

7 Stormwater System Analysis

The chapter summarizes the evaluations conducted for stormwater retrofit, conveyance capacity modeling, Lake Padden water balance, and reviews of existing data to help with the identification of system deficiencies. The City's stormwater drainage system was analyzed for the purpose of identifying system deficiencies that could be addressed by either maintenance activities or capital improvement projects. Many of the results of the analyses were submitted as recommended capital improvement projects that are identified and discussed in greater detail in Chapter 8, Capital Improvement Plan. Other results did not merit inclusion in the CIP, but are included in this chapter to document the existing problems and subsequent analysis. The objective of this chapter is to describe evaluations of identified drainage system deficiencies with the following subsections describing how problems were identified, the strategy for conducting the retrofit study, an analysis of hydraulic capacity of mainline storm pipes directly discharging to Bellingham Bay (marine outfalls), the City's fish passage prioritization plan, and an analysis of infrastructure deficient in capacity or condition.

7.1 Data Collection

Background data used for the stormwater system analysis were obtained from the City's GIS, existing reports, staff interviews, and direct field measurements. The following subsections briefly describe each data collection method.

7.1.1 Geographic Information System Data

City staff transmitted GIS data to HDR for use in the system analysis. The GIS data comprise geo-spatial and attribute information about the built stormwater drainage network including information on pipes, catch basin structures, detention ponds, and water quality BMPs. They also included information on streams, land use, drainage basin boundaries, and property ownership plus other features necessary for the analysis. GIS data layers acquired for the project were presumed to be complete and error-free. When data gaps were identified, City personnel were deployed to collect direct field measurements. For example, in support of the marine outfall hydraulic analysis, pipe attribute data were missing in numerous locations. City personnel provided HDR with depth-to-invert measurements and pipe material information that was critical to the analysis.

7.1.2 Existing Reports

The following reports were integral to the 2020 stormwater systems analysis and the identification of CIP projects and programs: the 1995 Watershed Master Plan, 2007 Stormwater Comprehensive Plan, Prioritization Report (City 2010), and Habitat Restoration Assessment (ESA 2015). Each report provides background information and recommendations that inform the 2020 system analysis.

7.1.3 City Staff Interview

City staff were interviewed to provide firsthand knowledge of drainage complaints, flooding problems, and other stormwater system deficiencies. The superintendent of maintenance, one of the two stormwater maintenance supervisors, and the GIS systems analyst, who is responsible for maintaining the City's GIS database that includes data on stormwater assets, attended the October 2018 meeting.

Topics discussed included the status and quality of attribute data needed for conducting the marine outfall hydraulic analysis of the conveyance lines directly discharging to Bellingham Bay. Known flooding problems, detention pond maintenance practices, and maintenance equipment needs were also discussed. The following decisions and actions were identified:

- The City provided survey invert elevations of the outfall pipes in the analysis. Other missing data and/or incorrect data would be (and eventually were) provided by City Maintenance and Operations (M&O) crews physically measuring the distance from the catch basin rim to the pipe invert.
- The City reported that a persistent flooding problem exists on Iowa Street just east of I-5 near the intersection of Moore Street. Otherwise, the City did not report other known flooding problems to be evaluated.
- Detention pond maintenance costs are increasing over time as the City accepts maintenance responsibility for privately constructed detention ponds. The City requested that the rate study include funding plans for detention pond maintenance.
- The City's PURC list of stormwater pipes identified those needing replacement because of condition.

7.2 Retrofit Program

The objective of the systems analysis retrofit task was to identify specific capital improvement projects that treat stormwater runoff from sub-watersheds where no water quality treatment facilities exist. Stormwater retrofit planning in this context targets developed areas where water quality treatment facilities do not currently exist and, if any were installed, they would benefit downstream receiving waters, in addition opportunities to equitably distributing neighborhood improvements (e.g., Birchwood Neighborhood CIP projects). The steps used to identify where and what type of retrofit BMP are as follows:

1. Focus priority sub-watersheds categorized by the City in past studies as Tier 1 sub-watersheds, and also areas where stormwater retrofit would provide ecological lift to the downstream receiving waters through LID opportunities. Also consider opportunities beyond just the Tier 1 areas.
2. Subdivide the target areas into smaller drainage areas (sub-basins) and develop "heat maps" that show impervious area gradations of each sub-basin.
3. Based on levels of impervious area and land use, propose stormwater retrofit BMPs for sub-basins with the highest levels of impervious surfaces. Select the BMP option known for addressing typical pollutants of concern based on land use.

4. The City and HDR discuss each proposed BMP and select top-priority projects to advance to concept design for the proposed CIP.

7.2.1 Targeted Sub-Watersheds

Retrofit planning for the 2020 SSWCP leveraged past planning investments made by the City. Target areas were identified in the Habitat Restoration Assessment (ESA 2015). In that earlier plan, stormwater retrofit was cited as a primary mechanism for improving aquatic habitat in downstream receiving waters by collecting and treating otherwise untreated stormwater runoff prior to it entering nearby streams. The Habitat Restoration Assessment (ESA 2015) focused on Tier 1 sub-watersheds, defined as sub-watersheds with high potential for ecological lift for multiple habitats and multiple functions. Among several methods cited in the 2015 Habitat Restoration Assessment, stormwater retrofit was specifically identified in the following Tier 1 sub-watersheds as a means for improving aquatic habitat. As such, the 2020 retrofit plan focused on the following Tier 1 sub-watersheds where stormwater retrofit was specifically identified:

- Baker Creek Tributary
- Lower Baker Creek
- Lower Padden Creek
- Lower Spring Creek
- Lower Squalicum Creek

With a focus on improving aquatic habitat, the next step was to narrow down areas within each Tier 1 sub-watershed where retrofits could have the greatest effect on improving water quality.

The Birchwood neighborhood was also evaluated for retrofit opportunities in addition to the above sub-watersheds, as this area exhibits soil characteristics to support infiltration, and has opportunities to support near-term habitat and nearshore restoration projects.

In looking beyond these sub-watersheds and the emphasis on retrofits, the next step in advancing the City's goals for stormwater management and watershed management in general should consider the other Tier 1 sub-watersheds, as well as the opportunity for natural stream corridor protection and restoration. The 2015 Habitat Restoration Assessment is well documented with these other opportunities and provides rankings to guide the City in deciding to expand the CIP in this manner. For example, Chuckanut Creek and Cemetery Creek are both Tier 1 sub-watersheds with areas designated for protection. Lower Squalicum Creek also has restoration opportunities identified. Policies and procedures would need to be evaluated with regard to streams on private property and what covenants would be necessary to preserve and/or restore these natural assets.

7.2.2 Heat Maps

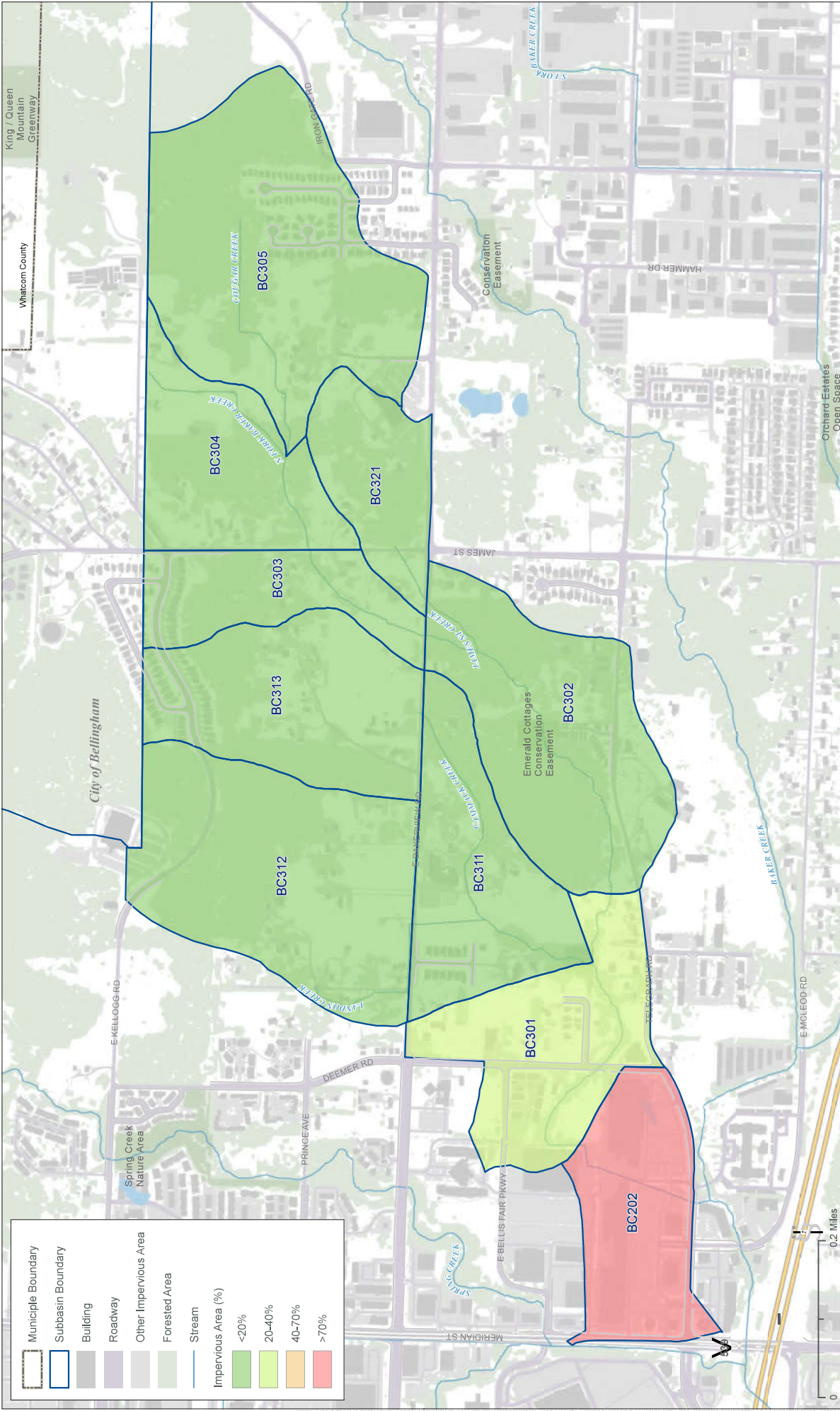
Using the City's existing drainage basin boundary line data, each Tier 1 sub-watershed was subdivided into smaller drainage basins to enable a desktop analysis that calculates impervious area. Impervious area is a surrogate for quantifying retrofit potential because impervious areas are where the highest concentrations of pollutants are found and therefore offer the greatest

potential for water quality improvement (see stormwater research data published by the Stormwater National Database in Chapter 2 showing pollutant loading rates by land use category). The desktop analysis identified the following four categories of impervious surface area intensity to focus the analysis:

- Less than 20 percent
- 20 to 40 percent
- 40 to 70 percent
- Greater than 70 percent

“Heat maps” were developed for each sub-basin within the sub-watershed to show gradations of impervious area, which narrowed down the study areas to smaller sub-basins that could be efficiently analyzed for retrofit opportunity.

