73	16.06	J106	0.0
L_C116	6.7	3.2	12	3.2	0.47	16.06	1.00	J105	2.4
L_C117	14.7	4.2	12	4.2	0.28	16.57	1.00	J110	2.6
L_C118	5.8	4.1	10	4.1	0.70	72.31	56.39	J114	2.5
L_C119	3.0	3.4	8	3.4	1.12	56.39	44.19	J113	0.0
L_C121	5.9	5.9	12	5.9	1.00	44.19	19.14	J112	2.1
L_C122	8.6	5.9	12	5.9	0.68	19.14	1.00	J111	2.3
L_C124	33.0	16.6	42	16.6	0.51	62.65	60.16	J28	1.1
L_C125	45.7	33.8	42	33.8	0.74	60.16	57.74	J124	5.1
L_C126	103.5	10.5	42	10.5	0.10	73.78	57.74	J123	2.8
L_C127	28.1	-42.4	42	-42.4	-1.51	57.74	56.52	J122	9.4
L_C128	34.8	47.8	42	47.8	1.37	56.52	54.08	J121	12.0
L_C129	61.2	58.1	42	58.1	0.95	54.08	51.96	J120	12.8
L_C130	99.3	58.1	42	58.1	0.59	51.96	46.91	J119	13.0
L_C131	136.1	67.4	42	67.4	0.50	46.91	33.70	J118	10.0
L_C132	77.1	75.7	42	75.7	0.98	33.70	30.00	J117	0.3
L_C133	63.9	59.7	42	59.7	0.93	30.00	27.65	J116	2.2
L_C134	94.4	62.0	42	62.0	0.66	27.65	22.75	J115	5.0
L_C135	5.3	2.5	12	2.5	0.46	53.01	43.92	J126	2.5
L_C136	7.1	2.5	12	2.5	0.34	43.92	27.65	J125	2.6
L_C137	5.6	5.5	10	5.5	0.98	44.31	24.50	J130	2.1
L_C138	5.4	5.4	12	5.4	1.00	24.50	16.70	J129	0.0
L_C139	5.6	6.4	18	6.4	1.14	16.70	15.33	J128	0.0
L_C140	9.4	12.2	18	12.2	1.30	15.33	13.13	J127	0.0
L_C141	4.8	3.5	12	3.5	0.72	94.61	86.95	J139	2.4
L_C142	5.2	3.4	12	3.4	0.66	86.95	75.81	J138	2.4
L_C143	2.0	-2.4	12	-2.4	-1.19	69.81	68.57	J135	2.4
L_C144	3.4	2.4	12	2.4	0.72	69.81	64.14	J135	2.4
L_C145	3.6	2.5	12	2.5	0.68	64.14	51.73	J134	2.4
L_C146	7.2	7.8	15	7.8	1.09	51.73	39.21	J133	0.0
L_C147	15.9	13.0	24	13.0	0.82	39.21	34.00	J132	0.0
L_C148	8.9	12.8	24	12.8	1.43	34.00	33.70	J131	1.5
L_C149	3.6	3.6	12	3.6	1.01	125.23	103.16	J148	0.0
L_C150	1.7	1.6	12	1.6	0.97	103.16	99.12	J147	0.0

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L_C151	1.5	1.8	8	1.8	1.19	99.12	90.01	J146	0.0
L_C152	1.8	1.8	8	1.8	0.98	90.01	78.20	J145	0.0
L_C153	1.1	1.5	8	1.5	1.29	78.20	75.76	J144	0.0
L_C154	1.6	1.4	8	1.4	0.87	75.76	70.44	J143	0.0
L_C155	1.8	2.0	8	2.0	1.13	70.44	62.38	J142	0.0
L_C156	1.8	2.0	8	2.0	1.10	62.38	52.20	J141	0.0
L_C157	1.7	3.8	12	3.8	2.21	52.20	51.73	J140	0.0
L_C158	1.5	1.6	8	1.6	1.06	111.41	103.58	J150	0.0
L_C159	1.3	1.4	8	1.4	1.00	103.58	99.12	J149	0.0
L_C160	6.0	6.0	12	6.0	0.99	73.42	54.08	J151	4.9
L_C161	4.4	4.5	12	4.5	1.02	146.74	111.74	J160	0.0
L_C162	3.1	3.3	12	3.3	1.08	111.74	97.60	J159	0.0
L_C163	4.1	3.3	12	3.3	0.80	97.60	93.00	J158	2.3
L_C164	22.3	8.2	24	8.2	0.37	93.00	91.01	J157	11.2
L_C165	15.6	21.2	24	21.2	1.36	91.01	89.26	J156	0.0
L_C166	40.4	22.0	24	22.0	0.54	89.26	74.26	J155	3.7
L_C167	42.6	22.0	30	22.0	0.52	74.26	70.54	J154	5.7
L_C168	45.3	22.0	30	22.0	0.48	70.54	65.49	J153	4.1
L_C169	44.3	22.1	30	22.1	0.50	65.49	62.65	J152	1.6
L_C170	7.4	7.5	18	7.5	1.02	110.36	105.82	J163	0.0
L_C171	9.1	11.5	24	11.5	1.27	105.82	103.66	J162	0.0
L_C172	29.0	19.2	24	19.2	0.66	103.66	91.01	J161	1.8
L_C173	3.2	3.2	12	3.2	1.01	98.66	89.02	J169	0.0
L_C174	2.6	2.5	12	2.5	0.95	89.02	79.40	J168	0.0
L_C175	18.4	4.2	18	4.2	0.23	79.40	69.27	J167	2.5
L_C176	10.0	7.9	18	7.9	0.78	69.27	69.17	J166	1.7
L_C177	87.6	40.8	24	40.8	0.47	69.17	66.00	J165	0.9
L_C178	186.2	40.5	36	40.5	0.22	66.00	65.00	J164	3.4
L_C179	12.0	-31.1	24	-31.1	-2.60	65.00	65.00	Stor4	4.3
L_C180	4.8	3.7	12	3.7	0.76	80.12	69.27	J170	2.4
L_C182	154.8	2.8	24	2.8	0.02	137.57	116.00	J175	2.7
L_C183	148.2	2.8	24	2.8	0.02	116.00	97.95	J174	2.7
L_C184	8.5	10.4	15	10.4	1.22	97.95	93.02	J173	0.0
L_C185	146.4	27.1	24	27.1	0.19	93.02	70.00	J172	1.7
L_C186	31.9	32.0	24	32.0	1.00	70.00	69.17	J171	0.2
L_C187	19.8	11.0	18	11.0	0.56	174.86	158.50	J181	2.2
L_C189	17.4	18.1	18	18.1	1.04	134.50	124.50	J179	0.0
L_C190	17.0	17.4	18	17.4	1.02	124.50	114.26	J178	0.0
L_C191	16.0	16.8	15	16.8	1.05	114.26	93.02	J177	0.0
L_C192	12.0	14.1	18	14.1	1.17	106.00	103.50	J182	0.0
L_C193	23.4	14.1	18	14.1	0.60	103.50	68.50	J183	2.2
L_C194	152.1	14.1	36	14.1	0.09	79.20	68.50	J184	2.1
L_C195	107.9	26.9	36	26.9	0.25	68.50	65.00	J185	3.2
L_C196	257.8	21.1	36	21.1	0.08	101.00	95.00	J186	4.3
L_C197	517.4	113.6	36	113.6	0.22	95.00	66.00	J187	3.1
L_C198	91.1	105.1	36	105.1	1.15	66.00	65.00	J188	0.8
L_C199	41.1	7.5	18	7.5	0.18	118.68	110.91	J189	2.1

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L_C200	5.0	5.0	12	5.0	1.00	75.81	68.57	J137	0.0
L_C201	65.5	20.5	24	20.5	0.31	244.00	240.00	J190	1.3
L_C202	56.6	19.5	24	19.5	0.35	240.00	236.00	J191	1.1
L_C203	204.4	39.5	24	39.5	0.19	236.00	184.00	J176	1.6
L_C204	296.5	39.4	24	39.4	0.13	184.00	66.00	J192	1.9
L_C205	128.5	65.2	36	65.2	0.51	66.00	65.00	J193	2.3
L_C206	312.8	57.2	24	57.2	0.18	236.00	95.00	J194	1.7
L_C207	11.1	5.3	12	5.3	0.47	162.32	80.73	J195	2.5
L_C208	54.8	0.0	24	0.0	0.00	101.90	88.77	J196	8.0
L_C209	93.7	40.7	24	40.7	0.43	135.89	124.47	J199	0.8
L_C210	52.5	40.7	24	40.7	0.77	124.47	111.00	J200	1.7
L_C211	99.1	91.3	36	91.3	0.92	111.00	105.00	J201	0.0
L_C212	2.9	3.6	12	3.6	1.23	189.26	180.47	J203	3.8
L_C213	20.8	3.6	18	3.6	0.17	180.47	180.00	J197	2.5
L_C214	292.1	3.6	36	3.6	0.01	180.00	113.00	J198	2.8
L_C215	56.7	3.6	36	3.6	0.06	113.00	111.00	J202	1.9
L_C217	15.9	17.1	18	17.1	1.07	104.77	86.69	J205	0.0
L_C218	20.9	16.7	18	16.7	0.80	140.40	104.77	J206	2.0
L_C219	114.0	16.6	24	16.6	0.15	184.00	146.00	J213	1.9
L_C220	187.0	27.1	24	27.1	0.14	146.00	123.00	J212	1.8
L_C221	35.6	27.1	18	27.1	0.76	123.00	109.00	J211	2.0
L_C222	519.8	205.3	36	205.3	0.40	109.50	109.00	Stor9	0.0
L_C223	54.5	54.9	36	54.9	1.01	109.50	109.00	Stor9	0.0
L_C224	292.3	53.3	36	53.3	0.18	110.00	95.00	J214	3.8
L_C225	117.1	54.1	36	54.1	0.46	95.00	93.00	J208	2.5
L_C226	220.1	59.4	36	59.4	0.27	93.00	86.69	J207	2.9
L_C227	20.1	53.3	24	53.3	2.65	109.00	110.00	J209	0.0
L_C228	0.3	-5.2	15	-5.2	-15.56	167.43	167.43	Stor11	0.0
L_C229	1.7	-0.9	12	-0.9	-0.50	188.00	187.09	J216	9.7
L_C230	3.0	4.5	12	4.5	1.49	187.09	185.09	J215	0.0
Link234	24.3	16.2	24	16.2	0.67	13.42	13.02	J77	10.4
Link235	164.2	57.3	42	57.3	0.35	5.50	4.98	Node246	0.0
Link236	212.8	57.4	48	57.4	0.27	4.98	4.14	Node247	4.3
Link237	29.5	16.2	24	16.2	0.55	13.02	12.39	Node249	10.9
Link238	12.1	0.0	24	0.0	0.00	20.45	13.02	Node251	20.5
Link239	103.1	0.0	24	0.0	0.00	20.35	13.02	Node248	5.4
Link240	32.6	17.8	24	17.8	0.55	20.83	12.18	J50	3.7
530.1	36.5	17.3	36	17.3	0.47	136.70	129.63	J85	0.7
625.1	18.9	10.4	18	10.4	0.55	158.50	134.50	J180	8.9

APPENDIX D

INFILTRATION TRENCH AND RAINGARDEN SIZING MEMORANDUM/CALCULATIONS

MEMORANDUM

TO: ARNIE PETERSCHMIDT
FROM: STACEY CLEAR, P.E.
DATE: JULY 7, 2017
SUBJECT: DOWNSPOUT INFILTRATION TRENCH RESIZING

The 2012 Ecology *Stormwater Management Manual for Western Washington*, as amended in 2014 (Manual), has set lengths for downspout infiltration trenches based upon soil types and an upstream roof area of 1,000 sf (reference Section 3.1.1 in Volume III). Due to the drier climate in Oak Harbor, the City feels these required lengths should be reduced. A letter was sent to Ecology recommending these revisions. Ecology's response on May 25, 2017 (via email), included the suggestion of performing a modeling analysis to determine appropriate trench lengths for 1,000 sf of roof area in the City of Oak Harbor.

Based on this recommendation, we modeled each soil type as listed in the Manual per Ecology's Western Washington Hydrology Model (WWHM). The current trench length requirements set in the Manual are shown in Table 1. Also shown within this table are the infiltration rates and porosities assumed for each soil type. The infiltration rates were taken from Table 3.7 on page 3-76 of Volume III of the 2005 Ecology *Stormwater Management Manual for Western Washington*. The porosities were determined from an internet research displaying typical values for the soil types shown in Table 1.

TABLE 1
Current Downspout Infiltration Trench Lengths per the Manual

Soil Type	Current Required Trench Length[(1)] (ft)	Assumed Long-term Infiltration Rate[(2)] (in/hr)	Typical Porosity[(3)]
Course sands and cobbles	20	10	0.3
Medium sand	30	2	0.39
Fine sand, Loamy sand	75	0.5	0.41
Sandy loam	125	0.25	0.43
Loam	190	0.13	0.45

1. Per the 2012 Manual.
2. Infiltration rates assumed from Table 3.7, p. 3-76, Volume III of the 2005 Manual.
3. Typical porosity values taken from Chapter 4, Soil Properties document from David Tarboton, Utah State University.

Using the dimensions in Figure III-3.1.2 within the 2012 Manual ("Typical Downspout Infiltration Trench"), a WWHM model was prepared where the infiltration trench was set at 2 feet wide and 1.5 feet deep. The infiltration rates and porosities listed in Table 1 were inserted and then various trench lengths were modeled with the goal of determining the shortest trench length necessary to provide 100% infiltration for the 1,000 sf of impervious roof surface located upstream. The results of the modeling analysis are presented in Table 2.

TABLE 2
Model Results Showing Infiltration Trench Lengths Required in Oak Harbor

Soil Type	Current Required Trench Length[(1)] (ft)	Modeled Trench Length[(2)] (ft)	Reduction of Trench Length (ft)	New Surface Area[(2)] (sf)
Course sands and cobbles	20	16	**- 4**	32
Medium Sand	30	36	+ 6	72
Fine sand, Loamy sand	75	84	+ 9	168
Sandy loam	125	122	**- 3**	244
Loam	190	155	**- 35**	310

1. Per the 2012 Manual.
2. Assuming 2 foot width, per 2012 Manual

As shown in Table 2, trench length reductions were possible with course sands and cobbles, sandy loam and loam soil types with the most significant reduction resulting with loam soils. It should be noted that the trench lengths shown in Table 2 are based upon a 2-foot width per the Manual. The critical dimension for infiltration is the surface area. The trench lengths can be reduced even further if the trench is wider as long as the same surface area is maintained (i.e. a loam trench can become 77.5' long with a 4' width which equates to 310 sf or the same area as a 155' x 2' trench).

The City is also interested in the prospect of utilizing a covered chamber system within the infiltration trench to act as storage until runoff could fully infiltrate into the native soil. A number of these chambers are proprietary and can be purchased from such companies as Contech (ChamberMaxx), ADS (StormTech Chambers), or Infiltrator Water Technologies (Infiltrator). WWHM models were run to mimic a 34" wide by 12" high arched chamber. Within the model, this translates to a first "soil" layer having a depth of 0.7' depth and a width of 2.8' with 100% voids or a porosity of 1.0 to mimic the storage within the

chamber itself. The second soil layer within the model mimicked 1' of the actual soil type and its corresponding porosity. Table 3 displays the resulting trench lengths necessary when utilizing a sample chamber system within the infiltration trench.

TABLE 3
Model Results Showing Infiltration Trench Lengths Required with a Chamber System

Soil Type	Current Required Trench Length[(1)] (ft)	Modeled Trench Length[(2)] (ft)	Reduction of Trench Length (ft)	New Surface Area[(2)] (sf)
Course sands and cobbles	14	9	**-5**	25
Medium Sand	22	21	**-1**	59
Fine sand, Loamy sand	54	48	**-6**	135
Sandy loam	90	64	**- 26**	180
Loam	136	81	**- 55**	226

1. Equivalent trench length to the 2012 Manual when using a 2.8' width.
2. Assuming 2.8 foot width to mimic 12" high by 34" wide chamber system installed within the trench

As shown in Table 3, modeling efforts reveal that a chamber system installed within the upper depths of a downspout infiltration trench would allow for shorter trench lengths compared to the dimensions currently provided in the Manual.

As an additional comparison, Table 4 demonstrates the size of a bioretention system that would be needed to infiltrate 100% of 1,000 sf of impervious surface based on the various soil types modeled above compared to what lengths would be required with the use of a traditional trench per the Ecology Manual, a trench as measured by WWHM in Oak Harbor, and a trench using a chamber system.

TABLE 4
Model Results Showing Bioretention Dimensions Required

Soil Type	Current Ecology Manual Required Trench Length[(1)] (ft)	Modeled Bioretention Length[(2)] (ft)	Oak Harbor Trench Length[(3)] (ft)	Trench w/ Chamber Length[(4)] (sf)
Course sands and cobbles	20	15	16	9
Medium Sand	30	28	36	21
Fine sand, Loamy sand	75	65	84	48
Sandy loam	125	81	122	64
Loam	190	110	155	81

1. Per the 2012 Manual. Assumes a 2' width.
2. Assuming a 2' width, planter strip style (i.e. vertical sides). 18" of soil mix was assumed with 12" ponding depth and 6" freeboard.
3. Infiltration trench sized to infiltrate 100% of runoff from 1,000 sf of impervious surface as measured in WWHM based on an Oak Harbor location. Width is assumed to be 2'.
4. Assuming a 2.8' width to mimic 12" high by 34" wide chamber system installed within the trench.

Based on these modeling efforts, we feel it is appropriate for the City to allow a reduction in required infiltration trench lengths as shown in Table 4, especially for less porous soils such as loam soils.

SAC/__

Comparison of Subgbrade Surface Area for Infiltration Trenches versus Rain Gardens of Equal Storage Volume

The square footage at subgrade and full volume of rain gardens are calculated. The volume of the rain gardens are then used to calculate the equivalent square footage at subgrade of an infiltration trench that uses a plastic chamber system instead of 4" perforated pipe surrounded by drain rock.

Square Rain Garden Shape with 3:1 Slopes*
3:1 slopes
12" deep
130 sf at water surface elevation

Pond Area	Square Root	Square Pond Center Dimensions	Pond (Above BSM) Volumes Square Pond Center Volume	18" BSM Water Storage volume (%15 Voids) Square Pond Center Volume
130	11.40175425	5.401754251	29.17895	6.565264
		Square Pond Area	Side Slopes Volume	Side Slopes Volume
		29.17894899	50.41053	22.68474
		1 Side Slope Areas (3:1)		
		25.20526275		
		4 Side Slope Areas (3:1)		
		100.821051		
	Area Check =	130		

	Total Storage Volume = Sum of
	29.17895
	50.41053
	6.565264
	22.68474
Total Rain Garden Volume	108.8395

Calculating Infiltration Trench Bottom Area at Subgrade versus 3:1 Side Slope Rain Garden (with no freeboard)

Trench bottom area =Total Volume divided by chamber storage per lf (1.57 cf/lf) x Trench width (3')	207.97	sf
Trench Bottom area divided by rain garden bottom area.	1.60	
Trench has this percent more surface area at the subgrade than the square rain garden	59.98	%

Square Rain Garden Shape with 2:1 Slopes*
2:1 slopes
12" deep
130 sf at water surface elevation

Pond Area	Square Root	Square Pond Center Dimensions	Pond (Above BSM) Volumes Square Pond Center Volume	18" BSM Water Storage volume (%15 Voids) Square Pond Center Volume
130	11.40	7.40	54.79	12.33

Square Pond Area	Side Slopes Volume	Side Slopes Volume
54.79	37.61	16.92
1 Side Slope Areas (2:1)		
18.80		
4 Side Slope Areas (2:1)		
75.21		
Area Check = 130		

Total Storage Volume = Sum of
54.79
37.61
12.33
16.92

Total Rain Garden Volume 121.64

Calculating Infiltration Trench Bottom Area at Subgrade versus 2:1 Side Slope Rain Garden (with no freeboard)

Trench bottom area =Total Volume divided by chamber storage per lf (1.57 cf/lf) x Trench width (3')	232.44	sf
Trench Bottom area divided by rain garden bottom area.	1.79	
Trench has this percent more surface area at the subgrade than the square rain garden	78.80	%

Calculating 6" Freeboard Storage Volume for the Rain Garden Pond with 2:1 Side Slopes*

6" freeboard at 2:1 side slopes will extend the pond storage horizontal surface dimensions by 1' on all sides making the sides 13.40' long

Pond Area	Square Root	6" Freeboard Square Pond Center Dimensions	6" Freeboard Pond Volumes Square Pond Center Volume	18" BSM Water Storage volume (%15 Voids) Square Pond Center Volume
179.56	13.4	7.40	27.38	12.32
		Square Pond Area	Side Slopes Volume	Side Slopes Volume
		54.76	31.2	28.08
		1 Side Slope Areas (2:1)		
		31.20		
		4 Side Slope Areas (2:1)		
		124.80		
	Area Check =	179.56		Total Storage Volume = Sum of
				27.38 6" Freeboard Square Pond Center Volume
				31.20 6" Freeboard Side Slope Volume
				12.32 BSM Square Pond Center Volume
				28.08 BSM Side Slopes Volume
				54.79 Square Center Pond (Above BSM) Volumes
				37.61 Side Slopes (Above BSM) Volume
			Total	191.37 cf

Trench bottom area =Total Volume divided by chamber storage per lf (1.57 cf/lf) x Trench width (3')	365.68
Trench Bottom area divided by rain garden bottom area.	2.04
Trench has this percent more surface area at the subgrade than the 2:1 side slope square rain garden with 6" freeboard, full to top of freeboard.	103.65 %

Summary Table

Square Rain Garden			Infiltration Trench W/Chamber		
Area		Volume	Area	Volume	Percent More Subgrade Surface Area
3:1 Side Slope	130	108.84	207.97	108.84	59.98
2:1 Side Slope	130	121.64	232.44	121.64	78.80
2:1 Side slope with 6" freeboard (full)	179.56	191.37	365.68	191.37	103.65

Summary Statement:

In each case, the Infiltration Trench with an Infiltrator Quick 4 Plus Standard chamber provides greater subgrade surface area than the rain garden of equal storage volume. Since the trench system provides equivalent storage, but more subgrade surface area for infiltration, it provides equivalent or better environmental protection than a rain garden when applied to single family homes under Minimum Requirement #5.

*Notes:

1) Infiltrator Water Technologies brand Quick 4 Plus Standard chamber model was utilized in calculations (1.57 cf storage per lf). Many other brands and models are available with differing geometry, storage volume, and loading capacities.

2) Square rain gardens were used in this comparison for ease of math.

3) Subgrade area of freeboard was not calcualted for the 3:1 side slope rain garden. The freeboard area is not intended as part of the design volume. slope
It was calculated for the 2:1 side slope as a conservative check on the relationship of the rain garden subgrade surface area versus Infiltration Trench subgrade surface area.

