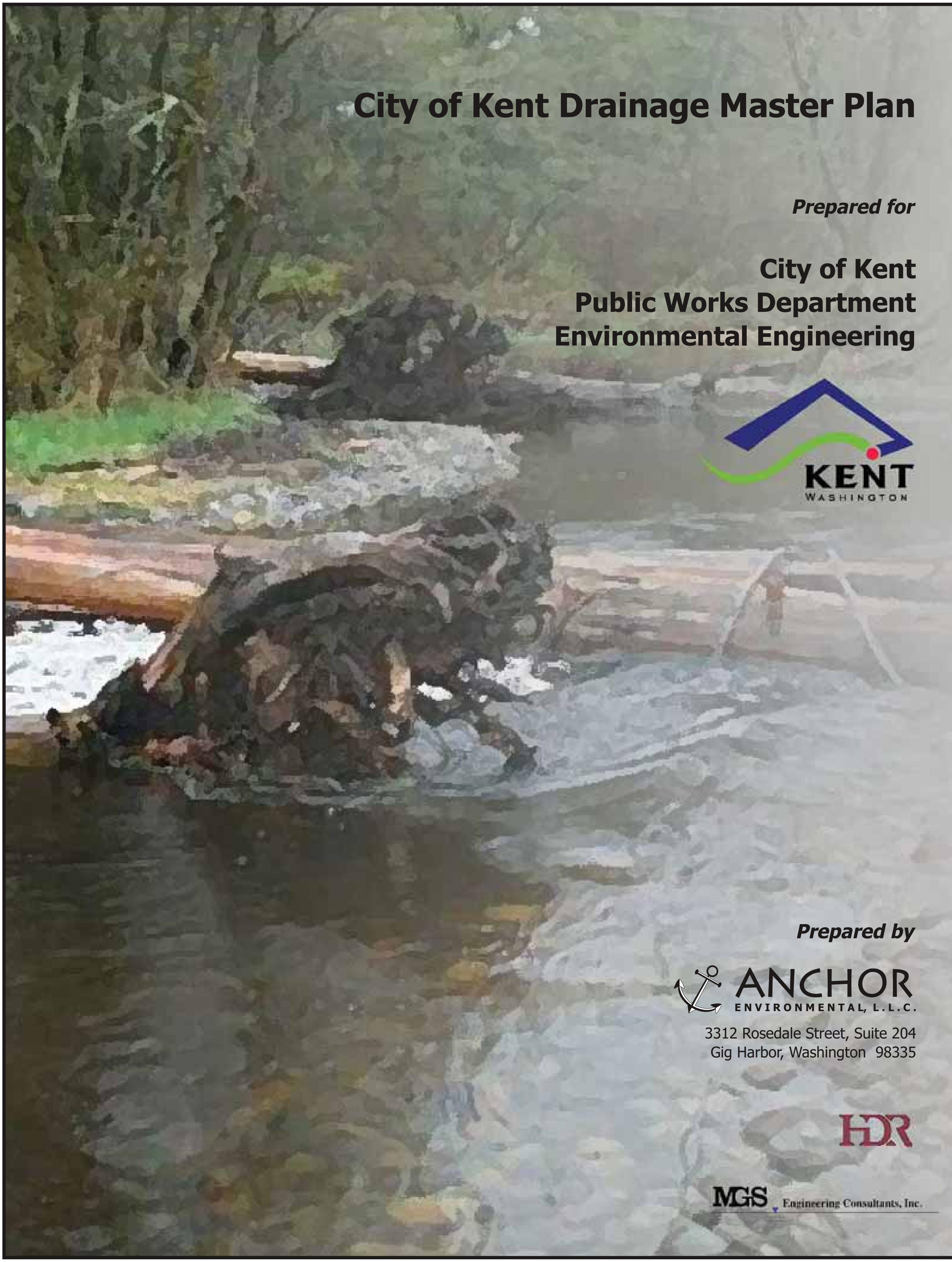

City of Kent Drainage Master Plan

Prepared for

City of Kent
Public Works Department
Environmental Engineering

KENT
WASHINGTON

Prepared by

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CITY OF KENT DRAINAGE MASTER PLAN

Prepared for

City of Kent

Public Works Department

Environmental Engineering

400 West Gowe Street

Kent, Washington 98032-5895

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September 2008

Anchor Environmental, L.L.C., would like to acknowledge the important and extremely valuable contributions and efforts of the following City of Kent elected officials, staff, Citizen's Advisory Committee representatives, and other consultants in the development of this Drainage Master Plan update.