In this application, heat maps are GIS-produced maps with color gradations that display retrofit potential. Existing drainage sub-basin delineations, identified in the City’s GIS database, were overlaid onto the heat maps to disaggregate the sub-watersheds into smaller sub-basin drainage areas. The results of the desktop analysis highlighting retrofit potential as a function of impervious area are shown in Figure 7-1 through Figure 7-5.

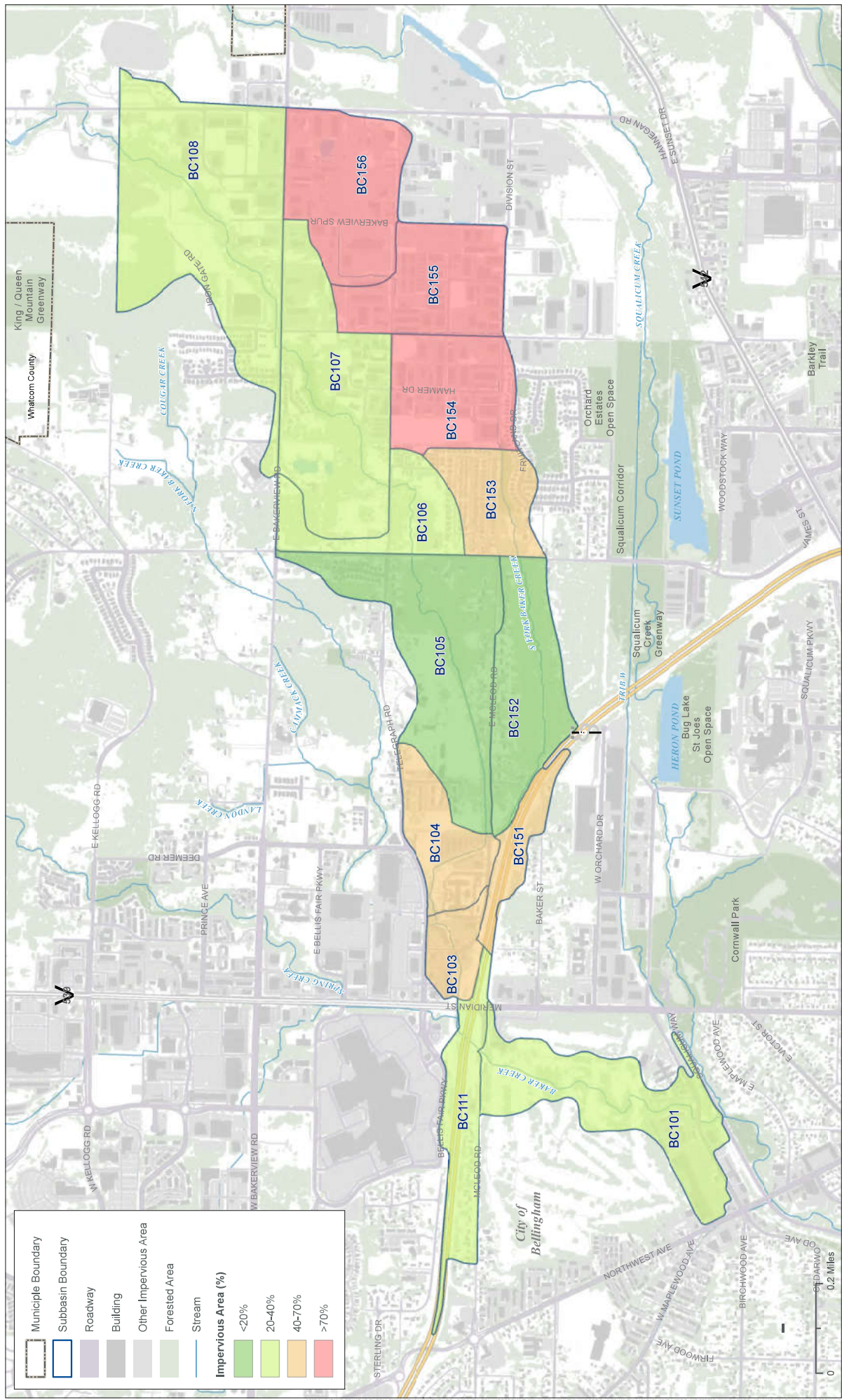


BAKER CREEK TRIBUTARY
 FIGURE 7-1
 City of Bellingham
 Surface and Stormwater Comprehensive Plan



SOURCE: City of Bellingham, WSDOT, etc.

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	Municiple Boundary
	Subbasin Boundary
	Roadway
	Building
	Other Impervious Area
	Forested Area
	Stream
Impervious Area (%)	
	<20%
	20-40%
	40-70%
	>70%

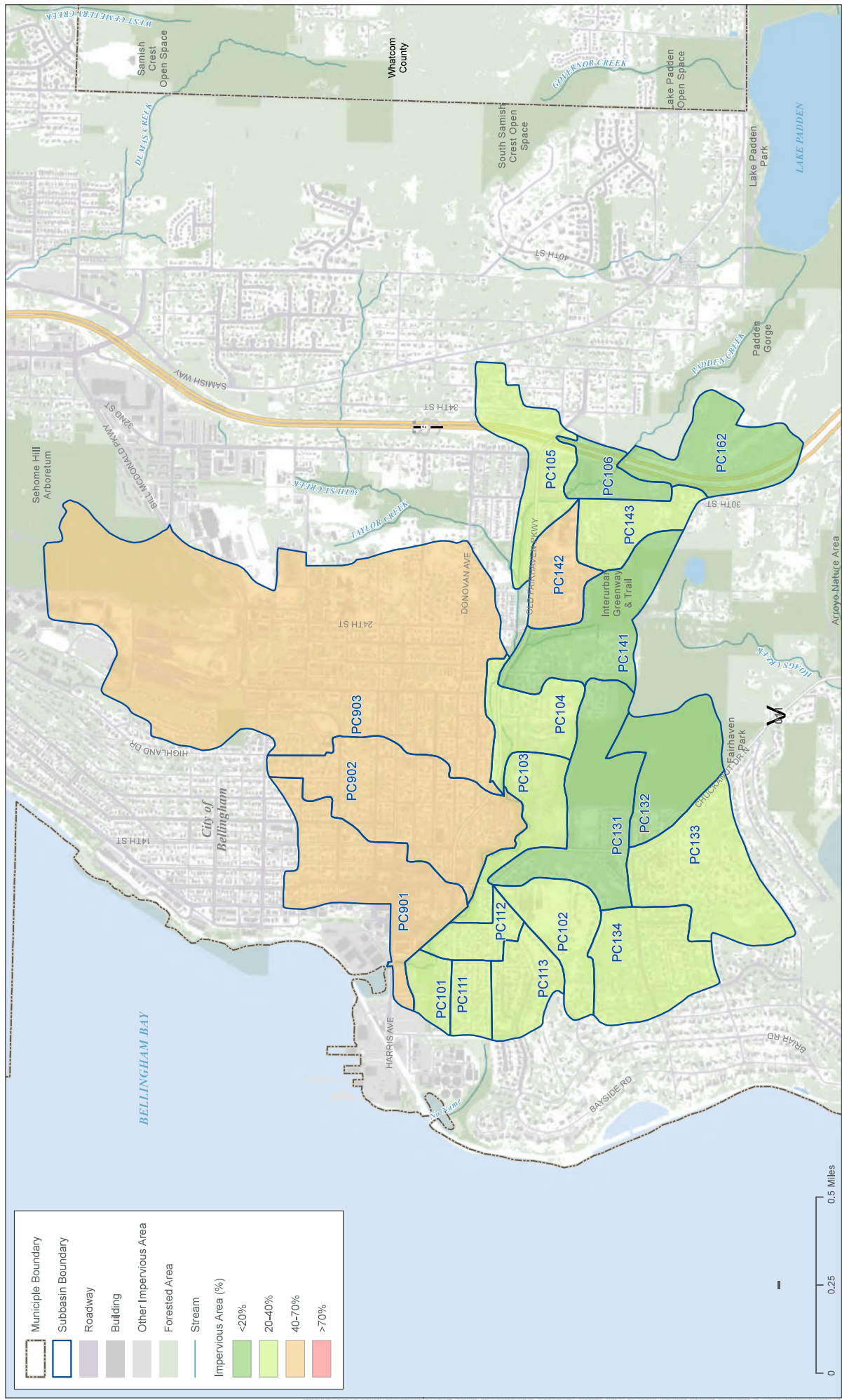
LOWER BAKER CREEK

FIGURE 7-2
City of Bellingham
Surface and Stormwater Comprehensive Plan



SOURCE: City of Bellingham, WSDOT, etc.