4) Rain Garden Handbook for Western Washington, June 2013 (DOE and WSU)
Applied: Region 1, Best, 0.10 to 0.24 in/hr, Sizing factor = 13% (0.13)
1,000 sf contributary roof area was used, therefore 130 sf rain garden area was used.

APPENDIX E

MAINTENANCE GUIDELINES

V-4.6 Maintenance Standards for Drainage Facilities

The facility-specific maintenance standards contained in this section are intended to be conditions for determining if maintenance actions are required as identified through inspection. They are not intended to be measures of the facility's required condition at all times between inspections. In other words, exceedence of these conditions at any time between inspections and/or maintenance does not automatically constitute a violation of these standards. However, based upon inspection observations, the inspection and maintenance schedules shall be adjusted to minimize the length of time that a facility is in a condition that requires a maintenance action.

Table V-4.5.2(1) Maintenance Standards - Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site
	Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations. (Apply requirements of adopted IPM policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department) Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants (Coordinate removal/cleanup with local water quality response agency).	No contaminants or pollutants present.
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)
	Beaver Dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies)
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies
	Tree Growth and Hazard Trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove If dead, diseased, or dying	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard Trees

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
		trees are identified (Use a certified Arborist to determine health of tree or removal requirements)	
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure(s); e.g.,rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a licensed civil engineer should be consulted to resolve source of erosion.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
	Liner (if Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.
Ponds Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation If settlement is apparent, measure berm to determine amount of settlement Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.

Table V-4.5.2(2) Maintenance Standards - Infiltration

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Poisonous/Noxious Vegetation	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Contaminants and Pollution	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Rodent Holes	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1)
Storage Area	Sediment	Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration. Treatment basins should infiltrate Water Quality Design Storm Volume within 48 hours, and empty within 24 hours after cessation of most rain events. (A percolation test pit or test of facility indicates facility is only working at 90% of its designed capabilities. Test every 2 to 5 years. If two inches or more sediment is present, remove).	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
Filter Bags (if applicable)	Filled with Sediment and Debris	Sediment and debris fill bag more than 1/2 full.	Filter bag is replaced or system is redesigned.
Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.	Gravel in rock filter is replaced.

Table V-4.5.2(3) Maintenance Standards - Closed Detention Systems (Tanks/Vaults)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Storage Area	Plugged Air Vents	One-half of the cross section of a vent is blocked at any point or the vent is damaged.	Vents open and functioning.
	Debris and Sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for 1/2 length of storage vault or any point depth exceeds 15% of diameter. (Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than 1/2 length of tank.)	All sediment and debris removed from storage area.
	Joints Between Tank/Pipe Section	Any openings or voids allowing material to be transported into facility. (Will require engineering analysis to determine structural stability).	All joint between tank/pipe sections are sealed.
	Tank Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape. (Review required by engineer to determine structural stability).	Tank/pipe repaired or replaced to design.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or any evidence of soil	Vault replaced or repaired to design specifications and is structurally sound. No cracks more than 1/4-inch wide at the joint of the inlet/outlet pipe.

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
		particles entering the vault through the walls.	
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Catch Basins	See "Catch Basins" (No. 5)	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

Table V-4.5.2(4) Maintenance Standards - Control Structure/Flow Restrictor

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris (Includes Sediment)	Material exceeds 25% of sump depth or 1 foot below orifice plate.	Control structure orifice is not blocked. All trash and debris removed.
	Structural Damage	Structure is not securely attached to manhole wall.	Structure securely attached to wall and outlet pipe.

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
		Structure is not in upright position (allow up to 10% from plumb). Connections to outlet pipe are not watertight and show signs of rust. Any holes - other than designed holes - in the structure.	Structure in correct position. Connections to outlet pipe are water tight; structure repaired or replaced and works as designed. Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing. Gate cannot be moved up and down by one maintenance person. Chain/rod leading to gate is missing or damaged. Gate is rusted over 50% of its surface area.	Gate is watertight and works as designed. Gate moves up and down easily and is watertight. Chain is in place and works as designed. Gate is repaired or replaced to meet design standards.
Orifice Plate	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Manhole	See "Closed Detention Systems" (No. 3).	See "Closed Detention Systems" (No. 3).	See "Closed Detention Systems" (No. 3).
Catch Basin	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

Table V-4.5.2(5) Maintenance Standards - Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%. Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe. Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height. Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No Trash or debris located immediately in front of catch basin or on grate opening. No trash or debris in the catch basin. Inlet and outlet pipes free of trash or debris. No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the	No sediment in the catch basin

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
		lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch. (Intent is to make sure no material is running into basin). Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Top slab is free of holes and cracks. Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound. Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Basin replaced or repaired to design standards. Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening. Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation blocking opening to basin. No vegetation or root growth present.

Table V-4.5.2(6) Maintenance Standards - Debris Barriers (e.g., Trash Racks)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier cleared to design flow capacity.
Metal	Damaged/ Missing Bars.	Bars are bent out of shape more than 3 inches. Bars are missing or entire barrier missing. Bars are loose and rust is causing 50% deterioration to any part of barrier.	Bars in place with no bends more than 3/4 inch. Bars in place according to design. Barrier replaced or repaired to design standards.
	Inlet/Outlet Pipe	Debris barrier missing or not attached to pipe	Barrier firmly attached to pipe

Table V-4.5.2(7) Maintenance Standards - Energy Dissipaters

Maintenance Components	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
External:			
Rock Pad	Missing or Moved Rock	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil.	Rock pad replaced to design standards.
	Erosion	Soil erosion in or adjacent to rock pad.	Rock pad replaced to design standards.
Dispersion Trench	Pipe Plugged with Sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed so that it matches design.

Maintenance Components	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
	Not Discharging Water Properly	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage.	Trench redesigned or rebuilt to standards.
	Perforations Plugged.	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Perforated pipe cleaned or replaced.
	Water Flows Out Top of "Distributor" Catch Basin.	Maintenance person observes or receives credible report of water flowing out during any storm less than the design storm or its causing or appears likely to cause damage.	Facility rebuilt or redesigned to standards.
	Receiving Area Over-Saturated	Water in receiving area is causing or has potential of causing landslide problems.	No danger of landslides.
Internal:			
Manhole/Chamber	Worn or Damaged Post, Baffles, Side of Chamber	Structure dissipating flow deteriorates to 1/2 of original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Structure replaced to design standards.
	Other Defects	See "Catch Basins" (No. 5).	See "Catch Basins" (No. 5).

Table V-4.5.2(8) Maintenance Standards - Typical Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment	Sediment depth exceeds	Remove sediment deposits on grass

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
	Accumulation on Grass	2 inches.	treatment area of the bio-swale. When finished, swale should be level from side to side and drain freely toward outlet. There should be no areas of standing water once inflow has ceased.
	Standing Water	When water stands in the swale between storms and does not drain freely.	Any of the following may apply: remove sediment or trash blockages, improve grade from head to foot of swale, remove clogged check dams, add underdrains or convert to a wet biofiltration swale.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire swale width.	Level the spreader and clean so that flows are spread evenly over entire swale width.
	Constant Baseflow	When small quantities of water continually flow through the swale, even when it has been dry for weeks, and an eroded, muddy channel has formed in the swale bottom.	Add a low-flow pea-gravel drain the length of the swale or by-pass the baseflow around the swale.
	Poor Vegetation Coverage	When grass is sparse or bare or eroded patches occur in more than 10% of the swale bottom.	Determine why grass growth is poor and correct that condition. Re-plant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals. Or re-seed into loosened, fertile soil.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow vegetation or remove nuisance vegetation so that flow not impeded. Grass should be mowed to a height of 3 to 4 inches. Remove grass clippings.
	Excessive Shading	Grass growth is poor because sunlight does not reach swale.	If possible, trim back over-hanging limbs and remove brushy vegetation on adjacent slopes.
	Inlet/Outlet	Inlet/outlet areas clogged with sediment and/or debris.	Remove material so that there is no clogging or blockage in the inlet and outlet area.
	Trash and Debris Accumulation	Trash and debris accumulated in the bio-swale.	Remove trash and debris from bioswale.
	Erosion/Scouring	Eroded or scoured swale bottom due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. If bare areas are large, generally greater than 12 inches wide, the swale should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident, or take plugs of grass from the upper slope and plant in the swale bottom at 8-inch intervals.

Table V-4.5.2(9) Maintenance Standards - Wet Biofiltration Swale

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation	Sediment depth exceeds 2-inches in 10% of the	Remove sediment deposits in treatment area.

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
		swale treatment area.	
	Water Depth	Water not retained to a depth of about 4 inches during the wet season.	Build up or repair outlet berm so that water is retained in the wet swale.
	Wetland Vegetation	Vegetation becomes sparse and does not provide adequate filtration, OR vegetation is crowded out by very dense clumps of cattail, which do not allow water to flow through the clumps.	Determine cause of lack of vigor of vegetation and correct. Replant as needed. For excessive cattail growth, cut cattail shoots back and compost off-site. Note: normally wetland vegetation does not need to be harvested unless die-back is causing oxygen depletion in downstream waters.
	Inlet/Outlet	Inlet/outlet area clogged with sediment and/or debris.	Remove clogging or blockage in the inlet and outlet areas.
	Trash and Debris Accumulation	See "Detention Ponds" (No. 1).	Remove trash and debris from wet swale.
	Erosion/Scouring	Swale has eroded or scoured due to flow channelization, or higher flows.	Check design flows to assure swale is large enough to handle flows. By-pass excess flows or enlarge swale. Replant eroded areas with fibrous-rooted plants such as Juncus effusus (soft rush) in wet areas or snowberry (Symphoricarpos albus) in dryer areas.

Table V-4.5.2(10) Maintenance Standards - Filter Strips

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem

Maintenance Component	Defect or Problem	Condition When Maintenance is Needed	Recommended Maintenance to Correct Problem
General	Sediment Accumulation on Grass	Sediment depth exceeds 2 inches.	Remove sediment deposits, re-level so slope is even and flows pass evenly through strip.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Mow grass, control nuisance vegetation, such that flow not impeded. Grass should be mowed to a height between 3-4 inches.
	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Remove trash and Debris from filter.
	Erosion/Scouring	Eroded or scoured areas due to flow channelization, or higher flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with crushed gravel. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the filter strip should be re-graded and re-seeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width.

Table V-4.5.2(11) Maintenance Standards - Wetponds

Maintenance	Defect	Condition When	Results Expected When

Component		Maintenance is Needed	Maintenance is Performed
General	Water level	First cell is empty, doesn't hold water.	Line the first cell to maintain at least 4 feet of water. Although the second cell may drain, the first cell must remain full to control turbulence of the incoming flow and reduce sediment resuspension.
	Trash and Debris	Accumulation that exceeds 1 CF per 1000-SF of pond area.	Trash and debris removed from pond.
	Inlet/Outlet Pipe	Inlet/Outlet pipe clogged with sediment and/or debris material.	No clogging or blockage in the inlet and outlet piping.
	Sediment Accumulation in Pond Bottom	Sediment accumulations in pond bottom that exceeds the depth of sediment zone plus 6-inches, usually in the first cell.	Sediment removed from pond bottom.
	Oil Sheen on Water	Prevalent and visible oil sheen.	Oil removed from water using oil-absorbent pads or vactor truck. Source of oil located and corrected. If chronic low levels of oil persist, plant wetland plants such as Juncus effusus (soft rush) which can uptake small concentrations of oil.
	Erosion	Erosion of the pond's side slopes and/or scouring of the pond bottom, that exceeds 6-inches, or where continued erosion is prevalent.	Slopes stabilized using proper erosion control measures and repair methods.

	Settlement of Pond Dike/Berm	Any part of these components that has settled 4-inches or lower than the design elevation, or inspector determines dike/berm is unsound.	Dike/berm is repaired to specifications.
	Internal Berm	Berm dividing cells should be level.	Berm surface is leveled so that water flows evenly over entire length of berm.
	Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Rocks replaced to specifications.

Table V-4.5.2(12) Maintenance Standards - Wetvaults

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash/Debris Accumulation	Trash and debris accumulated in vault, pipe or inlet/outlet (includes floatables and non-floatables).	Remove trash and debris from vault.
	Sediment Accumulation in Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6-inches.	Remove sediment from vault.
	Damaged Pipes	Inlet/outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened or removed, especially by one person.	Pipe repaired or replaced to proper working specifications.
	Ventilation	Ventilation area blocked or plugged.	Blocking material removed or cleared from ventilation area. A specified % of the vault surface area must provide ventilation to the vault interior (see design specifications).

Table V-4.5.2(13) Maintenance Standards - Sand Filters (Above Ground/Open)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Above Ground (open sand filter)	Sediment Accumulation on top layer	Sediment depth exceeds 1/2-inch.	No sediment deposit on grass layer of sand filter that would impede permeability of the filter section.
	Trash and Debris Accumulations	Trash and debris accumulated on sand filter bed.	Trash and debris removed from sand filter bed.
	Sediment/ Debris in Clean-Outs	When the clean-outs become full or partially plugged with sediment and/or debris.	Sediment removed from clean-outs.
	Sand Filter Media	Drawdown of water through the sand filter media takes longer than 24-hours, and/or flow through the overflow pipes occurs frequently.	Top several inches of sand are scraped. May require replacement of entire sand filter depth depending on extent of plugging (a sieve analysis is helpful to determine if the lower sand has too high a proportion of fine material).
	Prolonged Flows	Sand is saturated for prolonged periods of time (several weeks) and does not dry out between storms due to continuous base flow or prolonged flows from detention facilities.	Low, continuous flows are limited to a small portion of the facility by using a low wooden divider or slightly depressed sand surface.
	Short Circuiting	When flows become concentrated over one section of the sand filter rather than dispersed.	Flow and percolation of water through sand filter is uniform and dispersed across the entire filter area.
	Erosion Damage to Slopes	Erosion over 2-inches deep where cause of damage is prevalent or potential for	Slopes stabilized using proper erosion control measures.

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
		continued erosion is evident.	
	Rock Pad Missing or Out of Place	Soil beneath the rock is visible.	Rock pad replaced or rebuilt to design specifications.
	Flow Spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed across sand filter.	Spreader leveled and cleaned so that flows are spread evenly over sand filter.
	Damaged Pipes	Any part of the piping that is crushed or deformed more than 20% or any other failure to the piping.	Pipe repaired or replaced.

Table V-4.5.2(14) Maintenance Standards - Sand Filters (Below Ground/Enclosed)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Below Ground Vault.	Sediment Accumulation on Sand Media Section	Sediment depth exceeds 1/2-inch.	No sediment deposits on sand filter section that which would impede permeability of the filter section.
	Sediment Accumulation in Pre-Settling Portion of Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6-inches.	No sediment deposits in first chamber of vault.
	Trash/Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault and inlet/outlet piping.

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	Sediment in Drain Pipes/Cleanouts	When drain pipes, cleanouts become full with sediment and/or debris.	Sediment and debris removed.
	Short Circuiting	When seepage/flow occurs along the vault walls and corners. Sand eroding near inflow area.	Sand filter media section re-laid and compacted along perimeter of vault to form a semi-seal. Erosion protection added to dissipate force of incoming flow and curtail erosion.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover. Maintenance person cannot remove cover using normal lifting pressure.	Cover repaired to proper working specifications or replaced.
	Ventilation	Ventilation area blocked or plugged	Blocking material removed or cleared from ventilation area. A specified % of the vault surface area must provide ventilation to the vault interior (see design specifications).
	Vault Structure Damaged; Includes Cracks in Walls,	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or	Vault replaced or repairs made so that vault meets design specifications and

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	Bottom, Damage to Frame and/or Top Slab.	maintenance/inspection personnel determine that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	is structurally sound. Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles/Internal walls	Baffles or walls corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel.

Table V-4.5.2(15) Maintenance Standards - Manufactured Media Filters

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Below Ground Vault	Sediment Accumulation on Media.	Sediment depth exceeds 0.25-inches.	No sediment deposits which would impede permeability of the compost media.
	Sediment Accumulation in Vault	Sediment depth exceeds 6-inches in first chamber.	No sediment deposits in vault bottom of first chamber.

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	Trash/Debris Accumulation	Trash and debris accumulated on compost filter bed.	Trash and debris removed from the compost filter bed.
	Sediment in Drain Pipes/Clean-Outs	When drain pipes, clean-outs, become full with sediment and/or debris.	Sediment and debris removed.
	Damaged Pipes	Any part of the pipes that are crushed or damaged due to corrosion and/or settlement.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened; one person cannot open the cover using normal lifting pressure, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound. Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking warping, and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing	Ladder replaced or repaired and meets specifications, and is

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
		rungs, cracks, and misaligned.	safe to use as determined by inspection personnel.
Below Ground Cartridge Type	Media	Drawdown of water through the media takes longer than 1 hour, and/or overflow occurs frequently.	Media cartridges replaced.
	Short Circuiting	Flows do not properly enter filter cartridges.	Filter cartridges replaced.

Table V-4.5.2(16) Maintenance Standards - Baffle Oil/Water Separators (API Type)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with out thick visible sheen.
	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6-inches in depth.	No sediment deposits on vault bottom that would impede flow through the vault and reduce separation efficiency.
	Trash and Debris Accumulation	Trash and debris accumulation in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
	Oil Accumulation	Oil accumulations that exceed 1-inch, at the surface of the water.	Extract oil from vault by vactoring. Disposal in accordance with state and local rules and

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
			regulations.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened, corrosion/deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Damage - Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	See "Catch Basins" (No. 5) Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound. Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

Table V-4.5.2(17) Maintenance Standards - Coalescing Plate Oil/Water Separators

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is

			Performed
General	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with no thick visible sheen.
	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6-inches in depth and/or visible signs of sediment on plates.	No sediment deposits on vault bottom and plate media, which would impede flow through the vault and reduce separation efficiency.
	Trash and Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/outlet piping.
	Oil Accumulation	Oil accumulation that exceeds 1-inch at the water surface.	Oil is extracted from vault using vactoring methods. Coalescing plates are cleaned by thoroughly rinsing and flushing. Should be no visible oil depth on water.
	Damaged Coalescing Plates	Plate media broken, deformed, cracked and/or showing signs of failure.	A portion of the media pack or the entire plate pack is replaced depending on severity of failure.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and or replaced.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection person.	Baffles repaired or replaced to specifications.

	Vault Structure Damage - Includes Cracks in Walls, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch or evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determine that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound. Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, not securely attached to structure wall, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.

Table V-4.5.2(18) Maintenance Standards - Catch Basin Inserts

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment Accumulation	When sediment forms a cap over the insert media of the insert and/or unit.	No sediment cap on the insert media and its unit.
	Trash and Debris Accumulation	Trash and debris accumulates on insert unit creating a blockage/restriction.	Trash and debris removed from insert unit. Runoff freely flows into catch basin.
	Media Insert Not Removing Oil	Effluent water from media insert has a visible sheen.	Effluent water from media insert is free of oils and has no visible sheen.
	Media Insert Water Saturated	Catch basin insert is saturated with water and no longer has the capacity to absorb.	Remove and replace media insert

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
	Media Insert-Oil Saturated	Media oil saturated due to petroleum spill that drains into catch basin.	Remove and replace media insert.
	Media Insert Use Beyond Product Life	Media has been used beyond the typical average life of media insert product.	Remove and replace media at regular intervals, depending on insert product.

Table V-4.5.2(19) Maintenance Standards - Media Filter Drain (MFD)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation on grass filter strip	Sediment depth exceeds 2 inches or creates uneven grading that interferes with sheet flow.	Remove sediment deposits on grass treatment area of the embankment. When finished, embankment should be level from side to side and drain freely toward the toe of the embankment slope. There should be no areas of standing water once inflow has ceased.
	No-vegetation zone/flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire embankment width.	Level the spreader and clean to spread flows evenly over entire embankment width.
	Poor vegetation coverage	Grass is sparse or bare, or eroded patches are observed in more than 10% of the grass strip surface area.	Determine why grass growth is poor and correct the offending condition. Reseed into loosened, fertile soil or compost; or, replant with plugs of grass from the upper slope.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance	Mow vegetation or remove nuisance vegetation to not

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
		weeds and other vegetation start to take over.	impede flow. Mow grass to a height of 6 inches.
	Media filter drain mix replacement	Water is seen on the surface of the media filter drain mix long after the storms have ceased. Typically, the 6-month, 24-hour precipitation event should drain within 48 hours. More common storms should drain within 24 hours. Maintenance also needed on a 10-year cycle and during a preservation project.	Excavate and replace all of the media filter drain mix contained within the media filter drain.
	Excessive shading	Grass growth is poor because sunlight does not reach embankment.	If possible, trim back overhanging limbs and remove brushy vegetation on adjacent slopes.
	Trash and debris	Trash and debris have accumulated on embankment.	Remove trash and debris from embankment.
	Flooding of Media filter drain	When media filter drain is inundated by flood water	Evaluate media filter drain material for acceptable infiltration rate and replace if media filter drain does not meet long-term infiltration rate standards.