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Norton Arnold & Company

FCS Group

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Anchor	Anchor Environmental, L.L.C.
AEP	annual exceedance probability
BMP	Best Management Practice
BNSF RR	Burlington Northern Santa Fe Railroad
CAC	Citizen's Advisory Committee
cfs	cubic feet per second
CIP	Capital Improvement Plan
City	City of Kent
Committee	Climate Change Technical Committee
Comprehensive Plan	City of Kent Comprehensive Plan
Corps	U.S. Army Corps of Engineers
CRS	Community Rating System
CWA	Clean Water Act
DMP	Drainage Master Plan
Ecology	Washington State Department of Ecology
EDS	Ecology Dam Safety
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	equivalent service unit
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GFC	General Facilities Charge
GIS	geographic information system
GMA	Growth Management Act
GRNRA	Green River Natural Resource Area
HDR	HDR, Inc.
HEC-2	Hydraulic Engineering Center Step-Backwater
HEC-RAS	HEC River Analysis System
HPA	Hydraulic Project Approval
HSPF	Hydrologic Simulation Program Fortran
I-5	Interstate 5
IDDE	illicit discharge detection and elimination

JARPA	Joint Aquatic Resources Permit Application
KCSWDM	King County Surface Water Design Manual
LID	Low Impact Development
MEP	Maximum Extent Practicable
MGS	MGS Engineering Consultants, Inc.
MS4	municipal separate storm sewer system
NFIP	National Flood Insurance Program
NOAA	National Oceanic and Atmospheric Administration
Norton-Arnold	Norton-Arnold & Company
NPDES	National Pollutant Discharge Elimination System
NPDES Phase II Permit	Western Washington Phase II Municipal Stormwater Permit
NRCS	Natural Resource Conservation Service
O&M	operations and maintenance
PSP	Puget Sound Partnership
RCW	Revised Code of Washington
SEPA	State Environmental Policy Act
SMA	Shoreline Management Act
SMP	Shoreline Master Program
SOP	Standard Operating Procedure
SR 167	State Route 167
State	Washington State
SWMMWW	Stormwater Management Manual for Western Washington
SWMP	stormwater management program
SWPPP	Stormwater Pollution Prevention Plan
TIP	Transportation Improvement Program
TMDL	Total Maximum Daily Load
TSD	trunk storm drain
TV	television
UPRR	Union Pacific Railroad
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resource Inventory Area

CITY OF KENT DRAINAGE MASTER PLAN

The engineering material and data contained in the City of Kent Drainage Master Plan were prepared under the supervision and direction of the undersigned, whose seal, as a Professional Engineer licensed to practice as such, is affixed below.

Gerald A. Bibee, P.E. (Washington No. 24332)
Anchor Environmental, L.L.C.