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	Municipal Boundary
	Subbasin Boundary
	Roadway
	Building
	Other Impervious Area
	Forested Area
	Stream
Impervious Area (%)	
	<20%
	20-40%
	40-70%
	>70%

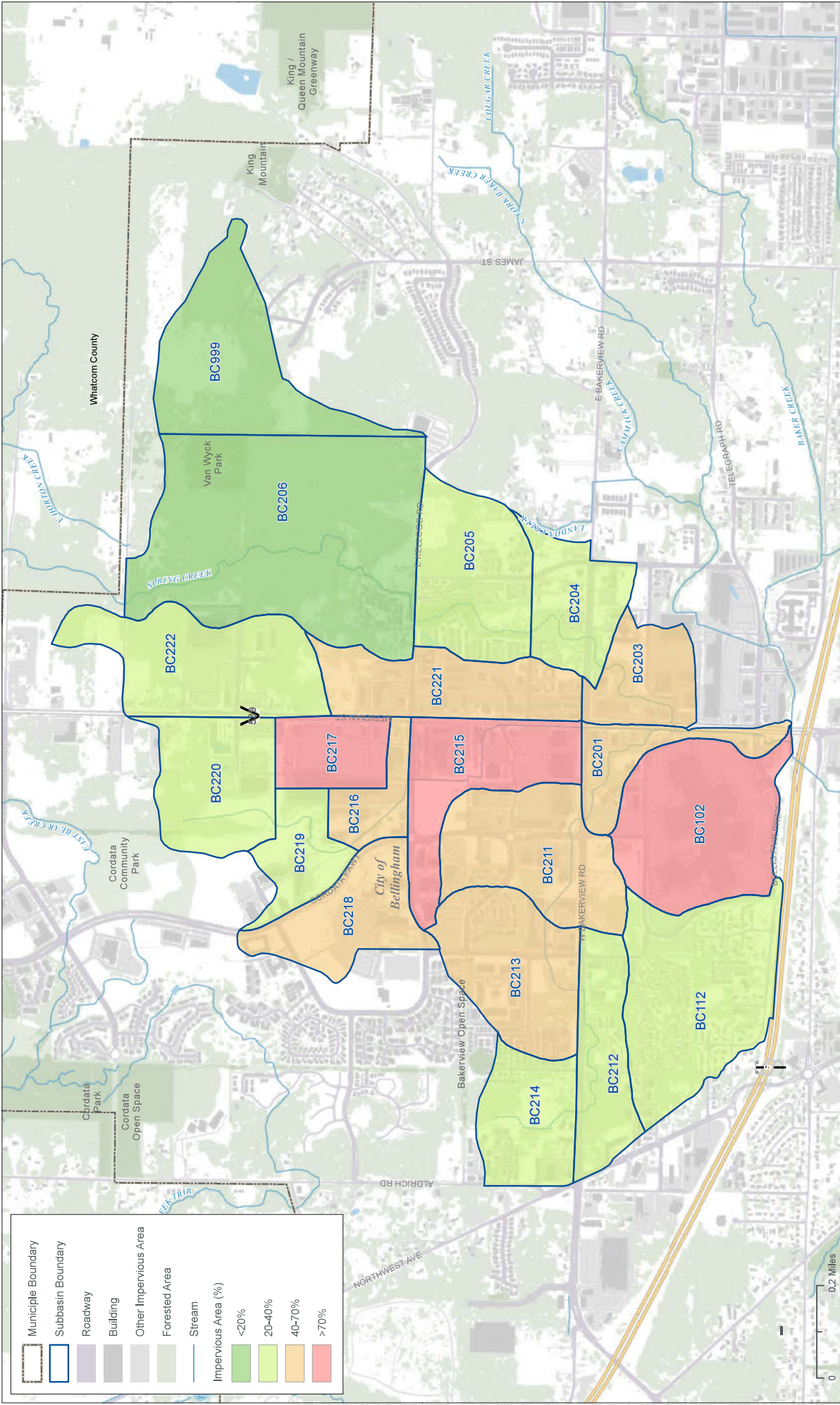


LOWER PADDEN CREEK

FIGURE 7-3
City of Bellingham
Surface and Stormwater Comprehensive Plan

SOURCE: City of Bellingham, WSDOT, etc.

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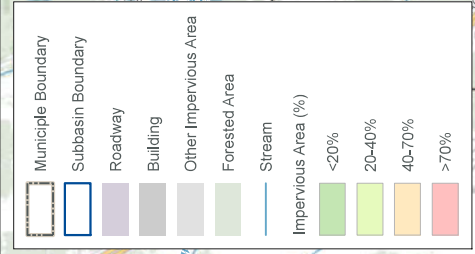
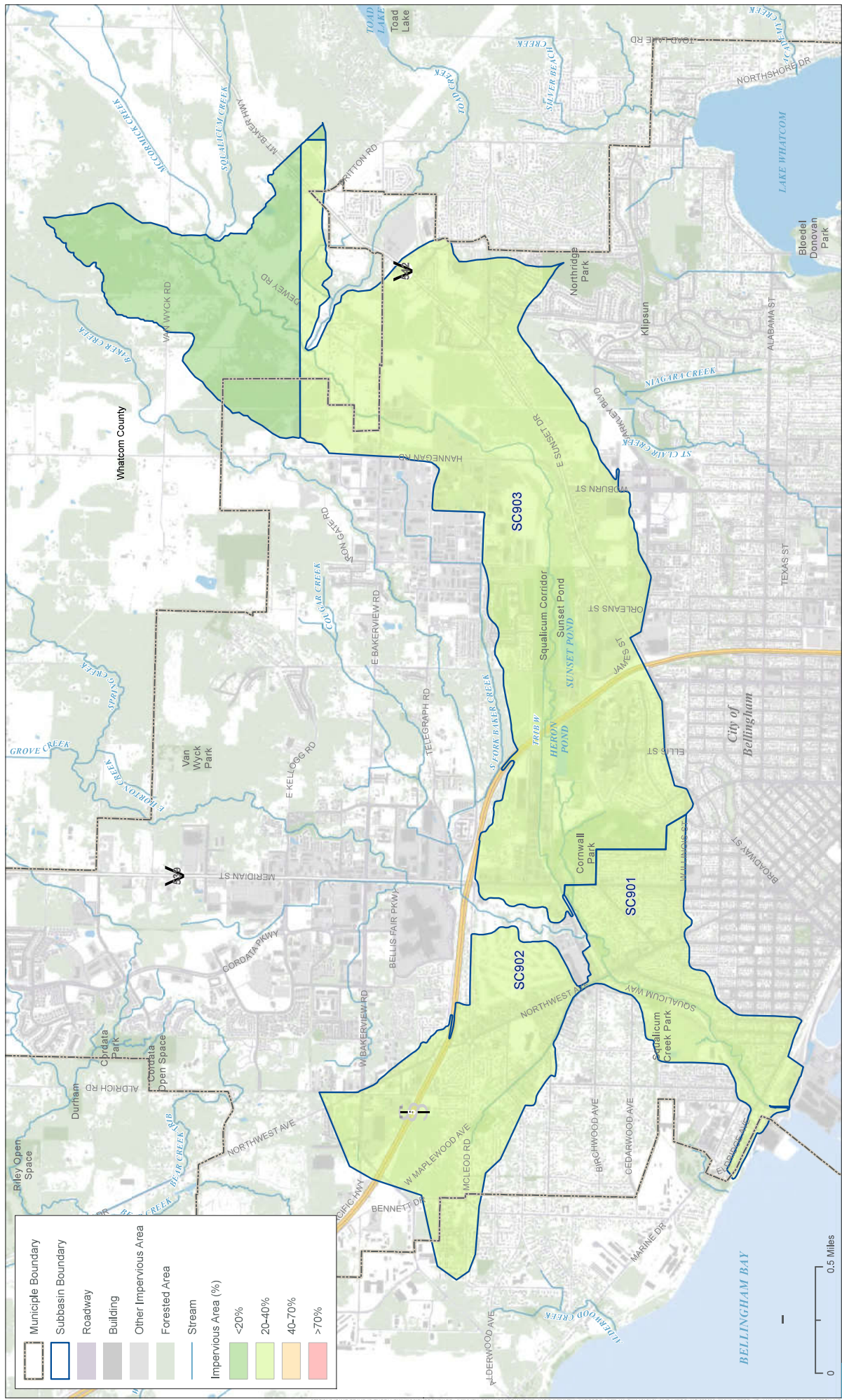
LOWER SPRING CREEK

FIGURE 7-4
City of Bellingham
Surface and Stormwater Comprehensive Plan



SOURCE: City of Bellingham, WSDOT, etc.

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LOWER SQUALICUM
 FIGURE 7-5
 City of Bellingham
 Surface and Stormwater Comprehensive Plan



SOURCE: City of Bellingham, WSDOT, etc.

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Based on impervious area intensities as shown in the heat maps, the top three sub-basins in each retrofit sub-watershed were selected for further analysis. A suite of water quality BMPs were initially identified for the top three sub-basins in each study area and presented to the City for its review. With assistance from City personnel, HDR selected BMPs to advance to concept design. The proposed BMPs reviewed at the workshop are shown in Appendix C, (C.1, Retrofit BMP Types and C.2 Retrofit Basin Maps Projects). The following sections summarize the retrofit projects evaluated for the targeted sub-watersheds.

Baker Creek Tributary

The Baker Creek Tributary basin is located north of I-5 and east of Guide Meridian Road. Except for the commercial district at the intersection of Guide Meridian Road and Telegraph Road, much of the Baker Creek Tributary sub-watershed has less than 20 percent impervious area, suggesting that stormwater retrofit potential is limited. Nonetheless, the following potential retrofit BMPs were proposed:

1. Filtration media vaults to capture and treat runoff from the commercial areas near the intersection of Telegraph Road and Guide Meridian Road
2. A bioretention or media filtration facility along Telegraph Road near the crossing of North Fork Baker Creek
3. A water quality basin filtration area that would be situated in the natural area upstream of the Telegraph Road dam

Each of the proposed BMPs listed above was discussed with the City within a workshop setting. Projects were not selected in this sub-watershed because of limited site availability and the relatively low level of impervious surface areas (that would aid in significant habitat improvement or water quality enhancement).

Lower Baker Creek

Lower Baker Creek comprises several smaller sub-basins that range in impervious area from less than 20 percent to greater than 70 percent. The heat map for this area indicated that the 130-acre (ac) industrial area in the eastern extent of the study area provides the best opportunity for stormwater retrofit.

Other sub-basins were evaluated for retrofit opportunities focusing on siting facilities on City-owned properties or within the ROW. Media filtration vaults, bioretention, and a regional water quality treatment facility were considered for the Lower Baker Creek sub-watershed. Based on contributing drainage area, impervious surfaces, and land use, a regional water quality treatment facility will provide the best retrofit opportunity to treat stormwater runoff. The site works well because it takes advantage of City-owned property, will treat runoff from an industrial area, and will result with a single end-of-pipe facility. Other areas within the sub-watershed sites that were considered, but dropped from retrofit BMPs, were not advanced because of property ownership, feasibility, and qualitative assessments of water quality improvement opportunity.