Table V-4.5.2(20) Maintenance Standards - Compost Amended Vegetated Filter Strip (CAVFS)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment accumulation on	Sediment depth exceeds 2 inches.	Remove sediment deposits. Relevel so slope is even and flows pass evenly

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
	grass		through strip.
	Vegetation	Grass becomes excessively tall (greater than 10 inches); nuisance weeds and other vegetation start to take over.	Mow grass and control nuisance vegetation so that flow is not impeded. Grass should be mowed to a height of 6 inches.
	Trash and debris	Trash and debris have accumulated on the vegetated filter strip.	Remove trash and debris from filter.
	Erosion/scouring	Areas have eroded or scoured due to flow channelization or high flows.	For ruts or bare areas less than 12 inches wide, repair the damaged area by filling with a 50/50 mixture of crushed gravel and compost. The grass will creep in over the rock in time. If bare areas are large, generally greater than 12 inches wide, the vegetated filter strip should be regraded and reseeded. For smaller bare areas, overseed when bare spots are evident.
	Flow spreader	Flow spreader is uneven or clogged so that flows are not uniformly distributed over entire filter width.	Level the spreader and clean so that flows are spread evenly over entire filter width

Table V-4.5.2(21) Maintenance Standards - Bioretention Facilities

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Facility Footprint				

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Earthen side slopes and berms	B, S		Erosion (gullies/ rills) greater than 2 inches deep around inlets, outlet, and alongside slopes	• Eliminate cause of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control matting) • For deep channels or cuts (over 3 inches in ponding depth), temporary erosion control measures should be put in place until permanent repairs can be made. • Properly designed, constructed and established facilities with appropriate flow velocities should not have erosion problems except perhaps in extreme events. If erosion problems persist, the following should be reassessed: (1) flow volumes from contributing areas and bioretention facility sizing; (2) flow velocities and gradients within the facility; and (3) flow dissipation and erosion protection strategies at the facility inlet.
	A		Erosion of sides causes slope to become a hazard	Take actions to eliminate the hazard and stabilize slopes
	A, S		Settlement greater than 3 inches (relative to undisturbed sections of berm)	Restore to design height
	A, S		Downstream face of berm wet, seeps or leaks evident	Plug any holes and compact berm (may require consultation with engineer, particularly for larger berms)
	A		Any evidence of rodent holes or water piping in berm	• Eradicate rodents (see "Pest control") • Fill holes and compact (may require consultation with engineer, particularly

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				for larger berms)
Concrete sidewalls	A		Cracks or failure of concrete sidewalls	• Repair/ seal cracks • Replace if repair is insufficient
Rockery sidewalls	A		Rockery side walls are insecure	Stabilize rockery sidewalls (may require consultation with engineer, particularly for walls 4 feet or greater in height)
Facility area		All maintenance visits (at least biannually)	Trash and debris present	Clean out trash and debris
Facility bottom area	A, S		Accumulated sediment to extent that infiltration rate is reduced (see "Ponded water") or surface storage capacity significantly impacted	• Remove excess sediment • Replace any vegetation damaged or destroyed by sediment accumulation and removal • Mulch newly planted vegetation • Identify and control the sediment source (if feasible) • If accumulated sediment is recurrent, consider adding presettlement or installing berms to create a forebay at the inlet
		During/after fall leaf drop	Accumulated leaves in facility	Remove leaves if there is a risk to clogging outlet structure or water flow is impeded
Low permeability check dams and weirs	A, S		Sediment, vegetation, or debris accumulated at or blocking (or having the potential to block) check dam, flow control weir or orifice	Clear the blockage
	A, S		Erosion and/or undercutting present	Repair and take preventative measures to prevent future erosion and/or undercutting

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
	A		Grade board or top of weir damaged or not level	Restore to level position
Ponded water	B, S		Excessive ponding water: Water overflows during storms smaller than the design event or ponded water remains in the basin 48 hours or longer after the end of a storm.	Determine cause and resolve in the following order: 1. Confirm leaf or debris buildup in the bottom of the facility is not impeding infiltration. If necessary, remove leaf litter/debris. 2. Ensure that underdrain (if present) is not clogged. If necessary, clear underdrain. 3. Check for other water inputs (e.g., groundwater, illicit connections). 4. Verify that the facility is sized appropriately for the contributing area. Confirm that the contributing area has not increased. If steps #1-4 do not solve the problem, the bioretention soil is likely clogged by sediment accumulation at the surface or has become overly compacted. Dig a small hole to observe soil profile and identify compaction depth or clogging front to help determine the soil depth to be removed or otherwise rehabilitated (e.g.,

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				tilled). Consultation with an engineer is recommended.
Bioretention soil media	As needed		Bioretention soil media protection is needed when performing maintenance requiring entrance into the facility footprint	• Minimize all loading in the facility footprint (foot traffic and other loads) to the degree feasible in order to prevent compaction of bioretention soils. • Never drive equipment or apply heavy loads in facility footprint. • Because the risk of compaction is higher during saturated soil conditions, any type of loading in the cell (including foot traffic) should be minimized during wet conditions. â€¢ Consider measures to distribute loading if heavy foot traffic is required or equipment must be placed in facility. As an example, boards may be placed across soil to distribute loads and minimize compaction. â€¢ If compaction occurs, soil must be loosened or otherwise rehabilitated to original design state.
Inlets/Outlets/Pipes				
Splash block inlet	A		Water is not being directed properly to the facility and away from the inlet structure	Reconfigure/ repair blocks to direct water to facility and away from structure
Curb cut inlet/outlet	M during the wet season and before severe storm is forecasted	Weekly during fall leaf drop	Accumulated leaves at curb cuts	Clear leaves (particularly important for key inlets and low points along long, linear facilities)
Pipe inlet/outlet	A		Pipe is damaged	Repair/ replace

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
	W		Pipe is clogged	Remove roots or debris
	A, S		Sediment, debris, trash, or mulch reducing capacity of inlet/outlet	• Clear the blockage • Identify the source of the blockage and take actions to prevent future blockages
		Weekly during fall leaf drop	Accumulated leaves at inlets/outlets	Clear leaves (particularly important for key inlets and low points along long, linear facilities)
		A	Maintain access for inspections	• Clear vegetation (transplant vegetation when possible) within 1 foot of inlets and outlets, maintain access pathways • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Erosion control at inlet	A		Concentrated flows are causing erosion	Maintain a cover of rock or cobbles or other erosion protection measure (e.g., matting) to protect the ground where concentrated water enters the facility (e.g., a pipe, curb cut or swale)
Trash rack	S		Trash or other debris present on trash rack	Remove/dispose
	A		Bar screen damaged or missing	Repair/replace
Overflow	A, S		Capacity reduced by sediment or debris	Remove sediment or debris/dispose
Underdrain pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	• Plant roots, sediment or debris reducing capacity of underdrain • Prolonged surface ponding (see "Ponded	• Jet clean or rotary cut debris/roots from underdrain(s) • If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly.

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
			water"	
Vegetation				
Facility bottom area and upland slope vegetation	Fall and Spring		Vegetation survival rate falls below 75% within first two years of establishment (unless project O&M manual or record drawing stipulates more or less than 75% survival rate).	• Determine cause of poor vegetation growth and correct condition • Replant as necessary to obtain 75% survival rate or greater. Refer to original planting plan, or approved jurisdictional species list for appropriate plant replacements (See Appendix 3 - Bioretention Plant List, in the LID Technical Guidance Manual for Puget Sound). • Confirm that plant selection is appropriate for site growing conditions • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Vegetation (general)	As needed		Presence of diseased plants and plant material	• Remove any diseased plants or plant parts and dispose of in an approved location (e.g., commercial landfill) to avoid risk of spreading the disease to other plants • Disinfect gardening tools after pruning to prevent the spread of disease • See Pacific Northwest Plant Disease Management Handbook for information on disease recognition and for additional resources • Replant as necessary according to recommendations provided for "facility bottom area and upland slope vegetation".

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Trees and shrubs		All pruning seasons (timing varies by species)	Pruning as needed	• Prune trees and shrubs in a manner appropriate for each species. Pruning should be performed by landscape professionals familiar with proper pruning techniques • All pruning of mature trees should be performed by or under the direct guidance of an ISA certified arborist
	A		Large trees and shrubs interfere with operation of the facility or access for maintenance	• Prune trees and shrubs using most current ANSI A300 standards and ISA BMPs. • Remove trees and shrubs, if necessary.
	Fall and Spring		Standing dead vegetation is present	• Remove standing dead vegetation • Replace dead vegetation within 30 days of reported dead and dying plants (as practical depending on weather/planting season) • If vegetation replacement is not feasible within 30 days, and absence of vegetation may result in erosion problems, temporary erosion control measures should be put in place immediately. • Determine cause of dead vegetation and address issue, if possible • If specific plants have a high mortality rate, assess the cause and replace with appropriate species. Consultation with a landscape architect is recommended.

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
	Fall and Spring		Planting beneath mature trees	• When working around and below mature trees, follow the most current ANSI A300 standards and ISA BMPs to the extent practicable (e.g., take care to minimize any damage to tree roots and avoid compaction of soil). • Planting of small shrubs or groundcovers beneath mature trees may be desirable in some cases; such plantings should use mainly plants that come as bulbs, bare root or in 4-inch pots; plants should be in no larger than 1-gallon containers.
	Fall and Spring		Presence of or need for stakes and guys (tree growth, maturation, and support needs)	• Verify location of facility liners and underdrain (if any) prior to stake installation in order to prevent liner puncture or pipe damage • Monitor tree support systems: Repair and adjust as needed to provide support and prevent damage to tree. • Remove tree supports (stakes, guys, etc.) after one growing season or maximum of 1 year. • Backfill stake holes after removal.
Trees and shrubs adjacent to vehicle travel areas (or areas where visibility needs to be maintained)	A		Vegetation causes some visibility (line of sight) or driver safety issues	• Maintain appropriate height for sight clearance • When continued, regular pruning (more than one time/ growing season) is required to maintain visual sight lines for safety or clearance along a walk or

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				drive, consider relocating the plant to a more appropriate location. • Remove or transplant if continual safety hazard • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Flowering plants		A	Dead or spent flowers present	Remove spent flowers (deadhead)
Perennials		Fall	Spent plants	Cut back dying or dead and fallen foliage and stems
Emergent vegetation		Spring	Vegetation compromises conveyance	Hand rake sedges and rushes with a small rake or fingers to remove dead foliage before new growth emerges in spring or earlier only if the foliage is blocking water flow (sedges and rushes do not respond well to pruning)
Ornamental grasses (perennial)		Winter and Spring	Dead material from previous year's growing cycle or dead collapsed foliage	• Leave dry foliage for winter interest • Hand rake with a small rake or fingers to remove dead foliage back to within several inches from the soil before new growth emerges in spring or earlier if the foliage collapses and is blocking water flow
Ornamental grasses (evergreen)		Fall and Spring	Dead growth present in spring	• Hand rake with a small rake or fingers to remove dead growth before new growth emerges in spring • Clean, rake, and comb grasses when they become too tall • Cut back to ground or thin every 2-3 years as needed
Noxious weeds		M (March - October,	Listed noxious vegetation is	• By law, class A & B noxious weeds must be removed,

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
		preceding seed dispersal)	present (refer to current county noxious weed list)	bagged and disposed as garbage immediately • Reasonable attempts must be made to remove and dispose of class C noxious weeds • It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality; use of herbicides and pesticides may be prohibited in some jurisdictions • Apply mulch after weed removal (see "Mulch")
Weeds		M (March - October, preceding seed dispersal)	Weeds are present	• Remove weeds with their roots manually with pincer-type weeding tools, flame weeders, or hot water weeders as appropriate • Follow IPM protocols for weed management (see "Additional Maintenance Resources" section for more information on IPM protocols)
Excessive vegetation		Once in early to mid- May and once in early- to mid- September	Low-lying vegetation growing beyond facility edge onto sidewalks, paths, or street edge poses pedestrian safety hazard or may clog adjacent permeable pavement surfaces due to associated leaf litter, mulch, and soil	• Edge or trim groundcovers and shrubs at facility edge • Avoid mechanical blade-type edger and do not use edger or trimmer within 2 feet of tree trunks • While some clippings can be left in the facility to replenish organic material in the soil, excessive leaf litter can cause surface soil clogging
	As needed		Excessive vegetation density inhibits stormwater	• Determine whether pruning or other routine maintenance is adequate to

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
			flow beyond design ponding or becomes a hazard for pedestrian and vehicular circulation and safety	maintain proper plant density and aesthetics • Determine if planting type should be replaced to avoid ongoing maintenance issues (an aggressive grower under perfect growing conditions should be transplanted to a location where it will not impact flow) • Remove plants that are weak, broken or not true to form; replace in-kind • Thin grass or plants impacting facility function without leaving visual holes or bare soil areas • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
	As needed		Vegetation blocking curb cuts, causing excessive sediment buildup and flow bypass	Remove vegetation and sediment buildup
Mulch				
Mulch		Following weeding	Bare spots (without mulch cover) are present or mulch depth less than 2 inches	• Supplement mulch with hand tools to a depth of 2 to 3 inches • Replenish mulch per O&M manual. Often coarse compost is used in the bottom of the facility and arborist wood chips are used on side slopes and rim (above typical water levels) • Keep all mulch away from woody stems
Watering				

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Irrigation system (if any)		Based on manufacturer's instructions	Irrigation system present	Follow manufacturer's instructions for O&M
	A		Sprinklers or drip irrigation not directed/located to properly water plants	Redirect sprinklers or move drip irrigation to desired areas

Summer watering (first year)		Once every 1-2 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in first year of establishment period	• 10 to 15 gallons per tree
				• 3 to 5 gallons per shrub
				• 2 gallons water per square foot for groundcover areas
				• Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist
				• Use soaker hoses or spot water with a shower type wand when irrigation system is not present
				  ○ Pulse water to enhance soil absorption, when feasible
				  ○ Pre-moisten soil to break surface tension of dry or hydrophobic soils/mulch, followed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff
				• Add a tree bag or slow-release watering device (e.g., bucket with a perforated bottom) for watering newly installed trees when irrigation system is not present

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		

Summer watering (second and third years)		Once every 2-4 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in second or third year of establishment period	• 10 to 15 gallons per tree
				• 3 to 5 gallons per shrub
				• 2 gallons water per square foot for groundcover areas
				• Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist
				• Use soaker hoses or spot water with a shower type wand when irrigation system is not present
				  ○ Pulse water to enhance soil absorption, when feasible
				  ○ Pre-moisten soil to break surface tension of dry or hydrophobic soils/mulch, followed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff

Summer watering (after establishment)		As needed	Established vegetation (after 3 years)	• Plants are typically selected to be drought tolerant and not require regular watering after establishment; however, trees may take up to 5 years of watering to become fully established • Identify trigger mechanisms for drought-stress (e.g., leaf wilt, leaf senescence, etc.) of different species and water immediately after initial signs of stress appear • Water during drought conditions or more often if necessary to maintain plant cover

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Pest Control				
Mosquitoes	B, S		Standing water remains for more than 3 days after the end of a storm	• Identify the cause of the standing water and take appropriate actions to address the problem (see "Ponded water") • To facilitate maintenance, manually remove standing water and direct to the storm drainage system (if runoff is from non pollution-generating surfaces) or sanitary sewer system (if runoff is from pollution-generating surfaces) after getting approval from sanitary sewer authority. • Use of pesticides or *Bacillus thuringiensis israelensis* (Bti) may be considered only as a temporary measure while addressing the standing water cause. If overflow to a surface water will occur within 2 weeks after pesticide use, apply for coverage under the Aquatic Mosquito Control NPDES General Permit.
Nuisance animals	As needed		Nuisance animals causing erosion, damaging plants, or depositing large volumes of feces	• Reduce site conditions that attract nuisance species where possible (e.g., plant shrubs and tall grasses to reduce open areas for geese, etc.) • Place predator decoys • Follow IPM protocols for specific nuisance animal issues (see "Additional Maintenance Resources" section for more information on IPM protocols) • Remove pet waste

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				regularly • For public and right-of-way sites consider adding garbage cans with dog bags for picking up pet waste.
Insect pests	Every site visit associated with vegetation management		Signs of pests, such as wilting leaves, chewed leaves and bark, spotting or other indicators	• Reduce hiding places for pests by removing diseased and dead plants • For infestations, follow IPM protocols (see "Additional Maintenance Resources" section for more information on IPM protocols)

Note that the inspection and routine maintenance frequencies listed above are recommended by Ecology. They do not supersede or replace the municipal stormwater permit requirements for inspection frequency required of municipal stormwater permittees for "stormwater treatment and flow control BMPs/facilities".

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

IPM - Integrated Pest Management

ISA - International Society of Arboriculture

Table V-4.5.2(22) Maintenance Standards - Permeable Pavement

Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Surface/Wearing Course				
Permeable Pavements, all	A, S		Runoff from adjacent pervious areas deposits soil, mulch or	• Clean deposited soil or other materials from permeable pavement or other adjacent surfacing

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
			sediment on paving	• Check if surface elevation of planted area is too high, or slopes towards pavement, and can be regraded (prior to regrading, protect permeable pavement by covering with temporary plastic and secure covering in place) • Mulch and/or plant all exposed soils that may erode to pavement surface
Porous asphalt or pervious concrete		A or B	None (routine maintenance)	Clean surface debris from pavement surface using one or a combination of the following methods: • Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves) • Vacuum/sweep permeable paving installation using: ○ Walk-behind vacuum (sidewalks) ○ High efficiency regenerative air or vacuum sweeper (roadways, parking lots) ○ ShopVac or brush brooms (small areas) • Hand held pressure washer or power washer with rotating brushes Follow equipment manufacturer guidelines for when equipment is most effective for cleaning permeable pavement. Dry weather is more effective for some equipment.
	A_b		Surface is clogged: Ponding on surface or	• Review the overall performance of the facility (note that small clogged areas may not reduce

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
			water flows off the permeable pavement surface during a rain event (does not infiltrate)	overall performance of facility) • Test the surface infiltration rate using ASTM C1701 as a corrective maintenance indicator. Perform one test per installation, up to 2,500 square feet. Perform an additional test for each additional 2,500 square feet up to 15,000 square feet total. Above 15,000 square feet, add one test for every 10,000 square feet. • If the results indicate an infiltration rate of 10 inches per hour or less, then perform corrective maintenance to restore permeability. To clean clogged pavement surfaces, use one or combination of the following methods: ○ Combined pressure wash and vacuum system calibrated to not dislodge wearing course aggregate. ○ Hand held pressure washer or power washer with rotating brushes ○ Pure vacuum sweepers Note: If the annual/biannual routine maintenance standard to clean the pavement surface is conducted using equipment from the list above, corrective maintenance may not be needed.
	A		Sediment present at the surface of the pavement	• Assess the overall performance of the pavement system during a rain event. If water runs off the pavement and/or there is ponding then see above.

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				• Determine source of sediment loading and evaluate whether or not the source can be reduced/eliminated. If the source cannot be addressed, consider increasing frequency of routine cleaning (e.g., twice per year instead of once per year).
	Summer		Moss growth inhibits infiltration or poses slip safety hazard	• Sidewalks: Use a stiff broom to remove moss in the summer when it is dry • Parking lots and roadways: Pressure wash, vacuum sweep, or use a combination of the two for cleaning moss from pavement surface. May require stiff broom or power brush in areas of heavy moss.
	A		Major cracks or trip hazards and concrete spalling and raveling	• Fill potholes or small cracks with patching mixes • Large cracks and settlement may require cutting and replacing the pavement section. Replace in-kind where feasible. Replacing porous asphalt with conventional asphalt is acceptable if it is a small percentage of the total facility area and does not impact the overall facility function. • Take appropriate precautions during pavement repair and replacement efforts to prevent clogging of adjacent porous materials
Interlocking concrete paver blocks and aggregate pavers		A or B	None (routine maintenance)	Clean pavement surface using one or a combination of the following methods: • Remove sediment, debris, trash, vegetation, and other

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves) • Vacuum/sweep permeable paving installation using: ○ Walk-behind vacuum (sidewalks) ○ High efficiency regenerative air or vacuum sweeper (roadways, parking lots) ○ ShopVac or brush brooms (small areas) Note: Vacuum settings may have to be adjusted to prevent excess uptake of aggregate from paver openings or joints. Vacuum surface openings in dry weather to remove dry, encrusted sediment.
	A_b		Surface is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	• Review the overall performance of the facility (note that small clogged areas may not reduce overall performance of facility) • Test the surface infiltration rate using ASTM C1701 as a corrective maintenance indicator. Perform one test per installation, up to 2,500 square feet. Perform an additional test for each additional 2,500 square feet up to 15,000 square feet total. Above 15,000 square feet, add one test for every 10,000 square feet. • If the results indicate an infiltration rate of 10 inches per hour or less, then perform corrective maintenance to restore permeability.

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				• Clogging is usually an issue in the upper 2 to 3 centimeters of aggregate. Remove the upper layer of encrusted sediment, and fines, and/or vegetation from openings and joints between the pavers by mechanical means and/or suction equipment (e.g., pure vacuum sweeper). • Replace aggregate in paver cells, joints, or openings per manufacturer's recommendations
	A		Sediment present at the surface of the pavement	• Assess the overall performance of the pavement system during a rain event. If water runs off the pavement and/or there is ponding, then see above. • Determine source of sediment loading and evaluate whether or not the source can be reduced/eliminated. If the source cannot be addressed, consider increasing frequency of routine cleaning (e.g., twice per year instead of once per year).
	Summer		Moss growth inhibits infiltration or poses slip safety hazard	• Sidewalks: Use a stiff broom to remove moss in the summer when it is dry • Parking lots and roadways: Vacuum sweep or stiff broom/power brush for cleaning moss from pavement surface
	A		Paver block missing or damaged	Remove individual damaged paver blocks by hand and replace or repair per manufacturer's recommendations
	A		Loss of aggregate material between paver blocks	Refill per manufacturer's recommendations for interlocking paver sections
	A		Settlement of surface	May require resetting

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Open-celled paving grid with gravel		A or B	None (routine maintenance)	• Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf blowers can be used for removing leaves) • Follow equipment manufacturer guidelines for cleaning surface.
	A_b		Aggregate is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	• Use vacuum truck to remove and replace top course aggregate • Replace aggregate in paving grid per manufacturer's recommendations
	A		Paving grid missing or damaged	• Remove pins, pry up grid segments, and replace gravel • Replace grid segments where three or more adjacent rings are broken or damaged • Follow manufacturer guidelines for repairing surface.
	A		Settlement of surface	May require resetting
	A		Loss of aggregate material in paving grid	Replenish aggregate material by spreading gravel with a rake (gravel level should be maintained at the same level as the plastic rings or no more than 1/4 inch above the top of rings). See manufacturer's recommendations.
		A	Weeds present	• Manually remove weeds • Presence of weeds may indicate that too many fines are present (refer to Actions Needed under "Aggregate is clogged" to address this issue)
Open-celled paving grid with grass		A or B	None (routine maintenance)	• Remove sediment, debris, trash, vegetation, and other debris deposited onto pavement (rakes and leaf

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
				blowers can be used for removing leaves) • Follow equipment manufacturer guidelines for cleaning surface.
	A_b		Aggregate is clogged: Ponding on surface or water flows off the permeable pavement surface during a rain event (does not infiltrate)	Rehabilitate per manufacturer's recommendations.
	A		Paving grid missing or damaged	• Remove pins, pry up grid segments, and replace grass • Replace grid segments where three or more adjacent rings are broken or damaged • Follow manufacturer guidelines for repairing surface.
	A		Settlement of surface	May require resetting
	A		Poor grass coverage in paving grid	• Restore growing medium, reseed or plant, aerate, and/or amend vegetated area as needed • Traffic loading may be inhibiting grass growth; reconsider traffic loading if feasible
		As needed	None (routine maintenance)	Use a mulch mower to mow grass
		A	None (routine maintenance)	• Sprinkle a thin layer of compost on top of grass surface (1/2" top dressing) and sweep it in • Do not use fertilizer
		A	Weeds present	• Manually remove weeds • Mow, torch, or inoculate and replace with preferred vegetation
Inlets/Outlets/Pipes				
Inlet/outlet pipe	A		Pipe is damaged	Repair/replace
	A		Pipe is clogged	Remove roots or debris

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Underdrain pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	Plant roots, sediment or debris reducing capacity of underdrain (may cause prolonged drawdown period)	• Jet clean or rotary cut debris/roots from underdrain(s) • If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly
Raised subsurface overflow pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	Plant roots, sediment or debris reducing capacity of underdrain	• Jet clean or rotary cut debris/roots from under-drain(s) • If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly
Outlet structure	A, S		Sediment, vegetation, or debris reducing capacity of outlet structure	• Clear the blockage • Identify the source of the blockage and take actions to prevent future blockages
Overflow	B		Native soil is exposed or other signs of erosion damage are present at discharge point	Repair erosion and stabilize surface
Aggregate Storage Reservoir				
Observation port	A, S		Water remains in the storage aggregate longer than anticipated by design after the end of a storm	If immediate cause of extended ponding is not identified, schedule investigation of subsurface materials or other potential causes of system failure.
Vegetation				
Adjacent large shrubs or trees		As needed	Vegetation related fallout clogs or will potentially clog voids	• Sweep leaf litter and sediment to prevent surface clogging and ponding • Prevent large root systems from damaging subsurface structural components
		Once in May and Once in September	Vegetation growing beyond facility edge onto sidewalks, paths,	Edging and trimming of planted areas to control groundcovers and shrubs from overreaching the sidewalks, paths and street edge

Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
			and street edge	improves appearance and reduces clogging of permeable pavements by leaf litter, mulch and soil.
Leaves, needles, and organic debris		In fall (October to December) after leaf drop (1-3 times, depending on canopy cover)	Accumulation of organic debris and leaf litter	Use leaf blower or vacuum to blow or remove leaves, evergreen needles, and debris (i.e., flowers, blossoms) off of and away from permeable pavement

Note that the inspection and routine maintenance frequencies listed above are recommended by Ecology. They do not supersede or replace the municipal stormwater permit requirements for inspection frequency required of municipal stormwater permittees for "stormwater treatment and flow control BMPs/facilities".

a Frequency: A= Annually; B= Biannually (twice per year); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

b Inspection should occur during storm event.