Lower Padden Creek

The impervious area in the Lower Padden Creek sub-watershed is split evenly between less than 20 percent, primarily south of Fairhaven Parkway, and the next higher category (20–40 percent), north of Fairhaven Parkway. The sub-basins with less than 20 percent impervious area were not good candidate areas for stormwater retrofit because there is little to no development in need of retrofit. The sub-basins north of Fairhaven Parkway, composed primarily of single-family residential (SFR) homes where impervious area ranges from 20 to 40 percent, became the focus for retrofit opportunities in this sub-watershed.

Infiltrating BMPs were considered because the soils map for this area indicated that good infiltration rates were possible (159—Squalicum-Urban land complex, gravelly loam soil with moderately well drained soils). Therefore, bioretention facilities were determined to be the preferred BMP type. Research and confirmation from the City indicated the presence of an existing regional water quality facility reducing the area for additional treatment to an area along Bill McDonald Parkway.

Lower Spring Creek

Retrofit opportunities in Lower Spring Creek focused on the sub-basins with commercial developments and public streets with high traffic counts. Filtration vaults and bioretention facilities were evaluated. Decisions at the CIP workshop supported use of filtration vaults along East Bakerview Road and Eliza Avenue, but when the sites were considered by the engineering team, challenges to locate the facilities where sufficient runoff volumes could be captured resulted in all of the facilities not advancing to the CIP.

Lower Squalicum Creek

Based on the heat map analysis, the impervious surface area analysis for Lower Squalicum Creek indicated that the sub-basins have less than 20 percent impervious area throughout, suggesting that retrofit potential is limited as a whole. However, the stream does experience flashy responses to storm events. Consequently, the City has been performing stream habitat restoration and bank stabilization activities such as in 2005 with the installation of large woody debris structures to enhance habitat and protect the banks. This area is monitored routinely for maintenance activity such as surveying for and controlling noxious weeds and other invasive plants. Squalicum Way, a high-volume truck route between the Port of Bellingham and I-5, provides opportunities for stormwater retrofit based on traffic volume. Filtration vaults and regional flow control facilities were explored and discussed at the CIP workshop. The filtration vaults emerged as the best option for this sub-watershed.

Birchwood Neighborhood Improvements

Retrofit opportunities in the Birchwood neighborhood focused on bioretention given the soil classifications, and with an emphasis on construction in the City-owned ROW to aid in implementation and maintenance. Ten facilities were evaluated using similar analysis conducted for this SSWCP that generated unit cost (dollars per square foot of bioretention area).

7.3 Potential Retrofit Facilities

The following retrofit facilities were analyzed and conceptually designed for the 2020 CIP. Each facility is described in greater detail in Chapter 8, Capital Improvement Plan.

7.3.1 Regional Flow Control

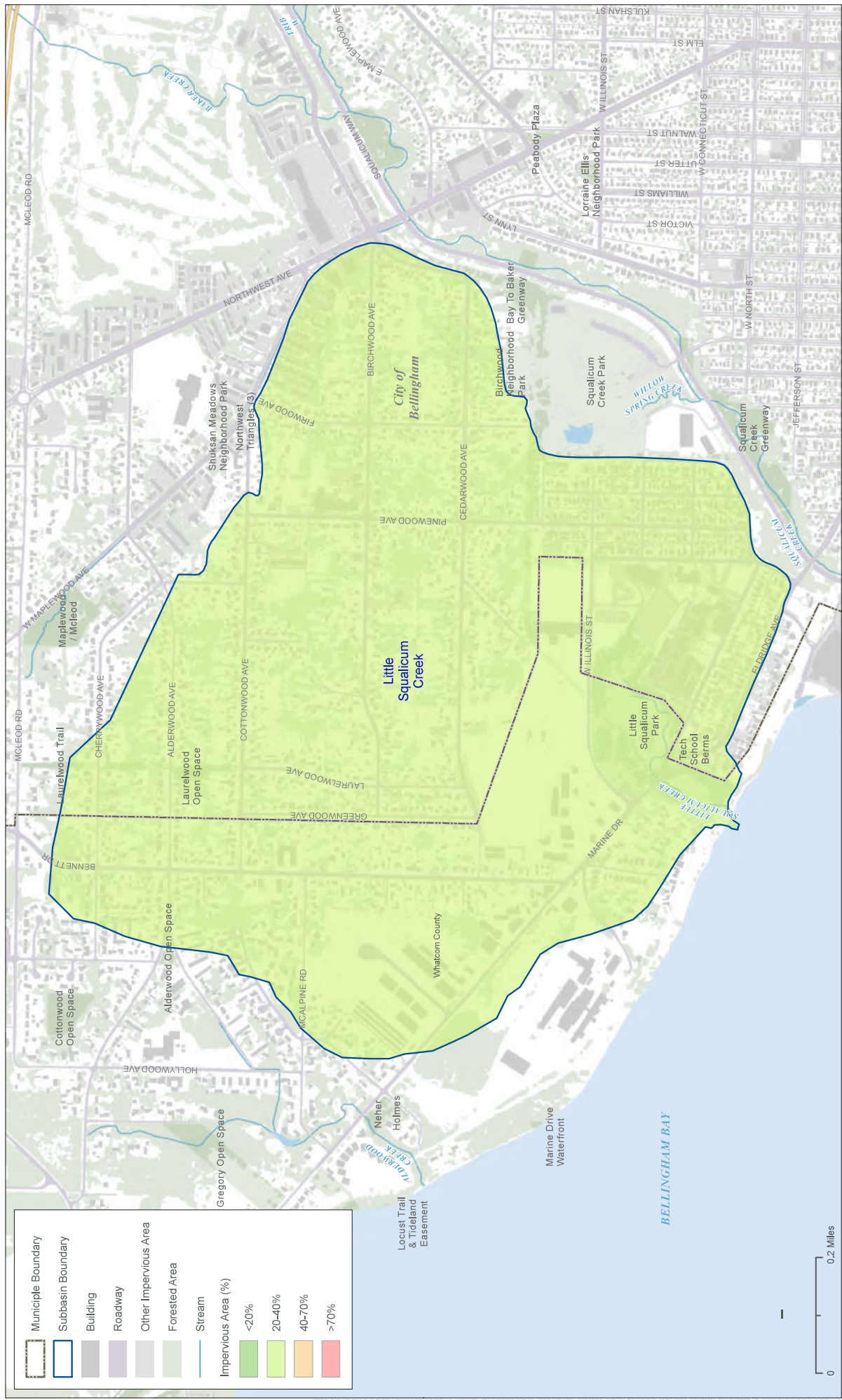
At the CIP workshop, City personnel supported developing a regional water quality and flow control facility in this sub-watershed where portions have industrial operations. The stormwater outfall pipe from the industrial basin is located on City-owned property, making the site a good candidate for a regional retrofit facility.

The proposed Baker Creek regional water quality and flow control treatment facility is a treatment-train system that includes a detention pond, pre-settling vault, and oil/water separator followed by a filtration chamber. The proposed facility layout is depicted in Figure 7-6.

The facility would receive runoff from two stormwater mainline conveyances from the east, one north and the other south of the facility and sized for the planning-level 2-year peak flow. The 2-year flow was selected based on Ecology SWMMWW treatment BMP criteria that filtration treatment downstream of detention ponds be sized for the 2-year pond discharge. The 2-year flow in the northern conveyance line is predicted to be 20 cfs, all of which would be routed to the detention pond. Flows exceeding 20 cfs would bypass the detention pond and would be routed directly to the facility, which would also be equipped with a high flow bypass at the southern end of the pre-settling vault. With this configuration, high flows in excess of the water quality design flow (3 cfs) would bypass the treatment train and discharge directly to Baker Creek.



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	Municipal Boundary
	Subbasin Boundary
	Building
	Roadway
	Other Impervious Area
	Forested Area
	Stream
Impervious Area (%)	
	<20%
	20-40%
	40-70%
	>70%



LITTLE SQUALICUM CREEK

FIGURE 7-5
City of Bellingham
Surface and Stormwater Comprehensive Plan



SOURCE: City of Bellingham, WSDOT, etc.

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The southern conveyance line drains an area approximately 8 acres in size. Runoff flow rates for the 2-year event are expected to be about 0.15 cfs per acre or 1.2 cfs for the 8-acre sub-area. The cfs per acre value is derived from modeling results calculated for the northern conveyance line. Flows from the south line would also flow through the treatment facility.

The treatment-train design is premised on purchasing undeveloped land adjacent to and north of the proposed treatment facility, where a detention pond would be sited. The proposed detention pond attenuates flow and serves as a pre-settling facility removing large sediment particles and lowering total suspended sediment (TSS) prior to runoff being routed to and treated by the water quality BMPs. The water quality facility would comprise three components, in the following order of treatment:

1. A pre-settling chamber would further decrease TSS and create laminar flow conditions for effective removal of hydrocarbons and oil residue by the oil/water separator unit.
2. An open-air filtration unit would use bioretention soil mix and vegetation to remove metals from the runoff.
3. The treated stormwater would be collected in an underdrain pipe and discharged to South Fork Baker Creek.

Design Parameters

The Baker Creek sub-watershed was delineated and modeled in MGSFlood to determine water quality flow rates (see Appendix C, C.3, BC 154 Design Summary). Within the model, the default extended time series precipitation data (158-year period) for the region was used. The input parameters for pre- and post-conditions that characterize land use types delineated with GIS software based on 2019 pervious land (PERLND) and impervious land (IMPLND) areas are shown in Table 7-1 below.

Table 7-1. Existing and proposed impervious and pervious areas for Lower Baker Creek

Existing conditions		Proposed conditions	
Land use type	Area (ac)	Land use type	Area (ac)
Outwash forest	128	Till forest	0.95
		Till pasture	6.87
		Till grass	1.23
		Outwash forest	2.65
		Outwash pasture	4.64
		Outwash grass	3.81
		Wetland	1.06
		Impervious	107

In MGSFlood, these areas were routed through a flow splitter that conveyed 20 cfs of runoff into the pretreatment pond and the remainder of runoff into bypass as depicted in Figure 7-6 above. Water quality modeling results calculated total runoff volume to be 2,461 acre-feet (ac-ft) and the 2-year discharge rate to be 3.15 cfs.