APPENDIX F

DRAFT 2019 RATE STUDY

City of Oak Harbor
Storm Drain Rate Study
Summary of the Revenue Requirement
Exhibit 1

	Budget		*Projected*																		
	2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**
Revenues																					
Total Rate Revenues	$1,947,084	$1,946,305	$1,956,036	$1,965,816	$1,975,645	$1,985,524	$1,995,451	$2,005,428	$2,015,456	$2,025,533	$2,035,660	$2,045,839	$2,056,068	$2,066,348	$2,076,680	$2,087,063	$2,097,499	$2,107,986	$2,118,526	$2,129,119	$2,139,764
Total Miscellaneous Revenue	15,800	15,825	18,952	21,112	20,454	22,483	25,416	29,269	27,007	24,569	26,338	27,945	29,497	31,273	33,258	35,140	36,899	38,513	39,959	41,214	42,250
Total Revenues	**$1,962,884**	**$1,962,130**	**$1,974,988**	**$1,986,928**	**$1,996,099**	**$2,008,007**	**$2,020,867**	**$2,034,697**	**$2,042,462**	**$2,050,102**	**$2,061,999**	**$2,073,783**	**$2,085,565**	**$2,097,622**	**$2,109,938**	**$2,122,203**	**$2,134,397**	**$2,146,499**	**$2,158,485**	**$2,170,332**	**$2,182,015**
Expenses																					
Total Operations & Maintenance	$1,626,032	$1,580,001	$1,454,875	$1,711,185	$1,579,313	$1,619,337	$1,476,339	$1,530,403	$1,896,620	$1,645,083	$1,705,889	$1,769,143	$1,834,950	$1,903,424	$1,974,683	$2,048,851	$2,126,058	$2,206,439	$2,290,137	$2,377,302	$2,468,091
Taxes	146,031	145,973	146,703	147,436	148,173	148,914	149,659	150,407	151,159	151,915	152,675	153,438	154,205	154,976	155,751	156,530	157,312	158,099	158,889	159,684	160,482
Rate Funded Capital	250,000	265,000	280,000	295,000	350,000	380,000	415,000	475,000	380,000	500,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000	525,000
Net Debt Service	60,489	60,343	60,196	60,049	59,903	59,756	59,610	59,464	59,317	59,171	59,024	58,878	58,731	0	0	0	0	0	0	0	0
Reserve Funding	(119,668)	(21,835)	183,103	2,617	129,393	112,834	276,088	219,106	(220)	183,974	155,989	151,372	145,144	196,074	186,731	175,431	162,046	146,437	128,462	107,967	84,791
Total Revenue Requirement	**$1,962,884**	**$2,029,481**	**$2,124,876**	**$2,216,287**	**$2,266,783**	**$2,320,842**	**$2,376,696**	**$2,434,380**	**$2,486,876**	**$2,540,142**	**$2,598,577**	**$2,657,830**	**$2,718,031**	**$2,779,474**	**$2,842,165**	**$2,905,812**	**$2,970,416**	**$3,035,975**	**$3,102,488**	**$3,169,953**	**$3,238,365**
Bal./(Def.) of Funds Before Added Tax	$0	($67,352)	($149,889)	($229,359)	($270,684)	($312,835)	($355,829)	($399,683)	($444,414)	($490,040)	($536,578)	($584,047)	($632,465)	($681,852)	($732,227)	($783,609)	($836,018)	($889,476)	($944,003)	($999,620)	($1,056,350)
Plus: Add'l Taxes with Rate Adj.	0	(4,041)	(8,993)	(13,762)	(16,241)	(18,770)	(21,350)	(23,981)	(26,665)	(29,402)	(32,195)	(35,043)	(37,948)	(40,911)	(43,934)	(47,017)	(50,161)	(53,369)	(56,640)	(59,977)	(63,381)
Bal./(Def.) of Funds With Added Tax	$0	($71,393)	($158,882)	($243,121)	($286,925)	($331,605)	($377,179)	($423,664)	($471,079)	($519,442)	($568,773)	($619,090)	($670,413)	($722,763)	($776,160)	($830,625)	($886,179)	($942,845)	($1,000,643)	($1,059,598)	($1,119,731)
Bal. as a % of Rate Adj. Req'd	0.0%	3.7%	8.1%	12.4%	14.5%	16.7%	18.9%	21.1%	23.4%	25.6%	27.9%	30.3%	32.6%	35.0%	37.4%	39.8%	42.2%	44.7%	47.2%	49.8%	52.3%
Proposed Rate Adjustment	**0.0%**	**4.0%**	**4.0%**	**4.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**
Add'l Revenue with Proposed Rate Adj.	$0	$71,393	$158,882	$243,121	$286,925	$331,605	$377,179	$423,664	$471,079	$519,442	$568,773	$619,090	$670,413	$722,763	$776,160	$830,625	$886,179	$942,845	$1,000,643	$1,059,598	$1,119,731
Bal./(Def.) After Proposed Rate Adj.	$0	$0	($0)	($0)	$0	$0	$0	($0)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	($0)	$0	$0
Additional Rate Adjustment Required	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Average Residential Customer Bill	$14.22	(Single Family Monthly Charge)																			
Customer Bill on Proposed Adj.		$14.79	$15.38	$16.00	$16.32	$16.64	$16.97	$17.31	$17.66	$18.01	$18.37	$18.74	$19.12	$19.50	$19.89	$20.29	$20.69	$21.11	$21.53	$21.96	$22.40
Bill Difference - Monthly		0.57	0.59	0.62	0.32	0.33	0.33	0.34	0.35	0.35	0.36	0.37	0.37	0.38	0.39	0.40	0.41	0.41	0.42	0.43	0.44
Cumulative Bill Difference		0.57	1.16	1.78	2.10	2.42	2.75	3.09	3.44	3.79	4.15	4.52	4.90	5.28	5.67	6.07	6.47	6.89	7.31	7.74	8.18
Debt Service Coverage Ratio (all debt, including taxes)																					
Before Rate Adjustment		3.91	6.20	2.14	4.48	4.01	6.62	5.95	0.00	4.28	3.45	2.57	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
After Proposed Rate Adjustment		5.10	8.84	6.19	9.27	9.56	12.95	13.08	7.85	13.06	13.08	13.08	13.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ending Reserve Fund Balance	**$2,254,712**	**$1,447,876**	**$1,630,980**	**$928,597**	**$1,057,990**	**$1,170,824**	**$1,446,912**	**$1,666,018**	**$980,798**	**$1,164,772**	**$1,320,761**	**$1,472,133**	**$1,617,277**	**$1,813,351**	**$2,000,082**	**$2,175,513**	**$2,337,558**	**$2,483,995**	**$2,612,457**	**$2,720,424**	**$2,805,215**

** 2020 proposed rate adjustment assumed to be effective for 11 months*

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City of Oak Harbor
Storm Drain Rate Study
Escalation Factors
Exhibit 2

	Budget		*Projected*																		
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	*Notes*
Revenues																						
Customer Growth	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	
Miscellaneous Revenues	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	
Flat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Expenses																						
Labor	Budget	Budget	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	
Benefits - Medical	Budget	Budget	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	
Benefits - Other	Budget	Budget	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	
Materials & Supplies	Budget	Budget	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	
Equipment	Budget	Budget	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	
Miscellaneous	Budget	Budget	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	
Utilities	Budget	Budget	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	
Electricity	Budget	Budget	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	3.5%	
Insurance	Budget	Budget	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	
Flat	Budget	Budget	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Interest	0.5%	0.5%	0.5%	0.6%	0.7%	0.8%	0.9%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	
New Debt Service																						
Low Interest Loans																						
Term in Years	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	
Rate	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	
Revenue Bond																						
Term in Years	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	
Rate	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%	

4.6%
2018 actual = $1,861,071

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City of Oak Harbor
Storm Drain Rate Study
Revenue Requirement
Exhibit 3

	Budget		Projected																			
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	Notes
Revenue																						
Rate Revenues																						
Residential	$1,116,910	$1,116,463	$1,122,045	$1,127,655	$1,133,294	$1,138,960	$1,144,655	$1,150,378	$1,156,130	$1,161,911	$1,167,720	$1,173,559	$1,179,427	$1,185,324	$1,191,250	$1,197,207	$1,203,193	$1,209,209	$1,215,255	$1,221,331	$1,227,438	As Customer Growth
Commercial	830,174	829,842	833,991	838,161	842,352	846,563	850,796	855,050	859,325	863,622	867,940	872,280	876,641	881,024	885,430	889,857	894,306	898,778	903,271	907,788	912,327	As Customer Growth
Total Rate Revenues	**$1,947,084**	**$1,946,305**	**$1,956,036**	**$1,965,816**	**$1,975,645**	**$1,985,524**	**$1,995,451**	**$2,005,428**	**$2,015,456**	**$2,025,533**	**$2,035,660**	**$2,045,839**	**$2,056,068**	**$2,066,348**	**$2,076,680**	**$2,087,063**	**$2,097,499**	**$2,107,986**	**$2,118,526**	**$2,129,119**	**$2,139,764**	
Miscellaneous Revenue																						
Interest Income	$2,500	$2,525	$5,585	$7,679	$6,953	$8,915	$11,780	$15,565	$13,234	$10,728	$12,428	$13,964	$15,447	$17,153	$19,067	$20,878	$22,565	$24,108	$25,482	$26,664	$27,628	Calculated on Reserves
Navy Revenue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	As Miscellaneous Revenues
Storm Drainage Fees & Charges	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	As Miscellaneous Revenues
Equipment/Vehicle Rent - External	1,600	1,600	1,608	1,616	1,624	1,632	1,640	1,649	1,657	1,665	1,673	1,682	1,690	1,699	1,707	1,716	1,724	1,733	1,742	1,750	1,759	As Miscellaneous Revenues
Sale of Scrap & Junk	200	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	216	217	218	219	220	As Miscellaneous Revenues
Other Interfund Charges for Svc.	11,000	11,000	11,055	11,110	11,166	11,222	11,278	11,334	11,391	11,448	11,505	11,563	11,620	11,678	11,737	11,796	11,855	11,914	11,973	12,033	12,093	As Miscellaneous Revenues
Other Misc. Revenue - Non-Taxable	500	500	503	505	508	510	513	515	518	520	523	526	528	531	533	536	539	542	544	547	550	As Miscellaneous Revenues
Total Miscellaneous Revenue	**$15,800**	**$15,825**	**$18,952**	**$21,112**	**$20,454**	**$22,483**	**$25,416**	**$29,269**	**$27,007**	**$24,569**	**$26,338**	**$27,945**	**$29,497**	**$31,273**	**$33,258**	**$35,140**	**$36,899**	**$38,513**	**$39,959**	**$41,214**	**$42,250**	
Total Revenue Requirement	**$1,962,884**	**$1,962,130**	**$1,974,988**	**$1,986,928**	**$1,996,099**	**$2,008,007**	**$2,020,867**	**$2,034,697**	**$2,042,462**	**$2,050,102**	**$2,061,999**	**$2,073,783**	**$2,085,565**	**$2,097,622**	**$2,109,938**	**$2,122,203**	**$2,134,397**	**$2,146,499**	**$2,158,485**	**$2,170,332**	**$2,182,015**	
Expenses																						
Salaries & Wages	$367,749	$375,661	$388,809	$402,417	$416,502	$431,080	$446,167	$461,783	$477,946	$494,674	$511,987	$529,907	$548,454	$567,650	$587,517	$608,080	$629,363	$651,391	$674,190	$697,786	$722,209	As Labor
Overtime	7,500	7,500	7,763	8,034	8,315	8,606	8,908	9,219	9,542	9,876	10,222	10,579	10,950	11,333	11,730	12,140	12,565	13,005	13,460	13,931	14,419	As Labor
Personnel Benefits	155,678	159,253	168,808	178,937	189,673	201,053	213,116	225,903	239,458	253,825	269,055	285,198	302,310	320,448	339,675	360,056	381,659	404,559	428,832	454,562	481,836	As Benefits - Medical
Office Supplies	1,500	1,500	1,545	1,591	1,639	1,688	1,739	1,791	1,845	1,900	1,957	2,016	2,076	2,139	2,203	2,269	2,337	2,407	2,479	2,554	2,630	As Materials & Supplies
Operating Supplies	8,000	8,000	8,240	8,487	8,742	9,004	9,274	9,552	9,839	10,134	10,438	10,751	11,074	11,406	11,748	12,101	12,464	12,838	13,223	13,619	14,028	As Materials & Supplies
Small Tools	2,000	2,000	2,060	2,122	2,185	2,251	2,319	2,388	2,460	2,534	2,610	2,688	2,768	2,852	2,937	3,025	3,116	3,209	3,306	3,405	3,507	As Materials & Supplies
Professional Services	15,000	15,000	15,525	16,068	16,631	17,213	17,815	18,439	19,084	19,752	20,443	21,159	21,900	22,666	23,459	24,280	25,130	26,010	26,920	27,862	28,838	As Labor
Communications	13,000	13,000	13,390	13,792	14,205	14,632	15,071	15,523	15,988	16,468	16,962	17,471	17,995	18,535	19,091	19,664	20,254	20,861	21,487	22,132	22,796	As Materials & Supplies
Travel	1,500	1,500	1,545	1,591	1,639	1,688	1,739	1,791	1,845	1,900	1,957	2,016	2,076	2,139	2,203	2,269	2,337	2,407	2,479	2,554	2,630	As Materials & Supplies
Miscellaneous	6,500	6,500	6,663	6,829	7,000	7,175	7,354	7,538	7,726	7,920	8,118	8,321	8,529	8,742	8,960	9,184	9,414	9,649	9,891	10,138	10,391	As Miscellaneous
Operating Transfers	265,205	36,671	75,000	75,000	75,000	75,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Office Supplies (2)	2,000	2,000	2,060	2,122	2,185	2,251	2,319	2,388	2,460	2,534	2,610	2,688	2,768	2,852	2,937	3,025	3,116	3,209	3,306	3,405	3,507	As Materials & Supplies
Small Tools & Minor Equipment	1,500	1,500	1,545	1,591	1,639	1,688	1,739	1,791	1,845	1,900	1,957	2,016	2,076	2,139	2,203	2,269	2,337	2,407	2,479	2,554	2,630	As Materials & Supplies
Professional Services (2)	18,000	18,000	18,630	19,282	19,957	20,655	21,378	22,127	22,901	23,703	24,532	25,391	26,279	27,199	28,151	29,137	30,156	31,212	32,304	33,435	34,605	As Labor
Advertising	2,000	2,000	2,060	2,122	2,185	2,251	2,319	2,388	2,460	2,534	2,610	2,688	2,768	2,852	2,937	3,025	3,116	3,209	3,306	3,405	3,507	As Materials & Supplies
Travel (2)	1,500	1,500	1,545	1,591	1,639	1,688	1,739	1,791	1,845	1,900	1,957	2,016	2,076	2,139	2,203	2,269	2,337	2,407	2,479	2,554	2,630	As Materials & Supplies
Rental	1,500	1,500	1,545	1,591	1,639	1,688	1,739	1,791	1,845	1,900	1,957	2,016	2,076	2,139	2,203	2,269	2,337	2,407	2,479	2,554	2,630	As Materials & Supplies
Insurance	22,000	22,500	23,400	24,336	25,309	26,322	27,375	28,470	29,608	30,793	32,025	33,305	34,638	36,023	37,464	38,963	40,521	42,142	43,828	45,581	47,404	As Insurance
Repair & Maintenance	5,000	1,500	1,545	1,591	1,639	1,688	1,739	1,791	1,845	1,900	1,957	2,016	2,076	2,139	2,203	2,269	2,337	2,407	2,479	2,554	2,630	As Materials & Supplies
Miscellaneous (2)	50,000	50,000	51,250	52,531	53,845	55,191	56,570	57,985	59,434	60,920	62,443	64,004	65,604	67,244	68,926	70,649	72,415	74,225	76,081	77,983	79,933	As Miscellaneous
UB Write Off	500	500	513	525	538	552	566	580	594	609	624	640	656	672	689	706	724	742	761	780	799	As Miscellaneous
Operating Supplies (2)	500	500	515	530	546	563	580	597	615	633	652	672	692	713	734	756	779	802	826	851	877	As Materials & Supplies
Total	**$954,132**	**$734,085**	**$800,135**	**$829,049**	**$859,211**	**$890,681**	**$848,519**	**$882,791**	**$918,564**	**$955,909**	**$994,902**	**$1,035,621**	**$1,078,149**	**$1,122,573**	**$1,168,985**	**$1,217,481**	**$1,268,162**	**$1,321,135**	**$1,376,512**	**$1,434,411**	**$1,494,957**	

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	Budget		*Projected*																		
	2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	***Notes***
Interfund Charges																						
Motor Pool R&M	$62,000	$62,200	$64,688	$67,276	$69,967	$72,765	$75,676	$78,703	$81,851	$85,125	$88,530	$92,071	$95,754	$99,584	$103,568	$107,710	$112,019	$116,499	$121,159	$126,006	$131,046	As Equipment
Shop Ops & Maintenance	54,000	55,000	56,650	58,350	60,100	61,903	63,760	65,673	67,643	69,672	71,763	73,915	76,133	78,417	80,769	83,192	85,688	88,259	90,907	93,634	96,443	As Materials & Supplies
Vehicle Contribution	99,693	99,693	103,681	107,828	112,141	116,627	121,292	126,143	131,189	136,437	141,894	147,570	153,473	159,612	165,996	172,636	179,541	186,723	194,192	201,960	210,038	As Equipment
Hardware Contribution	1,500	1,500	1,560	1,622	1,687	1,755	1,825	1,898	1,974	2,053	2,135	2,220	2,309	2,402	2,498	2,598	2,701	2,809	2,922	3,039	3,160	As Equipment
Software Contribution	16,037	14,501	14,936	15,384	15,846	16,321	16,811	17,315	17,834	18,369	18,921	19,488	20,073	20,675	21,295	21,934	22,592	23,270	23,968	24,687	25,428	As Materials & Supplies
Engineering Allocation - Entp	140,670	308,022	100,000	310,000	130,000	120,000	0	0	310,000	0	0	0	0	0	0	0	0	0	0	0	0	
Supervisory Salaries Allocation	58,000	60,000	62,100	64,274	66,523	68,851	71,261	73,755	76,337	79,009	81,774	84,636	87,598	90,664	93,837	97,122	100,521	104,039	107,681	111,449	115,350	As Labor
Indirect Cost Allocation	240,000	245,000	251,125	257,403	263,838	270,434	277,195	284,125	291,228	298,509	305,971	313,621	321,461	329,498	337,735	346,179	354,833	363,704	372,796	382,116	391,669	As Miscellaneous
Total Interfund Charges	**$671,900**	**$845,916**	**$654,740**	**$882,136**	**$720,102**	**$728,656**	**$627,819**	**$647,612**	**$978,056**	**$689,174**	**$710,987**	**$733,522**	**$756,801**	**$780,851**	**$805,698**	**$831,371**	**$857,896**	**$885,304**	**$913,625**	**$942,891**	**$973,134**	
Total Operations & Maintenance	**$1,626,032**	**$1,580,001**	**$1,454,875**	**$1,711,185**	**$1,579,313**	**$1,619,337**	**$1,476,339**	**$1,530,403**	**$1,896,620**	**$1,645,083**	**$1,705,889**	**$1,769,143**	**$1,834,950**	**$1,903,424**	**$1,974,683**	**$2,048,851**	**$2,126,058**	**$2,206,439**	**$2,290,137**	**$2,377,302**	**$2,468,091**	
Taxes																						
City Utility Tax	$116,825	$116,778	$117,362	$117,949	$118,539	$119,131	$119,727	$120,326	$120,927	$121,532	$122,140	$122,750	$123,364	$123,981	$124,601	$125,224	$125,850	$126,479	$127,112	$127,747	$128,386	Calculated at 6.0% of rate rev
State Utility Tax	29,206	29,195	29,341	29,487	29,635	29,783	29,932	30,081	30,232	30,383	30,535	30,688	30,841	30,995	31,150	31,306	31,462	31,620	31,778	31,937	32,096	Calculated at 1.5% of rate rev
Total Taxes	**$146,031**	**$145,973**	**$146,703**	**$147,436**	**$148,173**	**$148,914**	**$149,659**	**$150,407**	**$151,159**	**$151,915**	**$152,675**	**$153,438**	**$154,205**	**$154,976**	**$155,751**	**$156,530**	**$157,312**	**$158,099**	**$158,889**	**$159,684**	**$160,482**	
Rate Funded Capital	**$250,000**	**$265,000**	**$280,000**	**$295,000**	**$350,000**	**$380,000**	**$415,000**	**$475,000**	**$380,000**	**$500,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	2016 Depr. Exp. = $250,774
Debt Service																						
PWTF - 42" Outfall	$60,489	$60,343	$60,196	$60,049	$59,903	$59,756	$59,610	$59,464	$59,317	$59,171	$59,024	$58,878	$58,731	$0	$0	$0	$0	$0	$0	$0	$0	Debt Schedule
New Low Interest Loans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Calculated
New Revenue Bonds	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Calculated
Total Debt Service	$60,489	$60,343	$60,196	$60,049	$59,903	$59,756	$59,610	$59,464	$59,317	$59,171	$59,024	$58,878	$58,731	$0	$0	$0	$0	$0	$0	$0	$0	
Less: SDC Revenue	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
Net Debt Service	**$60,489**	**$60,343**	**$60,196**	**$60,049**	**$59,903**	**$59,756**	**$59,610**	**$59,464**	**$59,317**	**$59,171**	**$59,024**	**$58,878**	**$58,731**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	
Reserve Funding																						
Operating Reserve - Fund 404	($119,668)	($21,835)	$183,103	$2,617	$129,393	$112,834	$276,088	$219,106	($220)	$183,974	$155,989	$151,372	$145,144	$196,074	$186,731	$175,431	$162,046	$146,437	$128,462	$107,967	$84,791	
System Development Charge (SDC) - Fund	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total Reserve Funding	**($119,668)**	**($21,835)**	**$183,103**	**$2,617**	**$129,393**	**$112,834**	**$276,088**	**$219,106**	**($220)**	**$183,974**	**$155,989**	**$151,372**	**$145,144**	**$196,074**	**$186,731**	**$175,431**	**$162,046**	**$146,437**	**$128,462**	**$107,967**	**$84,791**	
Total Revenue Requirement	**$1,962,884**	**$2,029,481**	**$2,124,876**	**$2,216,287**	**$2,266,783**	**$2,320,842**	**$2,376,696**	**$2,434,380**	**$2,486,876**	**$2,540,142**	**$2,598,577**	**$2,657,830**	**$2,718,031**	**$2,779,474**	**$2,842,165**	**$2,905,812**	**$2,970,416**	**$3,035,975**	**$3,102,488**	**$3,169,953**	**$3,238,365**	