This proposed treatment facility would clean stormwater runoff originating from an industrial/commercial drainage area. The detention/treatment facility would lower peak flow rates and remove petroleum hydrocarbons and heavy metals from stormwater prior to being discharged to South Fork Baker Creek. This facility would reduce flood risk, improve aquatic habitat, and generally improve the quality-of-life standards for the community.

7.3.2 Filtration Vaults

Filtration vaults are proprietary water quality treatment units that typically use filter cartridges or filtration media contained within a precast concrete vault (e.g., Modular Wetlands, Filterra units) to collect, treat, and then discharge stormwater runoff to receiving waters. They work particularly well in existing stormwater drainage lines because they integrate well into existing lines with minimal disruption.

In the 2020 retrofit plan, filtration vaults are proposed along heavily traveled roadways in the Squalicum and Padden Creek sub-watersheds. Two filtration units are proposed in Squalicum Way, a heavily traveled truck route between the Port of Bellingham and I-5. The two filtration units are proposed just upstream of outfalls to Squalicum Creek.

Both filtration vaults are included in each CIP scenario; therefore, a prioritization evaluation was not conducted.

7.3.3 Bioretention Facilities

Bioretention facilities sited in City-owned ROW are proposed in the Birchwood neighborhood. Ten Birchwood neighborhood facilities were identified in the 2019 Birchwood Retrofit Plan (Appendix C, C.4 Birchwood Retrofit Plan). Each was evaluated for inclusion in the proposed 2020 CIP though the area was not expressly identified as a Tier 1 sub-watershed. HDR evaluated the proposed facilities using desktop analyses and web-based Google street view technology to verify that recommended sites meet minimum criteria for siting ROW bioretention facilities. The criteria used in the evaluation and site ranking are discussed below.

Bioretention siting criteria include the presence or absence of mature trees, planter strip widths, adjacent grades, driveway frequency, landscaping, street parking, and utility conflicts. The Baker Creek sub-watershed was delineated and modeled in MGSFlood to determine water quality flow rates (see Appendix C, C.3, BC 154 Design Summary). Within the model, the default extended time series precipitation data (158-year period) for the region was used. Table 7-2 lists the 10 sites and includes summary notes describing site conditions. Appendix C illustrates the locations of these sites.



Table 7-2. Bioretention sites and ranking criteria

Site ID	Intersection	Recommendation	Notes
1	W Illinois St. and Nome St.	Yes	Site facilities on both sides of W Illinois St., east of Nome St. No sidewalks, no trees, OHP, but can work around.
2	Cedarwood Ave. and Pinewood Ave.	Maybe	Mature trees along Cedarwood Ave. (SW corner), below grade lot on NW corner, sidewalk (SE). NE corner could work, but small.
3	Cedarwood Ave. and Firwood Ave.	Maybe	Landscaping improvements (NW), mature tree (NE), trees/shrubs (SE), one possible site (SW).
4	Birchwood Ave. and Pinewood Ave.	No	Driveway (NW), mature trees (NE), mature trees, below-grade lot (SE), pavement improvements/parking (SW).
5	Birchwood Ave. and Firwood Ave.	Yes	Conflicts: mature trees, landscaping (SW), 1 mature tree but could work around it. Site facilities along Birchwood Ave. eastward and Firwood Ave. southward.
6	Alderwood Ave. and Cherrywood Ave.	No	Site 6 is not recommended because of trees, longitudinal slope, street parking, and below-grade adjacent lots.
7	Cottonwood Ave. and Pinewood Ave.	No	Conflicts with driveways, utilities, street parking, sidewalk.
8	Cherrywood Ave., north of Cottonwood Ave.	Yes	Open lawn, no landscaping or driveway conflicts.
9	The 3200 block of Laurelwood Ave.	Yes	ROW facility, west side of Laurelwood Ave. south of Cottonwood Ave. The proposed site spans across several lots, west side of Laurelwood Ave.
10	The 3100 block of Cedarwood Ave.	Yes	ROW facility, north side of road, spans 2 lots.
11	Bill McDonald Pkwy. ^a	Yes	Insert facility into existing conveyance line, include overflow structure to pass high flows. Will require removing SD line and providing traffic control.

a. The Bill McDonald Parkway site is not part of the Birchwood retrofit plan. It was identified by the Padden Creek evaluation.

Sites 4, 6, and 7 are not recommended because of conflicts with mature trees, driveways, adjacent lots being below grade, and utility conflicts. Sites 2 and 3 are marginal sites because of mature trees and other conflicts, but facilities could be arranged to avoid the conflicts. They rank lower in priority. Sites 1, 5, and 7–10 meet standards for ROW bioretention facilities and have a higher ranking. The Bill McDonald Parkway site (Site 11) also met standards.

The ranking criteria are based on recommendations cited in Table 7-2 and facility size because sizing equates to pollutant load reduction. In order of ranked priority the bioretention sites to be considered for the 2020 CIP are:



1. 3200 block of Laurelwood Avenue: A 350-by-16-foot facility along Laurelwood Avenue (Site 9).
2. W Illinois Street east of Nome Street: A 300-by-16-foot facility on both sides of W Illinois Street (Site 1).
3. 3100 block of Cedarwood Avenue: A 300-by-16-foot facility along the north side of the road; spans two lots (Site 10).
4. Cherrywood Avenue: North of Cottonwood Avenue a 116-by-16-foot facility (Site 8).
5. Birchwood Avenue and Firwood Avenue: A 115-by-12-foot walled facility. One mature tree in the corner can be avoided. Place facilities along Birchwood Avenue eastward and Firwood Avenue southward (southeast). West of the intersection on both sides of Birchwood, landscaping and shrubs are prohibitive (Site 5).
6. Bill McDonald Parkway: Place an 84-by-16-foot facility in a planter strip between the roadway and sidewalk. Possible utility conflicts (Site 11).
7. Cedarwood Avenue and Pinewood Avenue: Marginal site because of the presence of mature trees along Cedarwood Avenue (southwest corner), below-grade lot (northwest corner), and sidewalk (southeast). The northeast corner could work, but small (Site 6).
8. Cedarwood Avenue and Firwood Avenue: Marginal site. Landscaping improvements (northwest), mature tree (northeast), trees/shrubs (southeast), and one possible site (southwest) (Site 7).

7.4 Fish Passage Program

The City initiated a culvert improvement program in 2003 to address barriers to fish passage within city limits. The City is committed to stewarding fish and wildlife habitat and has a long history of improving fish passage throughout the city and urban growth area both with independent restoration projects and in conjunction with other capital improvement projects (City 2019).

The Washington Department of Fish and Wildlife (WDFW) uses a Priority Index (PI) to evaluate culverts and takes into account the severity barrier, habitat gain, species mobility, stock status, and projected cost of the project (WDFW 2019). The City uses the WDFW PI scores to create a draft list that goes through a data-driven process to identify the prioritized projects. The full decision-making process used during the 2019 update is shown in Figure 7-7. Barrier improvements are coordinated with other entities when possible to maximize habitat benefits and cost efficiencies, and has been since before requirements were set in place under the 2013 injunction requiring the State of Washington to correct fish barriers.



STEPS 1 -6: Identify Sites

1. Create a Draft Priority List consisting of the top 10 City-owned barriers within City limits identified in the Whatcom County Fish Passage Barrier Inventory (Whatcom County Public Works, 2006), ranked by 2006 PI score and listed by WDFW identifier number.
2. Update PI scores for the 10 barriers identified in 1, above, using the FPDSI database (WDFW, 2019a).
3. Review all City-owned barriers within City limits mapped on the FPDSI database (WDFW, 2019a) and add barriers with PI scores \geq lowest score identified in 2 (PI score \geq 15.48).
4. Add barriers to the Draft Priority List if they:
 - a. did not have a PI score but were lower in the system than barriers on the Draft Priority List from 3, above and/or
 - b. are within 2 miles of a restoration site or barrier removal completed or planned to be complete by 2025. Planned projects are based on the City’s adopted Six-Year (2020-2025) Transportation Improvement Program (City of Bellingham, 2019) and the WSDOT 2019 Project Delivery Plan (WSDOT, 2019).
5. Add any top 10 barriers from Anchor 2010 (from PI Ranks for All Barriers list), if not already on Draft Priority List from 4, above.

STEP 6: Refine Site Information

6. Update and add information:
 - a. Calculate lineal gain if not provided on WDFW barrier forms by estimating distance in GIS using City of Bellingham stream layer.
 - b. Update any data from qualified sources. In 2019, this consisted of updating fish Passability at the City’s flood dams based on a habitat assessment conducted by Environmental Science Associates (ESA), Waterfall Engineering, Aspect Consulting, and Wilson Engineering (2019). It also included updating the ESA species presence to include bull trout from WDFW (2019b).

STEP 7: Score and Rank Sites

7. Score and rank all culverts on the Draft Priority List from step 7 using the Prioritization Equation below. The equation uses 12 metrics. These metrics represent key information available for all barriers together with Additional Considerations (species listings, coordination, benefits, juveniles, community support, and funding opportunities) provided in the WDFW *Fish Passage Inventory, Assessment and Prioritization Manual* (WDFW, 2019c, p. 12-5). See the Prioritization Manual for methodologies and descriptions of each of the Additional Considerations.

Prioritization Equation:

<p>SCORE =</p> <p>Lineal Gain + Passability + ESA + Coord. Barriers + Coord. Other + (Benefits/3) + Juveniles + Comm. Support + Funding Opp. – Cost</p>

Figure 7-7. 2019 fish barrier prioritization methodology

The City provided HDR a list of ranked culverts from the Prioritization Report (City 2010) that included 2019 planning-level construction estimates. These estimates were developed only to determine orders of magnitude for the purposes of prioritizing culvert improvements. The list of ranked culverts are included in Appendix C (C.5 Ranked Fish Passage culverts).

The top five culverts from the City-provided list were selected; their locations are shown in Figure 8-1. The top five culvert projects were included in the 2020–2026 CIP.