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	Budget		*Projected*																		
	2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	***Notes***
Bal./(Def.) of Funds Before Added Tax	$0	($67,352)	($149,889)	($229,359)	($270,684)	($312,835)	($355,829)	($399,683)	($444,414)	($490,040)	($536,578)	($584,047)	($632,465)	($681,852)	($732,227)	($783,609)	($836,018)	($889,476)	($944,003)	($999,620)	($1,056,350)	
Plus: Add'l Taxes with Rate Adj.	0	(4,041)	(8,993)	(13,762)	(16,241)	(18,770)	(21,350)	(23,981)	(26,665)	(29,402)	(32,195)	(35,043)	(37,948)	(40,911)	(43,934)	(47,017)	(50,161)	(53,369)	(56,640)	(59,977)	(63,381)	
Bal./(Def.) of Funds With Added Tax	$0	($71,393)	($158,882)	($243,121)	($286,925)	($331,605)	($377,179)	($423,664)	($471,079)	($519,442)	($568,773)	($619,090)	($670,413)	($722,763)	($776,160)	($830,625)	($886,179)	($942,845)	($1,000,643)	($1,059,598)	($1,119,731)	
Bal. as a % of Rate Adj. Req'd	0.0%	3.7%	8.1%	12.4%	14.5%	16.7%	18.9%	21.1%	23.4%	25.6%	27.9%	30.3%	32.6%	35.0%	37.4%	39.8%	42.2%	44.7%	47.2%	49.8%	52.3%	
Proposed Rate Adjustment	**0.0%**	**4.0%**	**4.0%**	**4.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	**2.0%**	
Add'l Revenue with Proposed Rate Adj.	$0	$71,393	$158,882	$243,121	$286,925	$331,605	$377,179	$423,664	$471,079	$519,442	$568,773	$619,090	$670,413	$722,763	$776,160	$830,625	$886,179	$942,845	$1,000,643	$1,059,598	$1,119,731	
Bal./(Def.) After Proposed Rate Adj.	$0	$0	($0)	($0)	$0	$0	$0	($0)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	($0)	$0	$0	
Additional Rate Adjustment Required	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	
Average Residential Customer Bill	**$14.22**	*(Single Family Monthly Charge)*																				
Customer Bill on Proposed Adj.	$14.22	$14.79	$15.38	$16.00	$16.32	$16.64	$16.97	$17.31	$17.66	$18.01	$18.37	$18.74	$19.12	$19.50	$19.89	$20.29	$20.69	$21.11	$21.53	$21.96	$22.40	
Bill Difference - Monthly		0.57	0.59	0.62	0.32	0.33	0.33	0.34	0.35	0.35	0.36	0.37	0.37	0.38	0.39	0.40	0.41	0.41	0.42	0.43	0.44	
Cumulative Bill Difference		0.57	1.16	1.78	2.10	2.42	2.75	3.09	3.44	3.79	4.15	4.52	4.90	5.28	5.67	6.07	6.47	6.89	7.31	7.74	8.18	
Debt Service Coverage Ratio (all debt, including taxes)																						
Before Rate Adjustment		3.91	6.20	2.14	4.48	4.01	6.62	5.95	0.00	4.28	3.45	2.57	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
After Proposed Rate Adjustment		5.10	8.84	6.19	9.27	9.56	12.95	13.08	7.85	13.06	13.08	13.08	13.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Cash Reserves																						
Beginning Fund Balance	**$2,599,380**	**$2,254,712**	**$1,447,876**	**$1,630,980**	**$928,597**	**$1,057,990**	**$1,170,824**	**$1,446,912**	**$1,666,018**	**$980,798**	**$1,164,772**	**$1,320,761**	**$1,472,133**	**$1,617,277**	**$1,813,351**	**$2,000,082**	**$2,175,513**	**$2,337,558**	**$2,483,995**	**$2,612,457**	**$2,720,424**	
Operating Reserve - Fund 404																						
Beginning Reserve Fund Balance	**$2,176,999**	**$1,832,331**	**$1,025,495**	**$1,208,599**	**$506,216**	**$635,609**	**$748,443**	**$1,024,531**	**$1,243,637**	**$558,417**	**$742,391**	**$898,380**	**$1,049,752**	**$1,194,896**	**$1,390,970**	**$1,577,701**	**$1,753,132**	**$1,915,177**	**$2,061,614**	**$2,190,076**	**$2,298,043**	
Plus: To Reserve Fund	0	0	183,103	2,617	129,393	112,834	276,088	219,106	0	183,974	155,989	151,372	145,144	196,074	186,731	175,431	162,046	146,437	128,462	107,967	84,791	
Less: Uses of Funds	(344,668)	(806,835)	0	(705,000)	0	0	0	0	(685,220)	0	0	0	0	0	0	0	0	0	0	0	0	
Target: 25% of Rate Revenue	*$486,771*	*$486,576*	*$489,009*	*$491,454*	*$493,911*	*$496,381*	*$498,863*	*$501,357*	*$503,864*	*$506,383*	*$508,915*	*$511,460*	*$514,017*	*$516,587*	*$519,170*	*$521,766*	*$524,375*	*$526,997*	*$529,632*	*$532,280*	*$534,941*	
System Development Charge (SDC) - Fund 414																						
Beginning Reserve Fund Balance	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	
Plus: To Reserve Fund	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Less: Uses of Funds	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Ending Fund Balance	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	**$422,381**	
Ending Fund Balance	**$2,254,712**	**$1,447,876**	**$1,630,980**	**$928,597**	**$1,057,990**	**$1,170,824**	**$1,446,912**	**$1,666,018**	**$980,798**	**$1,164,772**	**$1,320,761**	**$1,472,133**	**$1,617,277**	**$1,813,351**	**$2,000,082**	**$2,175,513**	**$2,337,558**	**$2,483,995**	**$2,612,457**	**$2,720,424**	**$2,805,215**	

** 2020 proposed rate adjustment assumed to be effective for 11 months*

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City of Oak Harbor
Storm Drain Rate Study
Capital Improvement Program
Exhibit 4

	Project #	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	*Notes*
Capital Improvement Projects																							
Convert Well Site 10 to Detention Pond	*SD-1*	$0	$0	$75,000	$250,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
Scenic Heights Outfall	*SD-2*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Upsize Whidbey Ave & Fairhaven Lines	*SD-3*	0	0	100,000	200,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
West-Side Outfall Drainage Pump		0	200,000	0	550,000	310,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
East Outfall Repair		125,000	250,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Conveyance, Flow Control & Treatment		350,000	400,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Dock St Lines	*SD-4*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Freund Marsh Feasiblity Study (Prof Svc)		0	200,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Pasek Vault Treatment Retrofit Study		0	0	0	0	0	80,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7th Avenue Wetland BMP Study		0	0	0	0	0	200,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
DOE Required Retrofit (Based on Studies)		0	0	0	0	0	0	0	0	1,065,000	0	0	0	0	0	0	0	0	0	0	0	0	
Total Capital Improvement Projects		**$475,000**	**$1,050,000**	**$175,000**	**$1,000,000**	**$310,000**	**$280,000**	**$0**	**$0**	**$1,065,000**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	
Future Unidentified Capital Projects		**$0**	**$0**	**$105,000**	**$0**	**$40,000**	**$100,000**	**$415,000**	**$475,000**	**$0**	**$500,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	
Transfer to Capital Reserves		**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	
Total Capital Improvement Projects		**$475,000**	**$1,050,000**	**$280,000**	**$1,000,000**	**$350,000**	**$380,000**	**$415,000**	**$475,000**	**$1,065,000**	**$500,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	
Other Funding Sources																							
System Development Charge (SDC) - Fund 414		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	Input
Operating Reserve - Fund 404		225,000	785,000	0	705,000	0	0	0	0	685,000	0	0	0	0	0	0	0	0	0	0	0	0	Input
Capital Reserves		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Input
.09 Grant		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Input
New Low Interest Loans		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Input
New Revenue Bonds		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Calculated
Total Other Funding Sources		**$225,000**	**$785,000**	**$0**	**$705,000**	**$0**	**$0**	**$0**	**$0**	**$685,000**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	
Rate Funded Capital		**$250,000**	**$265,000**	**$280,000**	**$295,000**	**$350,000**	**$380,000**	**$415,000**	**$475,000**	**$380,000**	**$500,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	**$525,000**	

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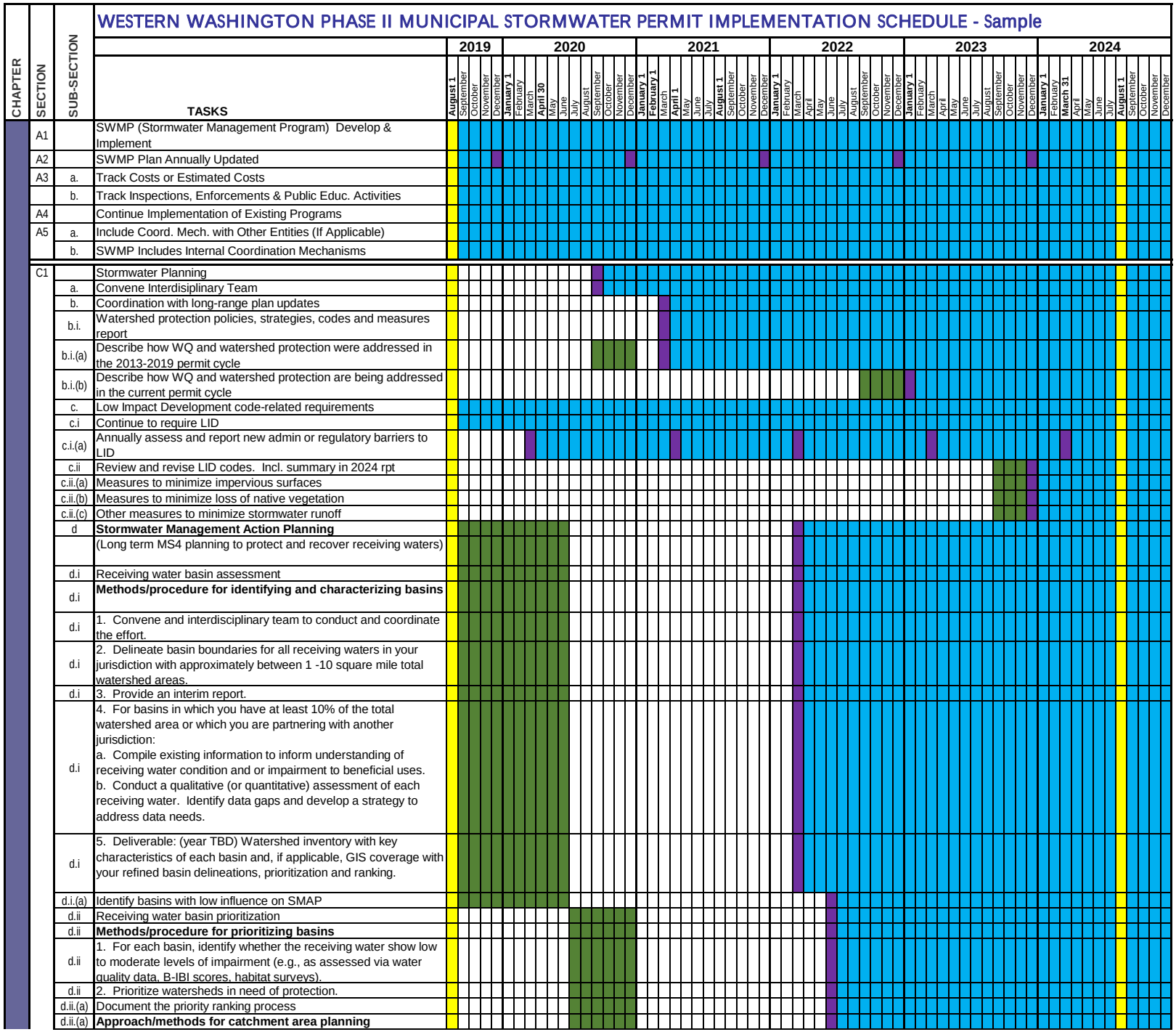
	Present	*Proposed*				
	2019	**2020**	**2021**	**2022**	**2023**	**2024**
Residential						
Single Family per account	$14.22	$14.79	$15.38	$16.00	$16.32	$16.65
Multi Family per unit	14.22	14.79	15.38	16.00	16.32	16.65
Commercial per ERU						
Commercial	$14.22	$14.79	$15.38	$16.00	$16.32	$16.65
Multi-Commercial	14.22	14.79	15.38	16.00	16.32	16.65
Hotel / Motel	14.22	14.79	15.38	16.00	16.32	16.65
Commercial / Residential	14.22	14.79	15.38	16.00	16.32	16.65
Schools	14.22	14.79	15.38	16.00	16.32	16.65
Church	14.22	14.79	15.38	16.00	16.32	16.65
Non-Profit	14.22	14.79	15.38	16.00	16.32	16.65

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APPENDIX G

SAMPLE NPDES PHASE II PERMIT SCHEDULE

WESTERN WASHINGTON PHASE II MUNICIPAL STORMWATER PERMIT IMPLEMENTATION SCHEDULE - Sample



CHAPTER	SECTION	SUB-SECTION	TASKS
	A1		SWMP (Stormwater Management Program) Develop & Implement
	A2		SWMP Plan Annually Updated
	A3	a.	Track Costs or Estimated Costs
		b.	Track Inspections, Enforcements & Public Educ. Activities
	A4		Continue Implementation of Existing Programs
	A5	a.	Include Coord. Mech. with Other Entities (If Applicable)
		b.	SWMP Includes Internal Coordination Mechanisms
	C1		Stormwater Planning
		a.	Convene Interdisiplinary Team
		b.	Coordination with long-range plan updates
		b.i.	Watershed protection policies, strategies, codes and measures report
		b.i.(a)	Describe how WQ and watershed protection were addressed in the 2013-2019 permit cycle
		b.i.(b)	Describe how WQ and watershed protection are being addressed in the current permit cycle
		c.	Low Impact Development code-related requirements
		c.i	Continue to require LID
		c.i.(a)	Annually assess and report new admin or regulatory barriers to LID
		c.ii	Review and revise LID codes. Incl. summary in 2024 rpt
		c.ii.(a)	Measures to minimize impervious surfaces
		c.ii.(b)	Measures to minimize loss of native vegetation
		c.ii.(c)	Other measures to minimize stormwater runoff
		d	**Stormwater Management Action Planning**
			(Long term MS4 planning to protect and recover receiving waters)
		d.i	Receiving water basin assessment
		d.i	**Methods/procedure for identifying and characterizing basins**
		d.i	1. Convene and interdisciplinary team to conduct and coordinate the effort.
		d.i	2. Delineate basin boundaries for all receiving waters in your jurisdiction with approximately between 1 -10 square mile total watershed areas.
		d.i	3. Provide an interim report.
		d.i	4. For basins in which you have at least 10% of the total watershed area or which you are partnering with another jurisdiction: a. Compile existing information to inform understanding of receiving water condition and or impairment to beneficial uses. b. Conduct a qualitative (or quantitative) assessment of each receiving water. Identify data gaps and develop a strategy to address data needs.
		d.i	5. Deliverable: (year TBD) Watershed inventory with key characteristics of each basin and, if applicable, GIS coverage with your refined basin delineations, prioritization and ranking.
		d.i.(a)	Identify basins with low influence on SMAP
		d.ii	Receiving water basin prioritization
		d.ii	**Methods/procedure for prioritizing basins**
		d.ii	1. For each basin, identify whether the receiving water show low to moderate levels of impairment (e.g., as assessed via water quality data, B-IBI scores, habitat surveys).
		d.ii	2. Prioritize watersheds in need of protection.
		d.ii.(a)	Document the priority ranking process
		d.ii.(a)	**Approach/methods for catchment area planning**

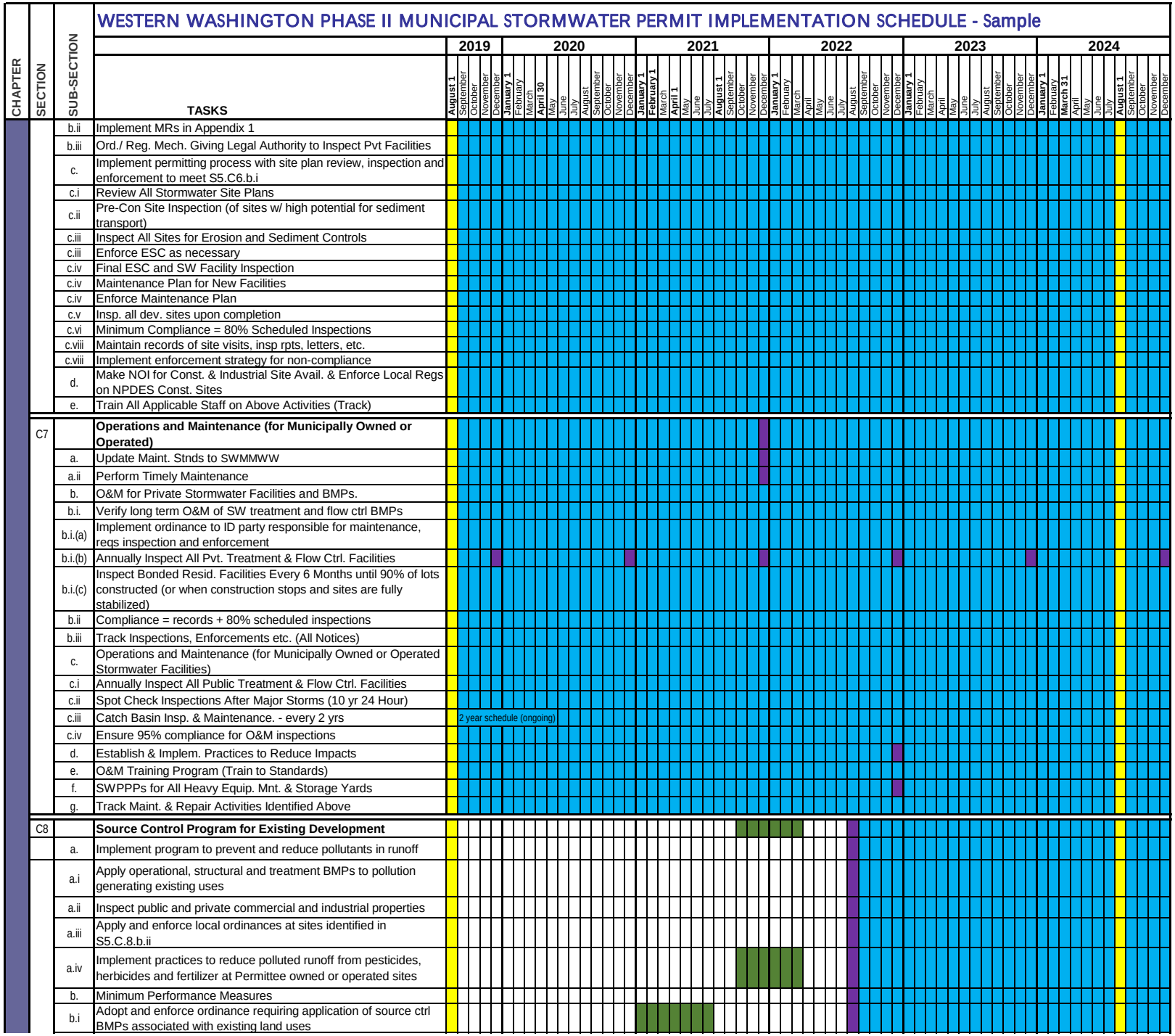
WESTERN WASHINGTON PHASE II MUNICIPAL STORMWATER PERMIT IMPLEMENTATION SCHEDULE - Sample

CHAPTER	SECTION	SUB-SECTION	TASKS
		d.ii.(a)	Develop a long-term MS4 plan for the catchment areas (receiving water body subbasins approximately 400-600 acres in size) which they identify in their priority basins.
		d.ii.(a)	1. Share the results of your prioritization process and engage your interdisciplinary team in identifying which catchment areas will be your focus for long-term MS4 planning. a. Include public/citizen representation and involvement in this process.
		d.ii.(a)	2. For **TBD** of your top priority basins, identify **TBD** catchment areas for planning.
		d.ii.(a)	3. Identify actions that are most likely to improve hydrologic and water quality conditions.
		d.ii.(a)	4. Conduct a public review process and have discussions with planning officials throughout the process.
		d.ii.(a)	5. Develop an effectiveness assessment to provide feedback on the implementation efforts.
		d.ii.(a)	6. Deliverable in year TBD of permit: proposed plan (including rationale for selected BMPs/actions) and estimated budget/funding approach.
		d.ii.(b)	ID and rank areas where receiving waters would benefit from retrofits and targeted implementation
		d.iii	Develop SMAP (Stormwater Management Action Plan) for at least one high priority area that identifies:
		d.iii.(a)	Desc. of needed facility retrofit, BMPs and locations
		d.iii.(b)	Land mgmt/development strategies
		d.iii.(c)	Targeted, enhanced or customized impl. of SW mgmt actions
		d.iii.(d)	Identify needed changes to long range plans
		d.iii.(e)	Proposed Implementation Schedule and budget for: Short-term actions (Less than 6 years), and Long-term actions (7-20 years)
		d.iii.(f)	Process to assess and provide feedback on planning process, implementation and projects.
	C2		**Public Education & Outreach**
		a.	Program based on Local WQ and Demographics
		a.i	General Awareness - **Annually** select 1 target audience and 1 subject from either S5.C2.a.i (a) or (b)
		a.i.(c)	Provide information to target audience on an ongoing or strategic schedule
		a.ii	Behavior Change - Select 1 target audience and 1 BMP from S5.C2.a.ii(a)
		a.ii.(b).	Evaluate Behavior Change program from 2013-2019 permit
		a.ii.(c)	Based on evaluation, develop social media marketing program tailored to community using Community-Based Social Marketing.
		a.ii.(c)1	Dev. strategy and sch. to effectively implement ex. prog., **or**
		a.ii.(c)2	Dev. strategy and sch. to expand ex. prog. to new audience or BMPs, **or**
		a.ii.(c)3	Dev. strategy and sch. for new target audience and BMP behavior change campaign
		a.ii.(d)	Begin to implement strategy from S5.C2.a.ii.(c)
		a.ii.(e)	Evaluate and report on changes in understanding and adoption and planned or recommended changes to campaign.
		a.ii.(f)	Use evaluation results to direct ongoing behavior change program
		a.iii	Create Stewardship Opportunities