7.5 Conveyance Improvements

Operating and maintaining an SSWU requires an intentional program to renew or replace stormwater conveyance lines. The 2007 Stormwater Comprehensive Plan and 2020 SSWCP each have analyses identifying stormwater pipelines in need of renewal or replacement to address deficiencies in condition or capacity. This section describes recommended conveyance improvements for the 2020–2026 CIP, including a marine outfall conveyance improvement plan, a marine outfall basin prioritization, PURC projects, and 2007 CIP conveyance.

7.5.1 Marine Outfall Conveyance Improvement Plan

The Shoreline Management Master Program includes the goal of shoreline protection. Specific shoreline protection policies focus on flood protection through the use of floodplain management. This is done through the use of flood protection and streamway modifications. It is recognized that improper flood control upstream results in increased flood damage downstream. Floodplain management as a means of flood control has advantages of maintaining the natural characteristics of the shoreline while protecting adjacent property without amplifying potential flood damage downstream.

Bellingham Bay contains nine direct discharge outfall systems from various highly developed areas of the city that are a concern for the City regarding upstream flooding and conveyance restrictions that could impact land use development and property values, in addition to impacts to the receiving water body, Bellingham Bay. As part of the 2020 SSWCP update, the City requested an analysis of mainline conveyance pipelines draining directly to Bellingham Bay to identify capacity-constrained sections of pipe. The objective of the analysis was to identify pipe segments to be upgraded and enlarged to meet the City's 25-year conveyance standard in the built future condition.

Hydrologic and hydraulic models were developed and used to conduct detailed analyses to characterize current- and future-conditions flooding in nine direct discharge marine outfall systems in the city of Bellingham. The hydraulic model was then used to develop and evaluate potential flood reduction alternatives with the goal of eliminating flooding during the 25-year full buildout conditions flood event, and evaluate the effect of SLR on the drainage systems. Modeling results show that two of the basins, Bennett Street outfall and Cedar Street outfall, have no flooding. They were removed from consideration in the CIP. The other seven basins have varying improvement needs to meet the objective of conveying the future 25-year flow.

To minimize the cost of the proposed improvements, solutions were sought that required replacing the shortest total length of pipe. In some instances, however, several alternatives were identified to achieve the desired level of flood reduction.

When testing pipe upsizing alternatives, the invert elevations for upsized pipes were kept at the existing invert elevations except in instances where the new pipe would have less than 1 foot of cover over the pipe crown to the ground surface at either end of the pipe. In these cases the invert elevations for the new pipe were lowered such that there would be at least 1 foot of cover. If the cover was less than 2 feet, then ductile-iron pipe (DIP) material was specified for cost implications. City standard pipe material would be assumed for pipes with cover of 2 feet

or more. To be conservative for the purposes of setting budgets, some solutions may indicate the replacement of the same size pipe but changing the pipe material to create higher conveyance. During the actual design phase of these projects, a value engineering review should be performed for alternatives such as sliplining or pipe-bursting that may produce lower overall costs and less disruption to traffic and utilities.

A future SLR analysis was also conducted to evaluate the effect of SLR on the proposed conveyance system improvements. Additional information on SLR as a result of climate change is provided in Chapter 4. The scope of this analysis has the time horizon set at 50 years in the future (i.e., 2070). Recent work by the UW CIG estimates that the median value of relative SLR in Bellingham Bay will be between 0.9 foot and 1.1 feet by 2070. The SWMM model of the flood reduction alternatives was run assuming that the tidal boundary condition was raised by 1.1 feet. While the higher tailwater condition results in increased water levels upstream of the outfalls, this analysis found that no additional flooding would result from the predicted SLR. The conclusion is that the proposed conveyance system improvements are robust enough to handle at least 1.1 feet of future SLR. While other SLR studies are looking at greater increases in tidal conditions (resulting from time horizons longer than 50 years), this horizon would be longer than that of the pipe system.

The following prioritization criteria were used to rank the outfall basins:

- Structural flooding risk
- Increase in impervious surface area between existing conditions and future full buildout conditions
- Percent increase in the simulated 25-year flow rate between existing and future land uses
- Number of predicted flooding catch basin structures in the future-conditions scenario
- Roadway classification where proposed improvements are needed
- If the pipe segment is identified as being in poor condition by the City's PURC program
- The type of land conversion between existing and future conditions

Data used in the prioritization are shown in Table 7-3. Point values for each criterion, based on the range of values and distributed evenly without weighting, are shown in Table 7-4. The actual scores and outfall basin rankings are shown in Table 7-5.

Figure 7-8 shows the recommended pipes to be upgraded to eliminate flooding for the 25-year design flood event with full buildout land use. The complete modeling report is included as Appendix C (C.6 Marine Outfall Tech Memo). Brief discussions of the solutions are provided below, organized by the street name where the outfall discharge is located.

Arbutus

Within the Arbutus basin, one hydrologic model node floods during the 25-year flood event. Replacing the existing 12-inch-diameter corrugated metal pipe (CMP) with a 15-inch-diameter RCP pipe or with a 12-inch-diameter smooth bore is recommended. Polyvinyl chloride (PVC)

pipe would eliminate predicted flooding. The reduction in roughness between these two pipe materials is sufficient to eliminate flooding at this location. The increase in size would provide additional capacity.

Broadway

The flooding within the Broadway basin is more extensive than any other basin, with flooding along both the Broadway branch and Eldridge branch of the drainage network for the 25-year storm. To eliminate flooding along the Broadway branch (Meridian, Kulshan, and Peabody Streets), 49 pipe segments were identified that need to be upsized (total length 6,575 feet). These modifications also would act to reduce water levels upstream in the drainage network and eliminate the inter-basin flooding at the intersection of H and Jenkins Streets to the Ellsworth basin. DIP is recommended for some of the replacement pipes as they have less than 2 feet of ground cover above the pipe crown. To eliminate flooding along the Eldridge branch, modifications to the main branch beneath Eldridge Street and the smaller branches leading to the main branch are recommended (total length 3,181 feet). However, it should be noted that the City does not own or maintain the stormwater outfall on Port of Bellingham property, as there are no easements or maintenance agreements. Improvements to this component of the system would require coordination with the Port of Bellingham.

C Street

Flooding in the C Street basin can be eliminated by upsizing 13 pipes with a total length of 1,421 feet. A portion of the recommended pipe upgrade in sizing will have to be installed at a lower invert elevation to maintain a minimum of 1 foot of cover (the existing concrete pipes have less than 1 foot of cover at this location). DIP is recommended for these and three other replacement pipes in the basin because they will have less than 2 feet of cover.

Ellsworth

Flooding within the Ellsworth basin can be eliminated by upsizing eight pipes with a total length of 1,509 feet. Currently the Broadway basin overflows into the Ellsworth basin. Modifications made to the Broadway system would eliminate interbasin overflows.

Laurel

Flooding within the Lauren basin can be eliminated by upsizing 10 pipes and changing the material on 1 pipe, with a total length of 1,162 feet.

Olive

The only simulated flooding in the Olive basin occurs from a manhole east of the railroad, immediately upstream from the outfall. Surface flooding may not be much of a problem at this location, in which case no action would be needed. However, if the City wants to eliminate any flooding, one pipe segment would need to be upsized.

Willow

In the Willow basin, four pipes need to be replaced to eliminate flooding along Bayside Road. Flooding can be eliminated by installing 24-inch-diameter RCP pipes, which have a lower roughness value than the existing CMP. The reduced roughness with concrete pipes is enough to eliminate flooding at this location, while the increase in size would provide additional capacity. An alternative to consider during engineering design of this project would be a sliplining approach. Sliplining has the ability in areas of congested utilities and surface features to be more cost-effective over “cut-and-cover pipe replacement.”

7.5.2 Pavement and Utility Rating Committee Projects

The City’s PURC uses condition assessments to identify conveyance lines in need of repair or replacement. The PURC pipe list is in part linked with the City’s roadway improvement overlay program with the goal of improving subsurface utility conveyance lines (water, sanitary, and storm) ahead of plans to improve the roadway surface. Flood protection is another driver of replacing or renewing stormwater conveyance lines. The PURC list comprises pipe segments inspected by the City’s video inspection program and marks the pipes as in “fair” or “poor” condition. For the 2020 SSWCP update, the following poor condition conveyance lines are included the CIP (see Chapter 8).

Valencia Street Conveyance

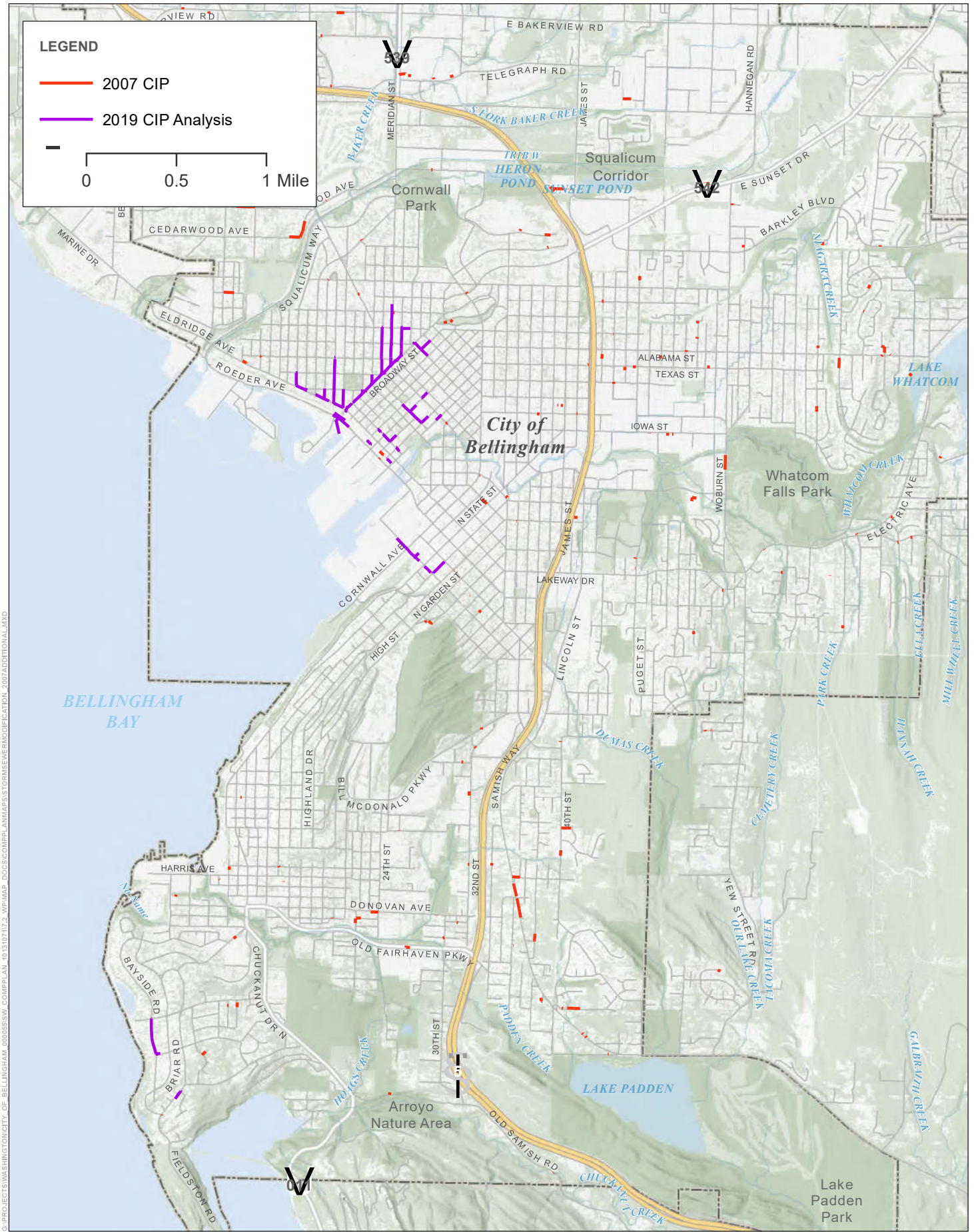
The Valencia Street Pipeline Repair project is a proposal to replace or repair approximately 1,600 lf of large-diameter storm pipe. A condition assessment report indicates that the pipe varies in diameter from 48 to 54 inches and notes that the bottom is rusted out in places. Because the pipe is located in the public ROW, there is concern of roadway damage if the structural integrity of the pipe were to fail. The pipe segment, constructed in 1984 along Valencia Street, currently conveys water from urban development and a portion of Fever Creek. Its repair will require temporary bypass of Upper Fever Creek to Lower Fever Creek for an approximate 2-week period. Pipe identifiers (IDs) were referenced to City GIS data and analyzed for recent improvements. A cost estimate was prepared for Valencia Street, which is further explained in Chapter 8, Capital Improvement Plan. The City is currently moving this project forward independent of this SSWCP.

North Garden Street

Along N Garden Street between E Pine Street and E Oak Street replace 500 lf of 12-inch-diameter pipe with 12-inch-diameter pipe.

Billy Frank Jr. Way

Between E Ellis Street and E Holly Street replace and enlarge 400 lf of 10-inch-diameter RCP with 12-inch-diameter RCP.



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Source: City of Bellingham (2018)

STORM SEWER MODIFICATION

FIGURE 7-8

City of Bellingham

Surface and Stormwater Comprehensive Plan



Table 7-3. Marine outfall prioritization data

Marine outfalls area ^a	Structural flooding risk ^b	Impervious area increase (%)	25-year flow existing (cfs)	25-year flow future (cfs)	Percent increase	Roadway classification ^c	Flooding nodes	PURC list ^d	Type of land conversion
Arbutus	High	13	11	16	45.5	Residential	1	No	SFR to SFR
Bennett	Low	13	19	27	42.1	Principal	0	No	SFR to MFR
Broadway Eldridge branch ^a	Low	15	103	132	28.2	Principal	16	Yes	SFR to MFR
Broadway Main branch ^a	Medium	15	103	132	28.2	Principal	17	No	SFR to MFR
C Street	Low	17	42	50	19.0	NA	11	No	Large conversion of SFR to MFR
Cedar	Low	7	21	28	33.3	Principal	0	Yes	Institutional and public space and parks
Ellsworth	Low	5	32	34	6.3	Other	4	Yes	SFR to MFR
Laurel	High	19	35	50	42.9	Residential	11	No	SFR to MFR
Olive	Low	11	22	32	45.5	Residential	1	No	No appreciable change
Willow	Low	10	17	24	41.2	Residential	4	No	Roadside ditch floods

SFR = single-family residential zoning; MFR = multifamily residential zoning.

- a. Broadway Main and Broadway Eldridge are both located in the Broadway basin. Eldridge is left branch. Flows reported at outfall. Because each sub-basin discharges at the same outfall, the flow value for each is equal. Flooding nodes: total is 33 (from Table 6 in Appendix C, Marine Outfalls Technical Memorandum). Fourteen are from Eldridge, per count in Table 7 for Eldridge (Appendix C, Marine Outfalls Technical Memorandum).
- b. Desktop review to assess flood risk determined qualitatively using Google street view. High risk: floodwaters could enter structure. Analysis based on Google street view and roadway profile; medium risk: residential flood risk is possible, no business flooding, drainage flows to railroad easement; low risk: floodwaters do not threaten structure and/or flow toward railroad easement.
- c. Roadway classification from CityIQ where improvements are identified (Principal, Secondary, Collector, Residential).
- d. PURC = Pavement and Utility Rating Committee.

Table 7-4. Marine outfall prioritization points criteria

Flooding risk	Flooding Pts. ^a	Impervious area delta (percent)	Pts. ^a	Percent flow increase	Pts. ^a	Flooding nodes	Pts. ^a	Roadway classification	Pts.	PURC list	Pts.	Land conversion type	Pts.
High	3	≥15	3	≥34.5	3	≥ 5	3	Collector	3	Yes	2	Comm, Instit, or Ind.	3
Medium	2	10 to <15	2	23 to <34.5	2	10 to <15	2	Principal	3	No	0	SFR to MFR (larger scale)	2
Low	1	5 to <10	1	11.5 to <23	1	5 to <10	1	Secondary	3	NA	NA	SFR to MFR smaller scale)	1
None	0	<5	0	<11.5	0	<5	0	Residential	0	NA	NA	No change	0

Pts. = points; Comm = commercial zoning; Instit = Institutional zoning; Ind = industrial zoning; SFR = single-family residential zoning; MFR = multifamily residential zoning; NA = not applicable.

Point categories evenly divided based on range of values for each category.



Table 7-5. Marine outfall scores and ranking

Rank	Marine outfall	Structural flooding risk	Impervious area increase	Percent increase in flow	Flooding nodes	Roadway classification	PURC list	Type of land conversion	Score
1	Laurel	3	3	3	2	3	0	2	16
2	Broadway Main branch	2	3	2	3	3	0	1	14
3	Broadway Eldridge branch	1	3	2	3	3	2		14
4	C Street	1	3	1	2	3	0	2	12
5	Arbutus	3	2	3	0	0	0	0	8
6	Ellsworth	1	1	0	0	3	2	1	8
7	Olive	1	2	3	0	0	0	0	6
8	Willow	1	2	3	0	0	0	0	6

7.5.3 2007 CIP Conveyance

The goals and objectives of the 2007 Stormwater Comprehensive Plan include:

- Analysis of existing stormwater facilities and aquatic resources
- Identification of existing stormwater problems
- Analysis of alternative stormwater solutions
- Documentation of the stormwater plan for implementation by City staff
- Providing City staff a tool to address stormwater and pollutant control obligations, as required by local, state, and federal law

The 2007 Stormwater Comprehensive Plan was an update to the 1995 Watershed Master Plan developed for the City of Bellingham by HDR. The recommendations found in the 2007 document included the use of conveyance system sizing information for future study prior to design and construction. The study areas included portions of six watersheds that flow through the city of Bellingham: Whatcom Creek, Silver Beach Creek, Padden Creek, Chuckanut Creek, Squalicum Creek, and Silver Creek. The study areas within each watershed were selected because of known and/or suspected stormwater problems.

The stormwater drainage analysis was conducted using the SWMM module of the WWHM3 software. The conveyance systems were modeled using the SWMM module. A detailed description of the modeling analysis can be found in the 2007 report. SWMM's automatic pipe resizing routine was used to aid in developing appropriate pipe diameters to meet the required level of service.

The 2007 Stormwater Comprehensive Plan includes a list of pipe deficiencies in basins throughout the city along with associated pipe increase suggestions. The pipes in the 2007 deficiency list were then analyzed in GIS with pipes coded for replacement under the marine outfall conveyance improvements (described in Section 7.5.1 of this chapter). Pipe code numbers that overlapped under the 2007 pipe deficiency list were filtered from the 2007 list. A summary of the 2007 Stormwater Comprehensive Plan pipe list, pipe lengths, and sub-watersheds are shown Table 7-6.



Table 7-6. Summary of conveyance pipes needing improvements from 2007 Stormwater Comprehensive Plan

Sub-basin	Improvement project group	Pipe upgrade quantity (lf)
Whatcom Creek	Ellis Street 1	2,250
	Ellis Street 2	2,050
	King/Virginia/Lincoln	3,400
	Meador Avenue	200
	State Street	900
	Misc. Whatcom outfalls	250
Fever Creek	Kentucky Street	1,050
	Orleans/Nevada	1,600
	Valencia/North/Verona	3,500
	Misc. improvements	700
Cemetery Creek	(Insufficient conveyance system data)	
Hannah Creek	Lakeway Drive	800
	Raymond Street	200
Lincoln Creek	Lincoln Creek	1,050

7.6 Padden Creek Flow Augmentation Project

Several aquatic habitat restoration projects have been built in lower Padden Creek downstream of Lake Padden since the last SSWCP update. Stream flow data collected from the Fairhaven Park flow gage show that during most summer months, the stream runs dry, putting the success of the habitat projects at risk. The analysis reported in this section was requested to provide the City information and data about augmenting flows in Padden Creek. Its purpose was to provide information to support possible future plans. As a possible capital improvement project to mitigate this problem, an analysis to withdraw water from Lake Padden and augment stream flow to the creek was performed. The analysis evaluated the effects on lake levels from two water withdrawal rate proposals.