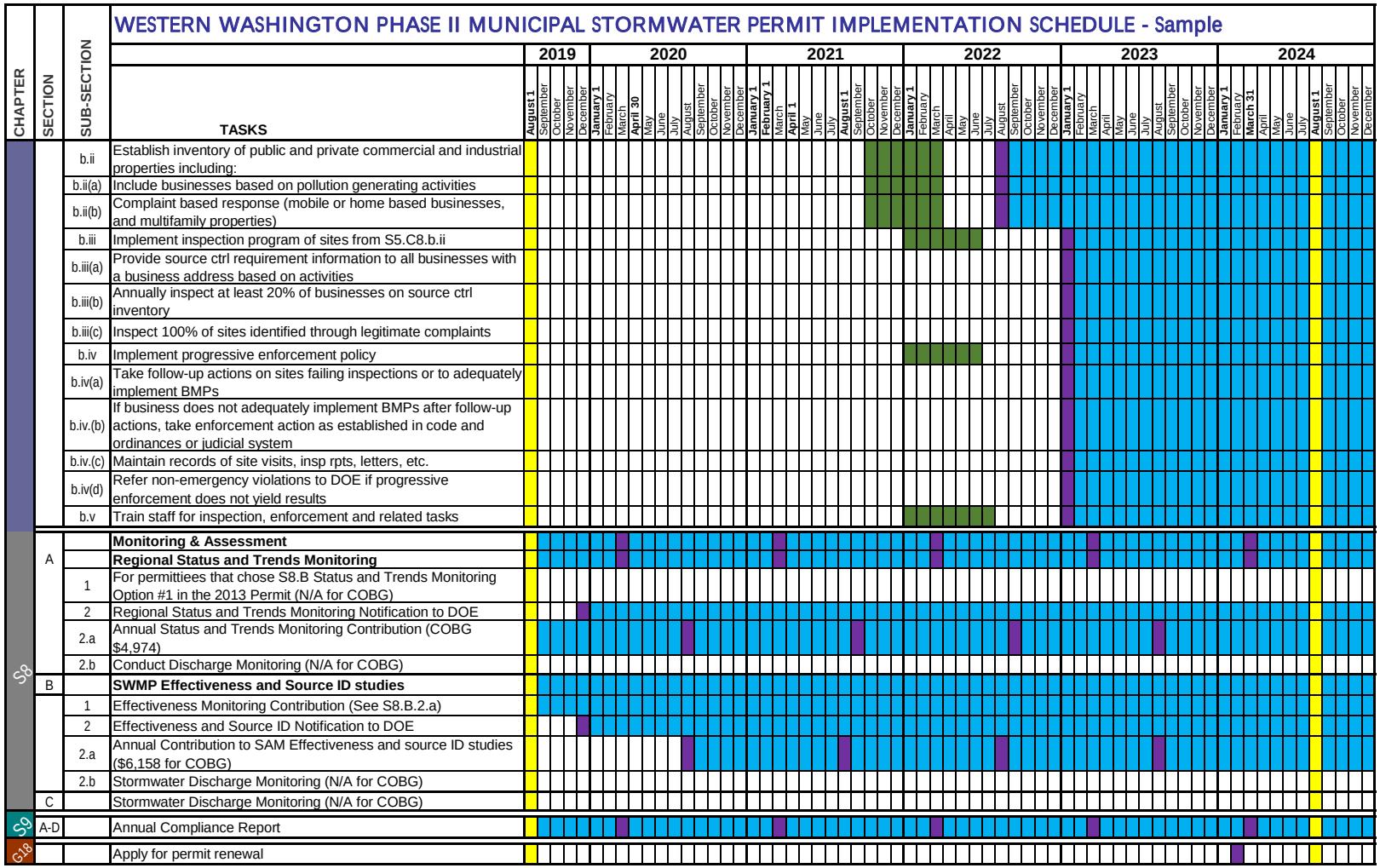
WESTERN WASHINGTON PHASE II MUNICIPAL STORMWATER PERMIT IMPLEMENTATION SCHEDULE - Sample

CHAPTER	SECTION	SUB-SECTION	TASKS
S5	C3		**Public Involvement and Participation**
		a.	Create Opportunities for Public Participation
		b.	SWMP & Annual Report Website Posting
	C4		**MS4 Mapping and Documentation**
		a.	Ongoing Stormwater Mapping - periodically update
		a.i	Update known MS4 outfalls and discharge points
		a.ii	Update receiving waters
		a.iii	SW treatment and flow ctrl BMPs/facilities owned or operated by Permittee
		a.iv	Geographic areas served by Permittee's MS4 that do not discharge to surface waters
		a.v	Tributary conveyances to all known outfalls 24" diameter or equivalent:
		a.v.(a)	Tributary conveyance type, material and size
		a.v.(b)	Associated drainage areas
		a.v.(c)	Land use
		a.vi	Connections between MS4 and other public entities
		a.vii	Map All New Connections Since February 16, 2007
		b	New Mapping
		b.i	Map size and material for all known MS4 outfalls
		b.ii	Map all known connections from MS4 to private storm systems
		c.	All mapping to be electronic fully described mapping standards
		d.	Make maps available to Ecology upon request
		e.	Make maps available to tribe, municipalities or Permittees upon request
	C5		**Illicit Discharge Detection & Elimination Program**
		a.	Include procedure for reporting, or removing illicit connections, spills or discharges
		b.	Inform public employees, businesses and general public of hazards of illicit discharges
		c.	Implement ordinance to prohibit non-stormwater illicit discharges
		c.iv	Ordinance shall include escalating enforcement
		d.	Implement program to detect illicit discharges
		d.i.a	Field screen 12% of MS4 each year
		d.ii	Publicly List Phone #'s for Reporting Spills
		d.iii	Ongoing Training all Muni. Field Staff
		e.	Ongoing IDDE Program to include:
		e.i	Procedures to characterize illicit discharge
		e.ii	Procedures to trace illicit discharge
		e.iii	Procedures for eliminating illicit discharges
		e.iv	Compliance = respond, investigate, eliminate w/i 6 months
		f.	Staff IDDE training
		g.	Track and keep records of IDDE Program **in WQWebIDDE format**
	C6		**Controlling Runoff from New Development, Redevelopment and Construction Sites**
		a.	Update Construction Site Runoff Ordinance
		a.i	Apply program (S5.C6.b.(i) through (iii) to projects submitted after 07/01/2022
		a.ii	Apply program to projects submitted prior to 01/01/2017 that have not started work by 01/01/2022
		a.iii	Apply program to projects submitted prior to 07/01/2022 that have not started work by 01/01/2022
		b.	The ordinance shall include:
		b.i	Site Plan & BMP Select per Append 1 or Approved Ph I

WESTERN WASHINGTON PHASE II MUNICIPAL STORMWATER PERMIT IMPLEMENTATION SCHEDULE - Sample



WESTERN WASHINGTON PHASE II MUNICIPAL STORMWATER PERMIT IMPLEMENTATION SCHEDULE - Sample



CHAPTER	SECTION	SUB-SECTION	TASKS
		b.ii	Establish inventory of public and private commercial and industrial properties including:
		b.ii(a)	Include businesses based on pollution generating activities
		b.ii(b)	Complaint based response (mobile or home based businesses, and multifamily properties)
		b.iii	Implement inspection program of sites from S5.C8.b.ii
		b.iii(a)	Provide source ctrl requirement information to all businesses with a business address based on activities
		b.iii(b)	Annually inspect at least 20% of businesses on source ctrl inventory
		b.iii(c)	Inspect 100% of sites identified through legitimate complaints
		b.iv	Implement progressive enforcement policy
		b.iv(a)	Take follow-up actions on sites failing inspections or to adequately implement BMPs
		b.iv.(b)	If business does not adequately implement BMPs after follow-up actions, take enforcement action as established in code and ordinances or judicial system
		b.iv.(c)	Maintain records of site visits, insp rpts, letters, etc.
		b.iv(d)	Refer non-emergency violations to DOE if progressive enforcement does not yield results
		b.v	Train staff for inspection, enforcement and related tasks
S8			**Monitoring & Assessment**
	A		**Regional Status and Trends Monitoring**
		1	For permittiees that chose S8.B Status and Trends Monitoring Option #1 in the 2013 Permit (N/A for COBG)
		2	Regional Status and Trends Monitoring Notification to DOE
		2.a	Annual Status and Trends Monitoring Contribution (COBG $4,974)
		2.b	Conduct Discharge Monitoring (N/A for COBG)
	B		**SWMP Effectiveness and Source ID studies**
		1	Effectiveness Monitoring Contribution (See S8.B.2.a)
		2	Effectiveness and Source ID Notification to DOE
		2.a	Annual Contribution to SAM Effectiveness and source ID studies ($6,158 for COBG)
		2.b	Stormwater Discharge Monitoring (N/A for COBG)
	C		Stormwater Discharge Monitoring (N/A for COBG)
S9	A-D		Annual Compliance Report
G18			Apply for permit renewal

LEGEND:

- **Effective & Expiration Dates of Permit**
- **Ongoing Requirement**
- **Permit Deadline**
- **Prep Work**

APPENDIX H

COST ESTIMATES

CITY OF OAK HARBOR
UDC-1: Stormwater Pipe Replacement (N. Oak Harbor St.)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		UNIT PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 37,000	$ 37,000
3.	Project Temporary Traffic Control	1	LS	$ 5,000	$ 5,000
4.	Locate Existing Utilities	1	LS	$ 5,000	$ 5,000
5.	Survey	1	LS	$ 10,000	$ 10,000
6.	Temporary Erosion Control	1	LS	$ 5,000	$ 5,000
7.	Sawcutting	2,800	LF	$ 5	$ 14,000
8.	Remove Asphalt Pavement	630	SY	$ 75	$ 47,250
9.	Excavation Incl. Haul	630	CY	$ 30	$ 18,900
10.	Remove Existing Pipe	1,400	LF	$ 30	$ 42,000
11.	Gravel Borrow, Incl. Haul	115	TN	$ 35	$ 4,025
12.	18-inch Storm Pipe (Incl. Bedding)	1,400	LF	$ 80	$ 112,000
13.	Crushed Surfacing Base Course	80	TN	$ 50	$ 4,000
14.	Crushed Surfacing Top Course	80	TN	$ 50	$ 4,000
15.	HMA, CL 1/2-in PG 64-22	215	TN	$ 150	$ 32,288
16.	Catch Basin, Type 1	15	EA	$ 2,000	$ 30,000
17.	Catch Basin, Type 2, 48-inch	4	EA	$ 3,000	$ 12,000
18.	Connect to Drainage Structure	4	EA	$ 1,500	$ 6,000
19.	Trench Excavation Safety Systems	1	LS	$ 5	$ 10,000
20.	Project Documentation	1	LS	$ 1,000	$ 1,000
	Subtotal			SUBTOTAL	$ 400,463
	Sales Tax (8.7%)				$ 36,442
	Subtotal				$ 436,905
	Construction Contingencies (20%)				$ 87,381
	Permitting (10%)				$ 43,690
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 568,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 142,000
	TOTAL PROJECT COST				**$ 710,000**

Year of Design:		2030
Year of Construction:		2031
Cost of Design in Year of Design:	$	208,000
Cost of Construction in Year of Construction:	$	859,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
UDC-2: Stormwater Pipe Replacement (NE 7th Ave. and NE Ellis)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 7,000	$ 7,000
3.	Project Temporary Traffic Control	1	LS	$ 3,000	$ 3,000
4.	Locate Existing Utilities	1	LS	$ 1,000	$ 1,000
5.	Survey	1	LS	$ 2,000	$ 2,000
6.	Dewatering	1	LS	$ 3,000	$ 3,000
7.	Temporary Erosion Control	1	LS	$ 3,000	$ 3,000
8.	Sawcutting	50	LF	$ 5	$ 250
9.	Remove Asphalt Pavement	15	SY	$ 75	$ 1,125
10.	Remove Existing Pipe	265	LF	$ 30	$ 7,950
11.	Excavation, Embankment and Grading, Incl. Haul	150	CY	$ 35	$ 5,250
12.	Gravel Borrow, Incl. Haul	30	TN	$ 35	$ 1,050
13.	Unsuitable Foundation Excavation, Incl. Haul	15	CY	$ 40	$ 600
14.	18-inch Storm Pipe (Incl. Bedding)	265	LF	$ 80	$ 21,200
15.	Crushed Surfacing Base Course	30	TN	$ 50	$ 1,500
16.	Crushed Surfacing Top Course	30	TN	$ 50	$ 1,500
17.	HMA, CL 1/2-in PG 64-22	10	TN	$ 150	$ 1,500
18.	Catch Basin, Type 1	1	EA	$ 2,000	$ 2,000
19.	Connect to Drainage Structure	2	EA	$ 1,500	$ 3,000
20.	Trench Excavation Safety Systems	265	LF	$ 5	$ 1,325
21.	Surface Restoration (seeding, fertilizing, planting, etc)		SY	$ 7	$ -
22.	Project Documentation	1	LS	$ 1,000	$ 1,000
	Subtotal			SUBTOTAL	$ 69,250
	Sales Tax (8.7%)				$ 6,302
	Subtotal				$ 75,552
	Construction Contingencies (20%)				$ 15,110
	Permitting (10%)				$ 7,555
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 98,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 25,000
	TOTAL PROJECT COST				**$ 123,000**

Year of Design:		2020
Year of Construction:		2021
Cost of Design in Year of Design:	$	26,000
Cost of Construction in Year of Construction:	$	105,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
UDC-3: Conveyance, flow control and treatment improvements in the vicinity of Goldie St., Koetje St., and Easy St.
ENGINEER'S COST ESTIMATE
Monday, October 14, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 26,000	$ 26,000
3.	Project Temporary Traffic Control	1	LS	$ 10,000	$ 10,000
4.	Locate Existing Utilities	1	LS	$ 2,000	$ 2,000
5.	Survey	1	LS	$ 5,000	$ 5,000
6.	Dewatering	1	LS	$ 20,000	$ 20,000
7.	Temporary Erosion Control	1	LS	$ 8,000	$ 8,000
8.	Flow Control/Water Quality Treatment Facility	1	LS	$ 120,000	$ 120,000
9.	Stormwater Conveyance	1	LS	$ 85,000	$ 85,000
10.	Project Documentation	1	LS	$ 5,000	$ 5,000
	Subtotal			SUBTOTAL	$ 282,000
	Sales Tax (8.7%)				$ 25,662
	Subtotal				$ 307,662
	Construction Contingencies (20%)				$ 61,532
	Permitting (10%)				$ 30,766
	CONSTRUCTION COST ESTIMATE				**$ 400,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 103,500
	TOTAL PROJECT COST				**$ 503,500**

Year of Design:		2019
Year of Construction:		2020
Cost of Design in Year of Design:	$	103,500
Cost of Construction in Year of Construction:	$	400,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
M-1: New Stormwater Infrastructure (NE Ronhaar St. and NE 6th Ave.)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 65,000	$ 65,000
3.	Project Temporary Traffic Control	1	LS	$ 31,000	$ 31,000
4.	Locate Existing Utilities	1	LS	$ 5,000	$ 5,000
5.	Survey	1	LS	$ 10,000	$ 10,000
6.	Dewatering	1	LS	$ 15,000	$ 15,000
7.	Temporary Erosion Control	1	LS	$ 10,000	$ 10,000
8.	Sawcutting	7,010	LF	$ 5	$ 35,050
9.	Remove Asphalt Pavement	1,167	SY	$ 75	$ 87,500
10.	Excavation Incl. Haul	1,365	CY	$ 30	$ 40,950
11.	Gravel Borrow, Incl. Haul	246	TN	$ 35	$ 8,600
12.	12-inch Storm Pipe (Incl. Bedding)	3,500	LF	$ 70	$ 245,000
13.	Crushed Surfacing Base Course	235	TN	$ 50	$ 11,750
14.	Crushed Surfacing Top Course	235	TN	$ 50	$ 11,750
15.	HMA, CL 1/2-in PG 64-22	400	TN	$ 150	$ 60,000
16.	Catch Basin, Type 1	20	EA	$ 2,000	$ 40,000
17.	Connect to Drainage Structure		EA	$ 1,500	$ -
18.	Trench Excavation Safety Systems	3,500	LF	$ 5	$ 17,500
19.	Utility Coordination	1	LS	$ 10,000	$ 10,000
20.	Project Documentation	1	LS	$ 5,000	$ 5,000
	Subtotal			SUBTOTAL	$ 710,100
	Sales Tax (8.7%)				$ 64,619
	Subtotal				$ 774,719
	Construction Contingencies (20%)				$ 154,944
	Permitting (10%)				$ 77,472
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 1,007,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 252,000
	TOTAL PROJECT COST				**$ 1,259,000**

Year of Design:		2038
Year of Construction:		2039
Cost of Design in Year of Design:	$	485,000
Cost of Construction in Year of Construction:	$	2,004,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
M-2: Stormwater Pipe Replacement (NE 7th Ave.)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 15,000	$ 15,000
3.	Project Temporary Traffic Control	1	LS	$ 7,000	$ 7,000
4.	Locate Existing Utilities	1	LS	$ 1,000	$ 1,000
5.	Survey	1	LS	$ 2,000	$ 2,000
6.	Dewatering	1	LS	$ 4,000	$ 4,000
7.	Temporary Erosion Control	1	LS	$ 4,000	$ 4,000
8.	Sawcutting	750	LF	$ 5	$ 3,750
9.	Remove Asphalt Pavement	210	SY	$ 75	$ 15,750
10.	Remove Existing Pipe	370	LF	$ 30	$ 11,100
11.	Excavation Incl. Haul	315	CY	$ 30	$ 9,450
12.	Gravel Borrow, Incl. Haul	57	TN	$ 35	$ 1,985
13.	30-inch Storm Pipe (Incl. Bedding)	370	LF	$ 150	$ 55,500
14.	Crushed Surfacing Base Course	45	TN	$ 50	$ 2,250
15.	Crushed Surfacing Top Course	45	TN	$ 50	$ 2,250
16.	HMA, CL 1/2-in PG 64-22	75	TN	$ 150	$ 11,250
17.	Catch Basin, Type 1	1	EA	$ 2,000	$ 2,000
18.	Connect to Drainage Structure	2	EA	$ 1,500	$ 3,000
19.	Trench Excavation Safety Systems	370	LF	$ 5	$ 1,850
20.	Project Documentation	1	LS	$ 1,000	$ 1,000
	Subtotal			SUBTOTAL	$ 155,135
	Sales Tax (8.7%)				$ 14,117
	Subtotal				$ 169,252
	Construction Contingencies (20%)				$ 33,850
	Permitting (10%)				$ 16,925
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 220,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 55,000
	TOTAL PROJECT COST				**$ 275,000**

Year of Design:		2033
Year of Construction:		2034
Cost of Design in Year of Design:	$	90,000
Cost of Construction in Year of Construction:	$	369,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
M-3: Stormwater Pipe Replacement (SE 4th Ave., SE 5th Ave., SE Ely St.)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 45,000	$ 45,000
3.	Project Temporary Traffic Control	1	LS	$ 22,000	$ 22,000
4.	Locate Existing Utilities	1	LS	$ 5,000	$ 5,000
5.	Survey	1	LS	$ 10,000	$ 10,000
6.	Dewatering	1	LS	$ 15,000	$ 15,000
7.	Temporary Erosion Control	1	LS	$ 10,000	$ 10,000
8.	Sawcutting	2,910	LF	$ 5	$ 14,550
9.	Remove Asphalt Pavement	803	SY	$ 75	$ 60,208
10.	Remove Existing Pipe	1,445	LF	$ 30	$ 43,350
11.	Excavation Incl. Haul	1,204	CY	$ 30	$ 36,125
12.	Gravel Borrow, Incl. Haul	217	TN	$ 35	$ 7,586
13.	12-inch Storm Pipe (Incl. Bedding)	1,290	LF	$ 70	$ 90,300
14.	18-inch Storm Pipe (Incl. Bedding)	155	LF	$ 80	$ 12,400
15.	Crushed Surfacing Base Course	165	TN	$ 50	$ 8,250
16.	Crushed Surfacing Top Course	165	TN	$ 50	$ 8,250
17.	HMA, CL 1/2-in PG 64-22	275	TN	$ 150	$ 41,250
18.	Catch Basin, Type 1	14	EA	$ 2,000	$ 28,000
19.	Catch Basin, Type 2, 48-inch	4	EA	$ 3,000	$ 12,000
20.	Connect to Drainage Structure	7	EA	$ 1,500	$ 10,500
21.	Trench Excavation Safety Systems	1,445	LF	$ 5	$ 7,225
22.	Surface Restoration (seeding, fertilizing, planting, etc)		SY	$ 7	$ -
23.	Utility Coordination		LS	$ 10,000	$ -
24.	Project Documentation	1	LS	$ 5,000	$ 5,000
	Subtotal			SUBTOTAL	$ 492,995
	Sales Tax (8.7%)				$ 44,863
	Subtotal				$ 537,857
	Construction Contingencies (20%)				$ 107,571
	Permitting (10%)				$ 53,786
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 699,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 175,000
	TOTAL PROJECT COST				**$ 874,000**

Year of Design:		2032
Year of Construction:		2033
Cost of Design in Year of Design:	$	274,000
Cost of Construction in Year of Construction:	$	1,132,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
M-4: Replace Corrugated Stormwater Pipe (South of Cabot Dr.)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 14,000	$ 14,000
3.	Project Temporary Traffic Control	1	LS	$ 7,000	$ 7,000
4.	Locate Existing Utilities	1	LS	$ 1,000	$ 1,000
5.	Survey	1	LS	$ 2,000	$ 2,000
6.	Dewatering	1	LS	$ 4,000	$ 4,000
7.	Temporary Erosion Control	1	LS	$ 4,000	$ 4,000
8.	Sawcutting	740	LF	$ 5	$ 3,700
9.	Remove Asphalt Pavement	203	SY	$ 75	$ 15,208
10.	Remove Existing Pipe	365	LF	$ 30	$ 10,950
11.	Excavation Incl. Haul	304	CY	$ 30	$ 9,125
12.	Gravel Borrow, Incl. Haul	55	TN	$ 35	$ 1,916
13.	24-inch Storm Pipe (Incl. Bedding)	365	LF	$ 120	$ 43,800
14.	Crushed Surfacing Base Course	45	TN	$ 50	$ 2,250
15.	Crushed Surfacing Top Course	45	TN	$ 50	$ 2,250
16.	HMA, CL 1/2-in PG 64-22	70	TN	$ 150	$ 10,500
17.	Catch Basin, Type 2, 48-inch	2	EA	$ 3,000	$ 6,000
18.	Connect to Drainage Structure	2	EA	$ 1,500	$ 3,000.00
19.	Trench Excavation Safety Systems	365	LF	$ 5	$ 1,825
20.	Surface Restoration (seeding, fertilizing, planting, etc)		SY	$ 7	$ -
21.	Utility Coordination		LS	$ 10,000	$ -
22.	Project Documentation	1	LS	$ 2,000	$ 2,000
	Subtotal			SUBTOTAL	$ 145,525
	Sales Tax (8.7%)				$ 13,243
	Subtotal				$ 158,767
	Construction Contingencies (20%)				$ 31,753
	Permitting (10%)				$ 15,877
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 206,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 52,000
	TOTAL PROJECT COST				**$ 258,000**