A water balance model was used to measure the effects on lake levels from a withdrawal rate of 1 cfs and 2 cfs for a few different augmentation periods. The following scenarios were analyzed:

1. Minimum withdraws (1 cfs in summer and fall)
2. Medium withdraws (2 cfs in summer and 1 cfs in the fall)

3. A maximum withdraw (2 cfs in summer and fall)

The results of the analysis showed that:

- Depths up to 0.7 foot in the habitat reach (where a previous daylighting project was installed) were obtained when 2 cfs were added.
- Augmenting stream flow by 2 cfs drops Lake Padden water levels by about 3 feet and produces channel depths of about 0.7 foot.
- Based on flow exceedance calculations, 2 cfs would be a significant flow augmentation rate that would have an impact of sustaining water in the lake (i.e., lake levels would reduce) and deemed by City staff to be unacceptable.
- Augmentation by 1 cfs drops Lake Padden by about 1 foot and produces channel depths of 0.6 foot in the receiving stream.

The findings show that the water level impacts may have effects for the management objectives of the lake, and thus the City should have additional discussion to guide next steps. The technical memorandum describing the water balance model is included in Appendix C, (C.7, Lake Padden Flow Augmentation Technical Memorandum).

7.7 Iowa Street Flooding

During staff interviews, persistent flooding along Iowa Street, just east of I-5, was identified as a problem to investigate. As of 2019, no formal analysis had been completed to identify the cause of the flooding. Because a basin-scale hydrologic analysis was beyond the scope of the SSWCP project, a desktop assessment was performed to investigate Iowa Street flooding and to consider if an end-of-pipe solution should be included in the CIP (e.g., tide gate).

During the staff interview, City personnel stated that about 3 feet of water had been observed in Iowa Street during a recent flooding event (date was unknown) and that Whatcom Creek was flowing during the event. It was speculated that backwater from Whatcom Creek may contribute to the flooding problem. The desktop assessment considered outflow data from Lake Whatcom dam and attribute data from CityIQ of stormwater assets in the surrounding area.

The rim elevation of the stormwater catch basin at the intersection of Iowa Street and Nevada Street is 59.61 feet (asset 8329NW-358), which puts the alleged flooding water surface elevation at about 62.6 feet. The invert elevation of the 60-inch-diameter outfall pipe to Whatcom Creek at Nevada Street is 50.95 feet, which means that if backwater from Whatcom Creek were causing the problem, the water surface in Whatcom Creek at the outfall would have to be at least elevation 60 feet or higher (e.g., 63 feet) to produce the observed flooding water surface elevation. Contour data from CityIQ show that ground elevations on the opposite bank of Whatcom Creek range from 55 feet to 60 feet, suggesting that the south side of Whatcom Creek would flood long before Iowa Street would flood (because Iowa Street is 3 feet higher in elevation).

The conclusions of the desktop assessment were that backwater from Whatcom Creek does not contribute to Iowa Street flooding and an end-of-pipe CIP solution is not warranted. During the

course of the desktop assessment, the City completed construction of a large stormwater detention vault in the Iowa Street sub-basin along the south side of the public works facility in Virginia Street. The vault was sized to meet flow control requirements of the redeveloped public works site with extra volume being designed to provide downstream flood relief.

A full-scale hydrologic and hydraulic modeling analysis is recommended for identifying engineered solutions to the Iowa Street flooding. The modeling approach will need to establish a stage-discharge curve for the flow splitting on Fever Creek at Valencia Street to calculate the respective flow values split off into the Valencia Street bypass and how much stays in lower Fever Creek flowing toward Iowa Street. The hydraulic analysis will need to evaluate existing detention volume in the basin as well, like what was recently constructed by the City to capture the effect that facility has on the flooding problem.

Given that this analysis shows downstream tailwater is contributing to the problem, one possible consideration would be that the conveyance system is constrained by pipe size or as a result of pipe failures. Considering how developed the sub-basins draining to the flooding locations are and the size of the existing conveyance network, engineered solutions will likely be centered on providing more detention and volume-reducing bioretention facilities in the upper basin.

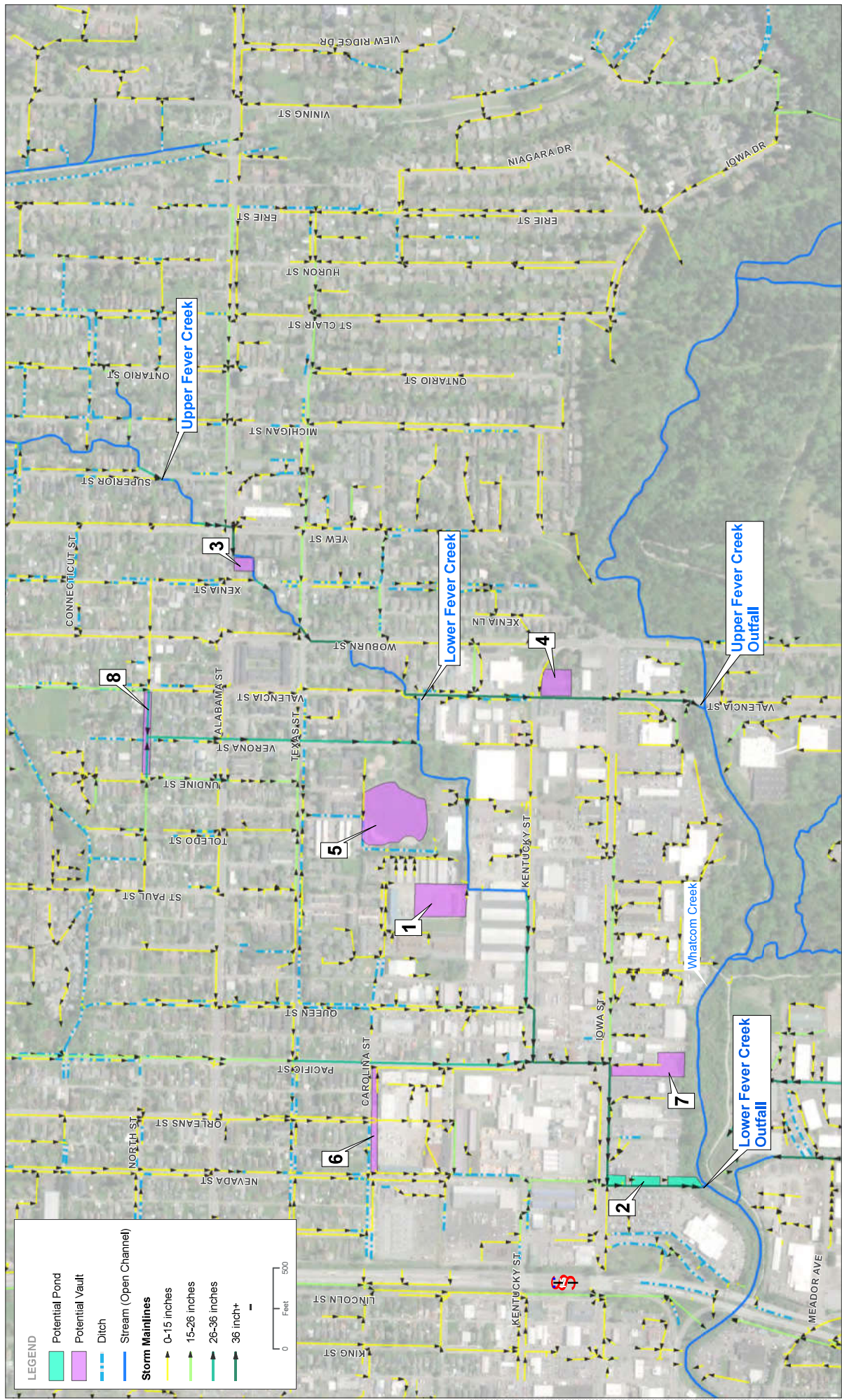
As part of the 2020 assessment, eight possible sites (parcels) were identified as locations where flow control facilities could be built. Table 7-7 presents a summary of these sites. Figure 7-9 shows the locations of the potential detention vaults.

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Table 7-7. Fever Creek basin analysis: potential detention sites

Solution #	Parcel #(s)	Total size (ac)	Landowner	Current Land Use	Basin	Drainage to parcel (ac)	Drainage Percentage of Total Fever Creek Basin	Acres impervious roads ^b	Acres impervious roofs ^b	Acres other impervious (driveways, walking paths, patios, etc.) ^b	Impervious total (percentage of drainage to parcel)
1 (vault)	380329329523 380329340519	2.03	Joan's Lane Properties LLC	Partially undeveloped field (land use code 91)	Lower Fever Creek	311	23.5	31 (10%)	40 (13%)	57 (18%)	41
2 (pond)	NA; ROW going south from (intersection of Iowa St. and Nevada St.)	0.98	City of Bellingham: Public Works	Existing UID stormwater BMP (rain garden)	Lower Fever Creek	614	46.3	67 (11%)	103 (17%)	148 (24%)	52%
3 (vault)	380320540078	0.23	Kathleen E. Briscoe	Managed undeveloped field adjacent to Fever Creek	Upper Fever Creek	526	39.7	48 (9%)	70 (13%)	34 (7%)	29
4 (vault)	380329474447	0.67 (additional adjacent parking lot)	Janna L. Palm	Maintained undeveloped field	Upper Fever Creek	706	53.3	69 (10%)	103 (15%)	52 (7%)	32
5 (vault)	380329400543	2.88	City of Bellingham: Finance Dept.	Grassy field within Roosevelt Park	Lower Fever Creek	286	21.6	30 (11%)	35 (12%)	51 (18%)	41
6 (vault)	NA; northern parking lot adjacent to parcel 380329146532	0.67	City of Bellingham: Finance Dept.	Parking lot along Carolina St.	Lower Fever Creek	166	12.5	22 (13%)	31 (19%)	24 (15%)	47
7 (vault)	380329208378	1.04	J&M's LLC	Pacific St. dead end/parking	Lower Fever Creek	480	36.2	50 (10%)	78 (16%)	109 (23%)	49
8 (vault)	NA; ROW between Undine St. and Verona St.	0.52	ROW	PSE transmission line ROW	Lower Fever Creek	243	18.3	25 (10%)	26 (11%)	41 (17%)	38

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FEVER CREEK BASIN ANALYSIS
FIGURE 7-9

City of Bellingham
Surface and Stormwater Comprehensive Plan

CITY OF BELLINGHAM COMPREHENSIVE STORMWATER PLAN UPDATE

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