Year of Design:		2028
Year of Construction:		2029
Cost of Design in Year of Design:	$	71,000
Cost of Construction in Year of Construction:	$	291,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
M-5: Stormwater Pipe Replacement (SE Bayshore Drive)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 15,000	$ 15,000
3.	Project Temporary Traffic Control	1	LS	$ 8,000	$ 8,000
4.	Locate Existing Utilities	1	LS	$ 1,000	$ 1,000
5.	Survey	1	LS	$ 2,000	$ 2,000
6.	Dewatering	1	LS	$ 4,000	$ 4,000
7.	Temporary Erosion Control	1	LS	$ 4,000	$ 4,000
8.	Sawcutting	740	LF	$ 5	$ 3,700
9.	Remove Asphalt Pavement	203	SY	$ 75	$ 15,208
10.	Remove Existing Pipe	365	LF	$ 30	$ 10,950
11.	Excavation Incl. Haul	304	CY	$ 30	$ 9,125
12.	Gravel Borrow, Incl. Haul	55	TN	$ 35	$ 1,916
13.	30-inch Storm Pipe (Incl. Bedding)	365	LF	$ 150	$ 54,750
14.	Crushed Surfacing Base Course	45	TN	$ 50	$ 2,250
15.	Crushed Surfacing Top Course	45	TN	$ 50	$ 2,250
16.	HMA, CL 1/2-in PG 64-22	70	TN	$ 150	$ 10,500
17.	Catch Basin, Type 1	1	EA	$ 2,000	$ 2,000
18.	Catch Basin, Type 2, 54-inch	3	EA	$ 3,000	$ 9,000
19.	Connect to Drainage Structure	2	EA	$ 1,500	$ 3,000
20.	Trench Excavation Safety Systems	365	LF	$ 5	$ 1,825
21.	Surface Restoration (seeding, fertilizing, planting, etc)		SY	$ 7	$ -
22.	Utility Coordination		LS	$ 10,000	$ -
23.	Project Documentation	1	LS	$ 2,000	$ 2,000
	Subtotal			SUBTOTAL	$ 163,475
	Sales Tax (8.7%)				$ 14,876
	Subtotal				$ 178,351
	Construction Contingencies (20%)				$ 35,670
	Permitting (10%)				$ 17,835
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 232,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 58,000
	TOTAL PROJECT COST				**$ 290,000**

Year of Design:		2027
Year of Construction:		2028
Cost of Design in Year of Design:	$	77,000
Cost of Construction in Year of Construction:	$	317,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
M-6: Pump Station with Treatment Vault (SW Bayshore Dr. and SW Beeksma Dr.)
ENGINEER'S COST ESTIMATE
Saturday, October 19, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 140,000	$ 140,000
3.	Project Temporary Traffic Control	1	LS	$ 67,000	$ 67,000
4.	Locate Existing Utilities	1	LS	$ 5,000	$ 5,000
5.	Survey	1	LS	$ 8,000	$ 8,000
6.	Dewatering	1	LS	$ 15,000	$ 15,000
7.	Temporary Erosion Control	1	LS	$ 10,000	$ 10,000
8.	Sawcutting	50	LF	$ 5	$ 250
9.	Remove Asphalt Pavement	6	SY	$ 75	$ 450
10.	Excavation Incl. Haul	75	CY	$ 30	$ 2,250
11.	Gravel Borrow, Incl. Haul	75	CY	$ 35	$ 2,625
12.	22-inch Force Main (Incl. Bedding)	100	LF	$ 80	$ 8,000
13.	22-inch Force Main Liner	1,070	LF	$ 40	$ 42,800
14.	Crushed Surfacing Base Course	2	TN	$ 50	$ 100
15.	HMA, CL 1/2-in PG 64-22	3	TN	$ 150	$ 450
16.	Catch Basin, Type 2, 48-inch	2	EA	$ 3,000	$ 6,000
17.	Treatment Vault	1	EA	$ 50,000	$ 50,000
18.	Fairbanks-Morse 5414 100 hp pumps	4	EA	$ 110,000	$ 440,000
19.	Electrical	1	LS	$ 90,000	$ 90,000
20.	Building	1	LS	$ 250,000	$ 250,000
21.	Motor Control Center	1	LS	$ 270,000	$ 270,000
22.	Generator	1	LS	$ 100,000	$ 100,000
23.	Connect to Drainage Structure	4	EA	$ 1,500	$ 6,000
24.	Trench Excavation Safety Systems	120	LF	$ 5	$ 600
25.	Surface Restoration (seeding, fertilizing, planting, etc)	60	SY	$ 7	$ 420
26.	Utility Coordination	1	LS	$ 10,000	$ 10,000
27.	Project Documentation	1	LS	$ 5,000	$ 5,000
	Subtotal			SUBTOTAL	$ 1,530,945
	Sales Tax (8.7%)				$ 139,316
	Subtotal				$ 1,670,261
	Construction Contingencies (20%)				$ 334,052
	Permitting (10%)				$ 167,026
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 2,171,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 543,000
	TOTAL PROJECT COST				**$ 2,714,000**

Year of Design:		2024
Year of Construction:		2025
Cost of Design in Year of Design:	$	645,000
Cost of Construction in Year of Construction:	$	2,669,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
M-7: Extend Outfall at SE City Beach
ENGINEER'S COST ESTIMATE
Saturday, October 19, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 14,000	$ 14,000
3.	Project Temporary Traffic Control	1	LS	$ 7,000	$ 7,000
4.	Locate Existing Utilities	1	LS	$ 1,000	$ 1,000
5.	Survey	1	LS	$ 2,000	$ 2,000
6.	Dewatering	1	LS	$ 4,000	$ 4,000
7.	Temporary Erosion Control	1	LS	$ 4,000	$ 4,000
8.	30-inch Storm Pipe (Incl. Bedding)	365	LF	$ 300	$ 109,500
9.	Catch Basin, Type 2, 54-inch	1	EA	$ 3,000	$ 3,000
10.	Connect to Drainage Structure	2	EA	$ 1,500	$ 3,000.00
11.	Surface Restoration (seeding, fertilizing, planting, etc)		SY	$ 7	$ -
12.	Project Documentation	1	LS	$ 2,000	$ 2,000
	Subtotal			SUBTOTAL	$ 150,500
	Sales Tax (8.7%)				$ 13,696
	Subtotal				$ 164,196
	Construction Contingencies (20%)				$ 32,839
	Permitting (15%)				$ 24,629
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 222,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 56,000
	TOTAL PROJECT COST				**$ 278,000**

Year of Design:		2019
Year of Construction:		2020
Cost of Design in Year of Design:	$	56,000
Cost of Construction in Year of Construction:	$	230,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
HS-1: Stormwater Pipe Replacement (W. Whidbey Ave.)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 58,000	$ 58,000
3.	Project Temporary Traffic Control	1	LS	$ 28,000	$ 28,000
4.	Locate Existing Utilities	1	LS	$ 5,000	$ 5,000
5.	Survey	1	LS	$ 10,000	$ 10,000
6.	Dewatering	1	LS	$ 15,000	$ 15,000
7.	Temporary Erosion Control	1	LS	$ 10,000	$ 10,000
8.	Sawcutting	3,760	LF	$ 5	$ 18,800
9.	Remove Asphalt Pavement	1,039	SY	$ 75	$ 77,917
10.	Remove Existing Pipe	1,870	LF	$ 30	$ 56,100
11.	Excavation Incl. Haul	1,558	CY	$ 30	$ 46,750
12.	Gravel Borrow, Incl. Haul	281	TN	$ 35	$ 9,818
13.	18-inch Storm Pipe (Incl. Bedding)	1,230	LF	$ 80	$ 98,400
14.	24-inch Storm Pipe (Incl. Bedding)	640	LF	$ 120	$ 76,800
15.	Crushed Surfacing Base Course	210	TN	$ 50	$ 10,500
16.	Crushed Surfacing Top Course	210	TN	$ 50	$ 10,500
17.	HMA, CL 1/2-in PG 64-22	355	TN	$ 150	$ 53,250
18.	Catch Basin, Type 1	2	EA	$ 2,000	$ 4,000
19.	Catch Basin, Type 2, 48-inch	5	EA	$ 3,000	$ 15,000
20.	Connect to Drainage Structure	7	EA	$ 1,500	$ 10,500
21.	Trench Excavation Safety Systems	1,870	LF	$ 5	$ 9,350
22.	Surface Restoration (seeding, fertilizing, planting, etc)		SY	$ 7	$ -
23.	Utility Coordination		LS	$ 10,000	$ -
24.	Project Documentation	1	LS	$ 5,000	$ 5,000
	Subtotal			SUBTOTAL	$ 629,684
	Sales Tax (8.7%)				$ 57,301
	Subtotal				$ 686,985
	Construction Contingencies (20%)				$ 137,397
	Permitting (10%)				$ 68,699
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 893,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 224,000
	TOTAL PROJECT COST				**$ 1,117,000**

Year of Design:		2035
Year of Construction:		2036
Cost of Design in Year of Design:	$	389,000
Cost of Construction in Year of Construction:	$	1,603,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
OP-1: Stormwater Pipe Replacement (SE Pasek St.)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 6,000	$ 6,000
3.	Project Temporary Traffic Control	1	LS	$ 3,000	$ 3,000
4.	Locate Existing Utilities	1	LS	$ 1,000	$ 1,000
5.	Survey	1	LS	$ 2,000	$ 2,000
6.	Dewatering	1	LS	$ 4,000	$ 4,000
7.	Temporary Erosion Control	1	LS	$ 3,000	$ 3,000
8.	Sawcutting	340	LF	$ 5	$ 1,700
9.	Remove Asphalt Pavement	55	SY	$ 75	$ 4,125
10.	Excavation Incl. Haul	83	CY	$ 30	$ 2,475
11.	Gravel Borrow, Incl. Haul	15	TN	$ 35	$ 520
12.	12-inch Storm Pipe (Incl. Bedding)	165	LF	$ 70	$ 11,550
13.	Crushed Surfacing Base Course	15	TN	$ 50	$ 750
14.	Crushed Surfacing Top Course	15	TN	$ 50	$ 750
15.	HMA, CL 1/2-in PG 64-22	20	TN	$ 150	$ 3,000
16.	Catch Basin, Type 1	2	EA	$ 2,000	$ 4,000
17.	Connect to Drainage Structure	2	EA	$ 1,500	$ 3,000
18.	Trench Excavation Safety Systems	165	LF	$ 5	$ 825
19.	Utility Coordination	1	LS	$ 10,000	$ 10,000
20.	Project Documentation	1	LS	$ 1,000	$ 1,000
	Subtotal			SUBTOTAL	$ 63,695
	Sales Tax (8.7%)				$ 5,796
	Subtotal				$ 69,491
	Construction Contingencies (20%)				$ 13,898
	Permitting (10%)				$ 6,949
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 90,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 23,000
	TOTAL PROJECT COST				**$ 113,000**

Year of Design:		2028
Year of Construction:		2029
Cost of Design in Year of Design:	$	32,000
Cost of Construction in Year of Construction:	$	127,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
OP-2: Retrofit Treatment Vault (SE Pasek St. and Pioneer Way)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 6,000	$ 6,000
3.	Project Temporary Traffic Control	1	LS	$ 3,000	$ 3,000
4.	Locate Existing Utilities	1	LS	$ 1,000	$ 1,000
5.	Survey	1	LS	$ 2,000	$ 2,000
6.	Dewatering	1	LS	$ 5,000	$ 5,000
7.	Temporary Erosion Control	1	LS	$ 3,000	$ 3,000
8.	Gravel Borrow, Incl. Haul	4	TN	$ 35	$ 126
9.	12-inch Storm Pipe (Incl. Bedding)	20	LF	$ 70	$ 1,400
10.	Catch Basin, Type 2, 48-inch	1	EA	$ 3,000	$ 3,000
11.	Retrofit Existing Vault	1	EA	$ 25,000	$ 25,000
12.	Connect to Drainage Structure	2	EA	$ 1,500	$ 3,000
13.	Trench Excavation Safety Systems	20	LF	$ 5	$ 100
14.	Utility Coordination	1	LS	$ 5,000	$ 5,000
15.	Project Documentation	1	LS	$ 1,000	$ 1,000
	Subtotal			SUBTOTAL	$ 59,626
	Sales Tax (8.7%)				$ 5,426
	Subtotal				$ 65,052
	Construction Contingencies (20%)				$ 13,010
	Permitting (10%)				$ 6,505
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 85,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 22,000
	TOTAL PROJECT COST				**$ 107,000**

Year of Design:		2026
Year of Construction:		2027
Cost of Design in Year of Design:	$	28,000
Cost of Construction in Year of Construction:	$	112,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
DC-1: Flow Control Facility and Stormwater Pipe Replacement (SW 6th Ave.)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 26,000	$ 26,000
3.	Project Temporary Traffic Control	1	LS	$ 13,000	$ 13,000
4.	Locate Existing Utilities	1	LS	$ 2,000	$ 2,000
5.	Survey	1	LS	$ 5,000	$ 5,000
6.	Dewatering	1	LS	$ 20,000	$ 20,000
7.	Temporary Erosion Control	1	LS	$ 10,000	$ 10,000
8.	Sawcutting	150	LF	$ 5	$ 750
9.	Remove Asphalt Pavement	30	SY	$ 75	$ 2,250
10.	Clearing and Grubing	700	SY	$ 5	$ 3,500
11.	Excavation Incl. Haul	280	CY	$ 30	$ 8,400
12.	Gravel Borrow, Incl. Haul	7	TN	$ 35	$ 252
13.	12-inch Storm Pipe (Incl. Bedding)	160	LF	$ 70	$ 11,200
14.	18-inch Storm Pipe (Incl. Bedding)	1,440	LF	$ 80	$ 115,200
15.	Crushed Surfacing Base Course	10	TN	$ 50	$ 500
16.	Crushed Surfacing Top Course	10	TN	$ 50	$ 500
17.	HMA, CL 1/2-in PG 64-22	15	TN	$ 150	$ 2,250
18.	Inlet Control	1	LS	$ 5,000	$ 5,000
19.	Outlet Control Structure	1	LS	$ 10,000	$ 10,000
20.	Catch Basin, Type 1	10	EA	$ 2,000	$ 20,000
21.	Catch Basin, Type 2, 48-inch	2	EA	$ 3,000	$ 6,000
22.	Connect to Drainage Structure	1	EA	$ 1,500	$ 1,500
23.	Trench Excavation Safety Systems	160	LF	$ 5	$ 800
24.	Surface Restoration (seeding, fertilizing, planting, etc)	700	SY	$ 7	$ 4,900
25.	Utility Coordination, Wellhead Protection	1	LS	$ 10,000	$ 10,000
26.	Project Documentation	1	LS	$ 5,000	$ 5,000
	Subtotal			SUBTOTAL	$ 285,002
	Sales Tax (8.7%)				$ 25,935
	Subtotal				$ 310,937
	Construction Contingencies (20%)				$ 62,187
	Permitting (10%)				$ 31,094
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 404,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 101,000
	TOTAL PROJECT COST				**$ 505,000**

Year of Design:		2025
Year of Construction:		2026
Cost of Design in Year of Design:	$	125,000
Cost of Construction in Year of Construction:	$	515,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
DC-2: Flow Control Facility (Oak Harbor Street and SW 6th Ave.)
ENGINEER'S COST ESTIMATE
Monday, October 14, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 18,000	$ 18,000
3.	Project Temporary Traffic Control	1	LS	$ 9,000	$ 9,000
4.	Locate Existing Utilities	1	LS	$ 2,000	$ 2,000
5.	Survey	1	LS	$ 5,000	$ 5,000
6.	Dewatering	1	LS	$ 15,000	$ 15,000
7.	Temporary Erosion Control	1	LS	$ 5,000	$ 5,000
8.	Sawcutting	50	LF	$ 5	$ 250
9.	Remove Asphalt Pavement	10	SY	$ 75	$ 750
10.	Clearing and Grubing	1,400	SY	$ 5	$ 7,000
11.	Excavation Incl. Haul	2,820	CY	$ 30	$ 84,600
12.	Gravel Borrow, Incl. Haul	7	TN	$ 35	$ 252
13.	12-inch Storm Pipe (Incl. Bedding)	100	LF	$ 70	$ 7,000
14.	Crushed Surfacing Base Course	5	TN	$ 50	$ 250
15.	Crushed Surfacing Top Course	5	TN	$ 50	$ 250
16.	HMA, CL 1/2-in PG 64-22	5	TN	$ 150	$ 750
17.	Inlet Control	1	LS	$ 1,000	$ 1,000
18.	Outlet Control Structure	1	LS	$ 10,000	$ 10,000
19.	Catch Basin, Type 1	1	EA	$ 2,000	$ 2,000
20.	Connect to Drainage Structure	1	EA	$ 1,500	$ 1,500
21.	Trench Excavation Safety Systems	100	LF	$ 5	$ 500
22.	Surface Restoration (seeding, fertilizing, planting, etc)	1,400	SY	$ 7	$ 9,800
23.	Utility Coordination, Wellhead Protection	1	LS	$ 10,000	$ 10,000
24.	Project Documentation	1	LS	$ 5,000	$ 5,000
	Subtotal			SUBTOTAL	$ 195,902
	Sales Tax (8.7%)				$ 17,827
	Subtotal				$ 213,729
	Construction Contingencies (20%)				$ 42,746
	Permitting (10%)				$ 21,373
	Easements (Temporary & Permanent)	0.5	AC	$ 40,000	$ 20,000
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 298,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 75,000
	TOTAL PROJECT COST				**$ 373,000**

Year of Design:		2026
Year of Construction:		2027
Cost of Design in Year of Design:	$	96,000
Cost of Construction in Year of Construction:	$	393,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
DC-3: Stormwater Pipe Replacement (Oak Harbor St.)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 17,000	$ 17,000
3.	Project Temporary Traffic Control	1	LS	$ 8,000	$ 8,000
4.	Locate Existing Utilities	1	LS	$ 1,000	$ 1,000
5.	Survey	1	LS	$ 2,000	$ 2,000
6.	Dewatering	1	LS	$ 4,000	$ 4,000
7.	Temporary Erosion Control	1	LS	$ 4,000	$ 4,000
8.	Sawcutting	890	LF	$ 5	$ 4,450
9.	Remove Asphalt Pavement	245	SY	$ 75	$ 18,375
10.	Excavation Incl. Haul	370	CY	$ 30	$ 11,100
11.	Gravel Borrow, Incl. Haul	67	TN	$ 35	$ 2,331
12.	30-inch Storm Pipe (Incl. Bedding)	440	LF	$ 150	$ 66,000
13.	Crushed Surfacing Base Course	50	TN	$ 50	$ 2,500
14.	Crushed Surfacing Top Course	50	TN	$ 50	$ 2,500
15.	HMA, CL 1/2-in PG 64-22	85	TN	$ 150	$ 12,750
16.	Catch Basin, Type 2, 54-inch	5	EA	$ 3,000	$ 15,000
17.	Connect to Drainage Structure	2	EA	$ 1,500	$ 3,000
18.	Trench Excavation Safety Systems	440	LF	$ 5	$ 2,200
19.	Project Documentation	1	LS	$ 2,000	$ 2,000
	Subtotal			SUBTOTAL	$ 179,206
	Sales Tax (8.7%)				$ 16,308
	Subtotal				$ 195,514
	Construction Contingencies (20%)				$ 39,103
	Permitting (10%)				$ 19,551
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 254,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 64,000
	TOTAL PROJECT COST				**$ 318,000**

Year of Design:		2038
Year of Construction:		2039
Cost of Design in Year of Design:	$	124,000
Cost of Construction in Year of Construction:	$	506,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
DC-4: Freund Marsh Regional Constructed Wetland
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 201,000	$ 201,000
3.	Locate Existing Utilities	1	LS	$ 2,000	$ 2,000
4.	Survey	1	LS	$ 5,000	$ 5,000
5.	Dewatering	1	LS	$ 100,000	$ 100,000
6.	Temporary Erosion Control	1	LS	$ 20,000	$ 20,000
7.	Clearing and Grubing	25,600	SY	$ 5	$ 128,000
8.	Excavation, Embankment and Grading, Incl. Haul	23,000	CY	$ 35	$ 805,000
9.	Topsoil, Type A	3,900	CY	$ 40	$ 156,000
10.	Emergent Vegetation, Clumps of 4	52,500	EA	$ 12	$ 630,000
11.	24-inch Storm Pipe (Incl. Bedding)	680	LF	$ 120	$ 81,600
12.	Debris Removal Inlet Manhole	1	LS	$ 6,000	$ 6,000
13.	Streambed Cobbles (Inlet Erosion Control)	40	TN	$ 45	$ 1,800
14.	Outlet Control Structure	1	LS	$ 6,000	$ 6,000
15.	Tide Gate (Duck Bill)	1	EA	$ 1,000	$ 1,000
16.	Connect to Drainage Structure	1	EA	$ 1,500	$ 1,500
17.	Crushed Surfacing Top Course	700	TN	$ 50	$ 35,000
18.	Unsuitable Foundation Excavation, Incl. Haul	80	CY	$ 40	$ 3,200
19.	Trench Excavation Safety Systems	1	LF	$ 5	$ 5
20.	Surface Restoration (seeding, fertilizing, planting, etc)	2,560	SY	$ 7	$ 17,920
21.	Project Documentation	1	LS	$ 5,000	$ 5,000
	Subtotal			SUBTOTAL	$ 2,207,025
	Sales Tax (8.7%)				$ 200,839
	Subtotal				$ 2,407,864
	Construction Contingencies (20%)				$ 481,573
	Permitting (10%)				$ 240,786
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 3,130,000**
	Feasibility Study (Year 2020)				$ 200,000
	Design, Engineering & Construction Management (25% Construction Cost)				$ 783,000
	TOTAL PROJECT COST				**$ 4,113,000**

Year of Design:		2038
Year of Construction:		2039
Cost of Design in Year of Design:	$	1,506,000
Cost of Construction in Year of Construction:	$	6,229,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
GC-1: Culvert Replacement (W. Fort Nugent Rd. / Loer's Pond)
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	SPCC Plan	1	LS	$ 1,000	$ 1,000
2.	Mobilization, Cleanup and Demobilization	1	LS	$ 9,000	$ 9,000
3.	Project Temporary Traffic Control	1	LS	$ 5,000	$ 5,000
4.	Locate Existing Utilities	1	LS	$ 1,000	$ 1,000
5.	Survey	1	LS	$ 2,000	$ 2,000
6.	Dewatering	1	LS	$ 10,000	$ 10,000
7.	Temporary Erosion Control	1	LS	$ 10,000	$ 10,000
8.	Sawcutting	60	LF	$ 5	$ 300
9.	Remove Asphalt Pavement	90	SY	$ 75	$ 6,750
10.	Remove Existing Pipe	75	LF	$ 30	$ 2,250
11.	Excavation Incl. Haul	380	CY	$ 30	$ 11,400
12.	Gravel Borrow, Incl. Haul	280	CY	$ 35	$ 9,800
13.	95" x 67" CMP Arch Culvert (Incl. Bedding)	75	LF	$ 215	$ 16,125
14.	Crushed Surfacing Base Course	30	TN	$ 50	$ 1,500
15.	Crushed Surfacing Top Course	30	TN	$ 50	$ 1,500
16.	HMA, CL 1/2-in PG 64-22	35	TN	$ 150	$ 5,250
17.	Connect to Drainage Structure	0	EA	$ 1,500	$ -
18.	Trench Excavation Safety Systems	60	LF	$ 5	$ 300
19.	Surface Restoration (seeding, fertilizing, planting, etc)	140	SY	$ 7	$ 980
20.	Utility Coordination	1	LS	$ 1,000	$ 1,000
21.	Project Documentation	1	LS	$ 2,000	$ 2,000
	Subtotal			SUBTOTAL	$ 97,155
	Sales Tax (8.7%)				$ 8,841
	Subtotal				$ 105,996
	Construction Contingencies (20%)				$ 21,199
	Permitting (10%)				$ 10,600
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 138,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 35,000
	TOTAL PROJECT COST				**$ 173,000**

Year of Design:		2026
Year of Construction:		2027
Cost of Design in Year of Design:	$	45,000
Cost of Construction in Year of Construction:	$	182,000
(Assumes 3.5% inflation)		

CITY OF OAK HARBOR
FM-1: Catch Basin Replacement / Drainage Analysis
ENGINEER'S COST ESTIMATE
Saturday, October 12, 2019
G&O # 16625

NO.	DESCRIPTION	QUANTITY		PRICE	AMOUNT
1.	Mobilization, Cleanup and Demobilization	1	LS	$ 2,000	$ 2,000
2.	Project Temporary Traffic Control	1	LS	$ 3,000	$ 3,000
3.	Locate Existing Utilities	1	LS	$ 2,000	$ 2,000
4.	Survey	1	LS	$ 2,500	$ 2,500
5.	Temporary Erosion Control	1	LS	$ 1,000	$ 1,000
6.	Sawcutting	10	LF	$ 5	$ 50
7.	Remove Asphalt Pavement	2	SY	$ 75	$ 150
8.	12-inch Storm Pipe (Incl. Bedding)	20	LF	$ 70	$ 1,400
9.	Crushed Surfacing Base Course	5	TN	$ 50	$ 250
10.	Crushed Surfacing Top Course	5	TN	$ 50	$ 250
11.	HMA, CL 1/2-in PG 64-22	2	TN	$ 150	$ 300
12.	Catch Basin, Type 1	1	EA	$ 2,000	$ 2,000
13.	Connect to Drainage Structure	1	EA	$ 1,500	$ 1,500
14.	Trench Excavation Safety Systems	20	LF	$ 5	$ 100
15.	Project Documentation	1	LS	$ 500	$ 500
	Subtotal			SUBTOTAL	$ 17,000
	Sales Tax (8.7%)				$ 1,547
	Subtotal				$ 18,547
	Construction Contingencies (20%)				$ 3,709
	Permitting (10%)				$ 1,855
	Easements (Temporary & Permanent)	0	AC	$ 40,000	$ -
	Fixed costs for Easements (Negotiations, Agent, Documents, Survey, etc.)	0	EA	$ 1,000	$ -
	CONSTRUCTION COST ESTIMATE				**$ 24,000**
	Design, Engineering & Construction Management (25% Construction Cost)				$ 6,000
	TOTAL PROJECT COST				**$ 30,000**

Year of Design:		2020
Year of Construction:		2021
Cost of Design in Year of Design:	$	7,000
Cost of Construction in Year of Construction:	$	26,000
(Assumes 3.5% inflation)		

APPENDIX I

SEPA CHECKLIST

SEPA ENVIRONMENTAL CHECKLIST

Purpose of checklist:

Governmental agencies use this checklist to help determine whether the environmental impacts of your proposal are significant. This information is also helpful to determine if available avoidance, minimization or compensatory mitigation measures will address the probable significant impacts or if an environmental impact statement will be prepared to further analyze the proposal.

Instructions for applicants:

This environmental checklist asks you to describe some basic information about your proposal. Please answer each question accurately and carefully, to the best of your knowledge. You may need to consult with an agency specialist or private consultant for some questions. You may use "not applicable" or "does not apply" only when you can explain why it does not apply and not when the answer is unknown. You may also attach or incorporate by reference additional studies reports. Complete and accurate answers to these questions often avoid delays with the SEPA process as well as later in the decision-making process.

The checklist questions apply to all parts of your proposal, even if you plan to do them over a period of time or on different parcels of land. Attach any additional information that will help describe your proposal or its environmental effects. The agency to which you submit this checklist may ask you to explain your answers or provide additional information reasonably related to determining if there may be significant adverse impact.

Instructions for Lead Agencies:

Please adjust the format of this template as needed. Additional information may be necessary to evaluate the existing environment, all interrelated aspects of the proposal and an analysis of adverse impacts. The checklist is considered the first but not necessarily the only source of information needed to make an adequate threshold determination. Once a threshold determination is made, the lead agency is responsible for the completeness and accuracy of the checklist and other supporting documents.

Use of checklist for nonproject proposals:

For nonproject proposals (such as ordinances, regulations, plans and programs), complete the applicable parts of sections A and B plus the SUPPLEMENTAL SHEET FOR NONPROJECT ACTIONS (part D). Please completely answer all questions that apply and note that the words "project," "applicant," and "property or site" should be read as "proposal," "proponent," and "affected geographic area," respectively. The lead agency may exclude (for non-projects) questions in Part B - Environmental Elements –that do not contribute meaningfully to the analysis of the proposal.

A. Background [HELP]

1. Name of proposed project, if applicable:

Oak Harbor Stormwater Comprehensive Plan

2. Name of applicant: **City of Oak Harbor**

3. Address and phone number of applicant and contact person:

City of Oak Harbor
Contact Person: Brad Gluth
865 SE Barriongton Drive
Oak Harbor, WA 98277
(360) 279-4526

4. Date checklist prepared: **October 17, 2019**

5. Agency requesting checklist: **City of Oak Harbor**

6. Proposed timing or schedule (including phasing, if applicable):

The Oak Harbor Stormwater Comprehensive Plan is designed to be used as a guide for the next 6 to 20 years regarding capital improvements, O&M procedures and financial strategies pertaining to stormwater. The Plan is intended to be adopted by the end of 2019.

7. Do you have any plans for future additions, expansion, or further activity related to or connected with this proposal? If yes, explain.

Individual stormwater projects and studies are to be completed per the stormwater comprehensive plan in the future. Additional environmental documents will be completed as required.

8. List any environmental information you know about that has been prepared, or will be prepared, directly related to this proposal.

None known.

9. Do you know whether applications are pending for governmental approvals of other proposals directly affecting the property covered by your proposal? If yes, explain.

None known.

10. List any government approvals or permits that will be needed for your proposal, if known.

Adoption of the Stormwater Comprehensive Plan by the Oak Harbor City Council.

11. Give brief, complete description of your proposal, including the proposed uses and the size of the project and site. There are several questions later in this checklist that ask you to describe certain aspects of your proposal. You do not need to repeat those answers on this page. (Lead agencies may modify this form to include additional specific information on project description.)

The Stormwater Comprehensive Plan is to be completed for the purpose of maintaining and improving the management of the City's stormwater system.

12. Location of the proposal. Give sufficient information for a person to understand the precise location of your proposed project, including a street address, if any, and section, township, and range, if known. If a proposal would occur over a range of area, provide the range or boundaries of the site(s). Provide a legal description, site plan, vicinity map, and topographic map, if reasonably available. While you should submit any plans required by the agency, you are not required to duplicate maps or detailed plans submitted with any permit applications related to this checklist.

The Comprehensive Stormwater Comprehensive Plan addresses the entire storm system service area which is contiguous to the incorporated area of the City of Oak Harbor. A storm system map is included within the plan.

B. Environmental Elements [HELP]

1. *Earth* [help]

a. General description of the site: **N/A**

(circle one): Flat, rolling, hilly, steep slopes, mountainous, other _____**N/A**_____

b. What is the steepest slope on the site (approximate percent slope)?

N/A

c. What general types of soils are found on the site (for example, clay, sand, gravel, peat, muck)? If you know the classification of agricultural soils, specify them and note any agricultural land of long-term commercial significance and whether the proposal results in removing any of these soils.

N/A

d. Are there surface indications or history of unstable soils in the immediate vicinity? If so, describe.

N/A

e. Describe the purpose, type, total area, and approximate quantities and total affected area of any filling, excavation, and grading proposed. Indicate source of fill.

N/A

f. Could erosion occur as a result of clearing, construction, or use? If so, generally describe.

N/A

g. About what percent of the site will be covered with impervious surfaces after project construction (for example, asphalt or buildings)?

N/A

h. Proposed measures to reduce or control erosion, or other impacts to the earth, if any:

N/A

2. Air [help]

a. What types of emissions to the air would result from the proposal during construction, operation, and maintenance when the project is completed? If any, generally describe and give approximate quantities if known.

N/A

b. Are there any off-site sources of emissions or odor that may affect your proposal? If so, generally describe.

N/A

c. Proposed measures to reduce or control emissions or other impacts to air, if any:

N/A

3. Water [help]

a. Surface Water: [help]

1) Is there any surface water body on or in the immediate vicinity of the site (including year-round and seasonal streams, saltwater, lakes, ponds, wetlands)? If yes, describe type and provide names. If appropriate, state what stream or river it flows into.

NA

2) Will the project require any work over, in, or adjacent to (within 200 feet) the described waters? If yes, please describe and attach available plans.

N/A

3) Estimate the amount of fill and dredge material that would be placed in or removed from surface water or wetlands and indicate the area of the site that would be affected. Indicate the source of fill material.

N/A

4) Will the proposal require surface water withdrawals or diversions? Give general description, purpose, and approximate quantities if known.

N/A

5) Does the proposal lie within a 100-year floodplain? If so, note location on the site plan.

N/A

6) Does the proposal involve any discharges of waste materials to surface waters? If so, describe the type of waste and anticipated volume of discharge.

N/A

b. Ground Water: [help]

1) Will groundwater be withdrawn from a well for drinking water or other purposes? If so, give a general description of the well, proposed uses and approximate quantities withdrawn from the well. Will water be discharged to groundwater? Give general description, purpose, and approximate quantities if known.

N/A

2) Describe waste material that will be discharged into the ground from septic tanks or other sources, if any (for example: Domestic sewage; industrial, containing the following chemicals. . . ; agricultural; etc.). Describe the general size of the system, the number of such systems, the number of houses to be served (if applicable), or the number of animals or humans the system(s) are expected to serve.

N/A

c. Water runoff (including stormwater):

1) Describe the source of runoff (including storm water) and method of collection and disposal, if any (include quantities, if known). Where will this water flow? Will this water flow into other waters? If so, describe.

N/A

2) Could waste materials enter ground or surface waters? If so, generally describe.

N/A

3) Does the proposal alter or otherwise affect drainage patterns in the vicinity of the site? If so, describe.

N/A

d. Proposed measures to reduce or control surface, ground, and runoff water, and drainage pattern impacts, if any:

N/A

4. Plants [help]

N/A

a. Check the types of vegetation found on the site:

____deciduous tree: alder, maple, aspen, other
____evergreen tree: fir, cedar, pine, other
____shrubs
____grass
____pasture
____crop or grain
____ Orchards, vineyards or other permanent crops.
____ wet soil plants: cattail, buttercup, bullrush, skunk cabbage, other
____water plants: water lily, eelgrass, milfoil, other
____other types of vegetation

b. What kind and amount of vegetation will be removed or altered?

N/A

c. List threatened and endangered species known to be on or near the site.

N/A

d. Proposed landscaping, use of native plants, or other measures to preserve or enhance vegetation on the site, if any:

N/A

e. List all noxious weeds and invasive species known to be on or near the site.

N/A

5. Animals [help]

N/A

List any birds and other animals which have been observed on or near the site or are known to be on or near the site.

Examples include:

birds: hawk, heron, eagle, songbirds, other:
mammals: deer, bear, elk, beaver, other:
fish: bass, salmon, trout, herring, shellfish, other _____

b. List any threatened and endangered species known to be on or near the site.

N/A

c. Is the site part of a migration route? If so, explain.

N/A

d. Proposed measures to preserve or enhance wildlife, if any:

N/A

e. List any invasive animal species known to be on or near the site.

N/A

6. Energy and Natural Resources [help]

a. What kinds of energy (electric, natural gas, oil, wood stove, solar) will be used to meet the completed project's energy needs? Describe whether it will be used for heating, manufacturing, etc.

N/A

b. Would your project affect the potential use of solar energy by adjacent properties? If so, generally describe.

N/A

c. What kinds of energy conservation features are included in the plans of this proposal? List other proposed measures to reduce or control energy impacts, if any:

N/A

7. Environmental Health [help]

a. Are there any environmental health hazards, including exposure to toxic chemicals, risk of fire and explosion, spill, or hazardous waste, that could occur as a result of this proposal? If so, describe.

1) Describe any known or possible contamination at the site from present or past uses.

N/A

2) Describe existing hazardous chemicals/conditions that might affect project development and design. This includes underground hazardous liquid and gas transmission pipelines located within the project area and in the vicinity.

N/A

3) Describe any toxic or hazardous chemicals that might be stored, used, or produced during the project's development or construction, or at any time during the operating life of the project.

N/A

4) Describe special emergency services that might be required.

N/A

5) Proposed measures to reduce or control environmental health hazards, if any:

N/A

b. Noise

1) What types of noise exist in the area which may affect your project (for example: traffic, equipment, operation, other)?

N/A

2) What types and levels of noise would be created by or associated with the project on a short-term or a long-term basis (for example: traffic, construction, operation, other)? Indicate what hours noise would come from the site.

N/A

3) Proposed measures to reduce or control noise impacts, if any:

N/A

8. Land and Shoreline Use [help]

a. What is the current use of the site and adjacent properties? Will the proposal affect current land uses on nearby or adjacent properties? If so, describe. **N/A**

b. Has the project site been used as working farmlands or working forest lands? If so, describe. How much agricultural or forest land of long-term commercial significance will be converted to other uses as a result of the proposal, if any? If resource lands have not been designated, how many acres in farmland or forest land tax status will be converted to nonfarm or nonforest use?

N/A

1) Will the proposal affect or be affected by surrounding working farm or forest land normal business operations, such as oversize equipment access, the application of pesticides, tilling, and harvesting? If so, how:

N/A

c. Describe any structures on the site.

N/A

d. Will any structures be demolished? If so, what?

N/A

e. What is the current zoning classification of the site?

N/A

f. What is the current comprehensive plan designation of the site?

N/A

g. If applicable, what is the current shoreline master program designation of the site?

N/A

h. Has any part of the site been classified as a critical area by the city or county? If so, specify.

N/A

i. Approximately how many people would reside or work in the completed project?

N/A

j. Approximately how many people would the completed project displace?

N/A

k. Proposed measures to avoid or reduce displacement impacts, if any:

N/A

L. Proposed measures to ensure the proposal is compatible with existing and projected land uses and plans, if any:

N/A

m. Proposed measures to reduce or control impacts to agricultural and forest lands of long-term commercial significance, if any:

N/A

9. Housing [help]

a. Approximately how many units would be provided, if any? Indicate whether high, middle, or low-income housing.

N/A

b. Approximately how many units, if any, would be eliminated? Indicate whether high, middle, or low-income housing.

N/A

c. Proposed measures to reduce or control housing impacts, if any:

N/A

10. Aesthetics [help]

a. What is the tallest height of any proposed structure(s), not including antennas; what is the principal exterior building material(s) proposed?

N/A

b. What views in the immediate vicinity would be altered or obstructed?

N/A

b. Proposed measures to reduce or control aesthetic impacts, if any:

N/A

11. Light and Glare [help]

a. What type of light or glare will the proposal produce? What time of day would it mainly occur?

N/A

b. Could light or glare from the finished project be a safety hazard or interfere with views?

N/A

c. What existing off-site sources of light or glare may affect your proposal?

N/A

d. Proposed measures to reduce or control light and glare impacts, if any:

N/A

12. Recreation [help]

a. What designated and informal recreational opportunities are in the immediate vicinity?

N/A

b. Would the proposed project displace any existing recreational uses? If so, describe.

N/A

c. Proposed measures to reduce or control impacts on recreation, including recreation opportunities to be provided by the project or applicant, if any:

N/A

13. Historic and cultural preservation [help]

a. Are there any buildings, structures, or sites, located on or near the site that are over 45 years old listed in or eligible for listing in national, state, or local preservation registers ? If so, specifically describe.

N/A

b. Are there any landmarks, features, or other evidence of Indian or historic use or occupation? This may include human burials or old cemeteries. Are there any material evidence, artifacts, or areas of cultural importance on or near the site? Please list any professional studies conducted at the site to identify such resources.

N/A

c. Describe the methods used to assess the potential impacts to cultural and historic resources on or near the project site. Examples include consultation with tribes and the department of archeology and historic preservation, archaeological surveys, historic maps, GIS data, etc.

N/A

d. Proposed measures to avoid, minimize, or compensate for loss, changes to, and disturbance to resources. Please include plans for the above and any permits that may be required.

N/A

14. Transportation [help]

a. Identify public streets and highways serving the site or affected geographic area and describe proposed access to the existing street system. Show on site plans, if any.

N/A

b. Is the site or affected geographic area currently served by public transit? If so, generally describe. If not, what is the approximate distance to the nearest transit stop?

N/A

c. How many additional parking spaces would the completed project or non-project proposal have? How many would the project or proposal eliminate?

N/A

d. Will the proposal require any new or improvements to existing roads, streets, pedestrian, bicycle or state transportation facilities, not including driveways? If so, generally describe (indicate whether public or private).

N/A

e. Will the project or proposal use (or occur in the immediate vicinity of) water, rail, or air transportation? If so, generally describe.

N/A

f. How many vehicular trips per day would be generated by the completed project or proposal? If known, indicate when peak volumes would occur and what percentage of the volume would be trucks (such as commercial and nonpassenger vehicles). What data or transportation models were used to make these estimates?

N/A

g. Will the proposal interfere with, affect or be affected by the movement of agricultural and forest products on roads or streets in the area? If so, generally describe.

N/A

h. Proposed measures to reduce or control transportation impacts, if any:

N/A

15. Public Services [help]

a. Would the project result in an increased need for public services (for example: fire protection, police protection, public transit, health care, schools, other)? If so, generally describe.

N/A

b. Proposed measures to reduce or control direct impacts on public services, if any.

16. Utilities [help]

a. Circle utilities currently available at the site:
electricity, natural gas, water, refuse service, telephone, sanitary sewer, septic system, other _____

N/A

c. Describe the utilities that are proposed for the project, the utility providing the service, and the general construction activities on the site or in the immediate vicinity which might be needed.

N/A

C. Signature [HELP]

The above answers are true and complete to the best of my knowledge. I understand that the lead agency is relying on them to make its decision.

Signature: _____

Name of signee __Brad Gluth_____

Position and Agency/Organization _Stormwater Engineer, CSM/ City of Oak Harbor

_____

Date Submitted: _____

D. Supplemental sheet for nonproject actions [HELP]

(**IT IS NOT NECESSARY** to use this sheet for project actions)

Because these questions are very general, it may be helpful to read them in conjunction with the list of the elements of the environment.

When answering these questions, be aware of the extent the proposal, or the types of activities likely to result from the proposal, would affect the item at a greater intensity or at a faster rate than if the proposal were not implemented. Respond briefly and in general terms.

1. How would the proposal be likely to increase discharge to water; emissions to air; production, storage, or release of toxic or hazardous substances; or production of noise?

The intent of the proposal is to provide a plan to reduce localized flooding and improve storm system capacity and water quality within the City. The plan will not produce an increase in any type of pollution. It offers recommendations on reducing the amount of pollution entering local waters.

Proposed measures to avoid or reduce such increases are:

Adoption of the plan provides a basis for funding approval for implementation of capital improvement projects and studies that are intended to help reduce stormwater pollution and improve stormwater conveyance.

2. How would the proposal be likely to affect plants, animals, fish, or marine life?

The plan will not directly affect plants, animals, fish or marine life. In protecting the water quality of the region, the plan will likely have a positive impact on plants and wildlife.

Proposed measures to protect or conserve plants, animals, fish, or marine life are:

As previously mentioned, the goal of the plan is to reduce effects to these items. Identified projects and studies will provide or assist in providing protections of these items.

3. How would the proposal be likely to deplete energy or natural resources?

A few projects may require electrical power for pumping, Many of the projects/studies are intended to directly provide protections of aquatic based natural resources.

Proposed measures to protect or conserve energy and natural resources are:

Any electrical power used in stormwater capital improvement projects will be minimal and per applicable energy codes. A significant portion of the Stormwater Comprehensive Plan is intended to protect aquatic natural resources.

4. How would the proposal be likely to use or affect environmentally sensitive areas or areas designated (or eligible or under study) for governmental protection; such as parks, wilderness, wild and scenic rivers, threatened or endangered species habitat, historic or cultural sites, wetlands, floodplains, or prime farmlands?

Adoption of the plan is not likey to negatively affect environmentally sensitive areas. Implementation is intended to provide protections of environmentally sensitive areas, particularly wetlands and shorelines. It will also help protect parks and recreational use of parks.

Proposed measures to protect such resources or to avoid or reduce impacts are:

N/A

5. How would the proposal be likely to affect land and shoreline use, including whether it would allow or encourage land or shoreline uses incompatible with existing plans?

Adoption and implementation of the plan will not affect land or shoreline use. The plan correlates with the regulations of the Washington State Department of Ecology for stormwater discharge and water quality measures and is not incompatible with existing land or shoreline use plans.

Proposed measures to avoid or reduce shoreline and land use impacts are:

None are required.

6. How would the proposal be likely to increase demands on transportation or public services and utilities?

The plan will likely increase public utility demands by recommending increased maintenance of existing stormwater facilities and new facilties. Impacts to transportation would be minimal or beneficial in the case of alleviating localized flooding.

Proposed measures to reduce or respond to such demand(s) are:

The Plan discusses financial measures to pay for operation and maintenance of the stormwater system. Implementation of the plan is expected to make system wide improvements that will minimize overall needs for existing and future improvments.

7. Identify, if possible, whether the proposal may conflict with local, state, or federal laws or requirements for the protection of the environment.

The plan was written in terms of complying with State NPDES Phase II Requirements and the Washington State Department of Ecology Stormwater Management Manual for Western Washington as well as current City municipal code with the intent to protect the environment.