September 2, 2008

1 EXECUTIVE SUMMARY

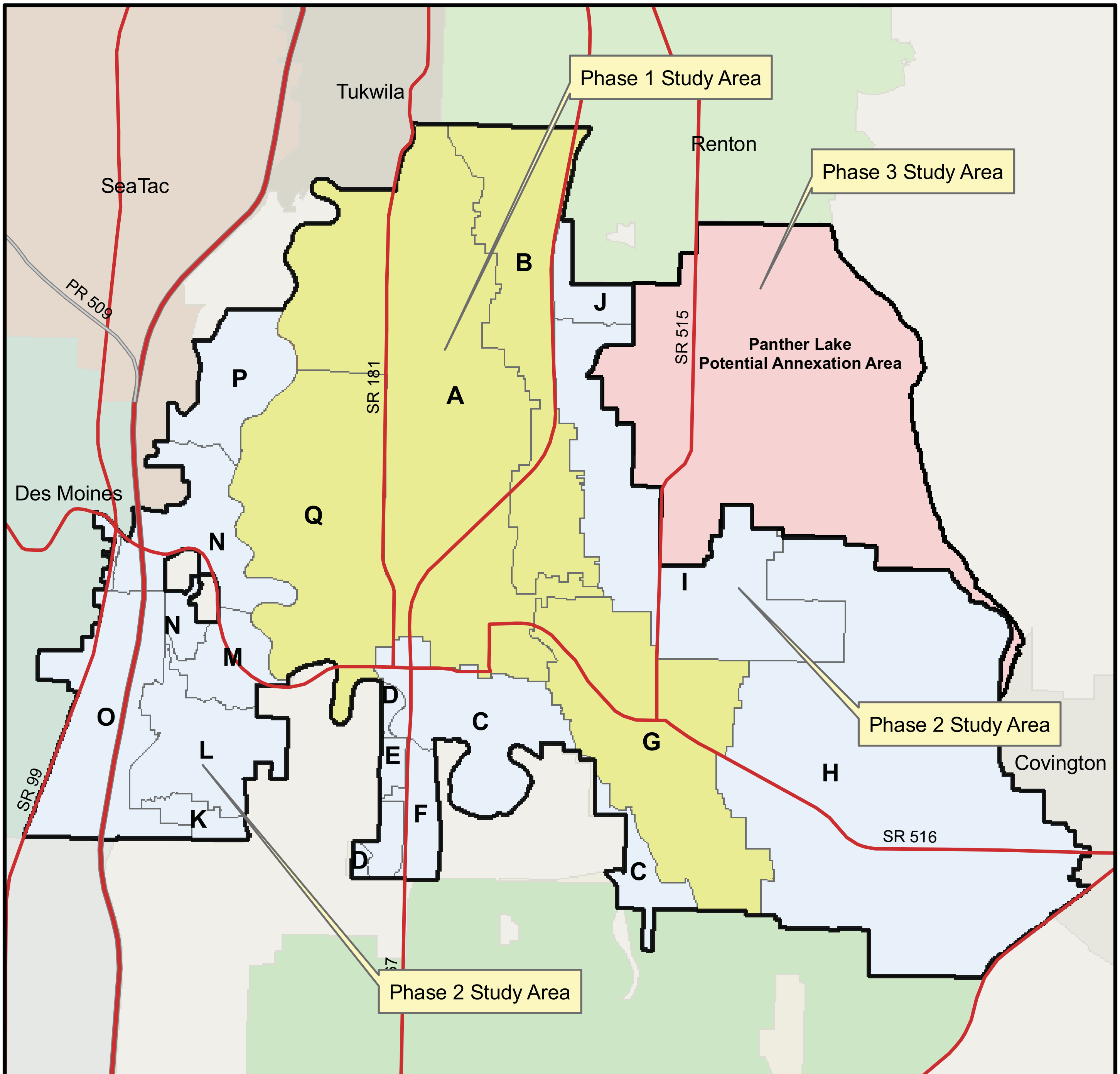
This City of Kent Drainage Master Plan (DMP) has been prepared by Anchor Environmental, L.L.C. (Anchor; prime consultant), in association with HDR, Inc., and MGS Engineering Consultants, Inc. (HDR and MGS; subconsultants), under contract with the City of Kent, Public Works Department, Environmental Engineering Section (City) to address City-wide update needs to its stormwater management plan and program. The DMP evaluates and recommends drainage facility capital improvement needs to reduce flood risks, improve water quality, enhance fish passage and instream/riparian habitats, and to efficiently serve planned growth. It also assesses the current stormwater program and recommends supplemental program actions, inclusive of City staffing and equipment needs, to meet current and anticipated water quality standards, permits, and operations and maintenance (O&M) needs. This DMP updates and will replace the City's prior DMP (URS Engineers et al. 1985), another subsequent drainage plan covering the Meridian Valley Annexation Area (R.W. Beck 1999), and a Mill Creek Stormwater Management Analysis Update (R.W. Beck 2000).

This Executive Summary provides a brief synopsis of the contents and key findings of the DMP. Details of the DMP and its recommendations, methods of assessment, database, supporting analysis, assumptions, and results are documented in the various report sections and appendices. This updated DMP is intended to serve as a comprehensive guide for the City's storm drainage capital improvement and surface water management program implementation actions. It is a companion document and component of the City's Comprehensive Plan (City of Kent 1995, 2004, and 2006 Updates) as required under the Growth Management Act (GMA). Drainage is affected by changes in land use, resulting in the need to effectively manage stormwater not only to correct existing drainage deficiencies but also to plan for future stormwater system infrastructure needs consistent with those changes. When implemented, the DMP will reduce flood hazards and public safety risks, improve water quality, facilitate fish passage and enhance habitat, and will provide opportunities for public use and education activities that ultimately benefit the City's surface water resources.

The DMP evaluation is being conducted in three phases; the first two phases included in this plan cover areas within the City's current corporate limits. Phase 1 includes Lower and Upper Mill Creek, Springbrook Creek, and the Green River Natural Resources Area (GRNRA). Phase 2 includes the remaining Green River valley floor drainage basins tributary to the Green River along with priority East and West Hill drainage basins. Phase 3 (to be completed at a later date) will be inclusive of the City's Panther Lake Potential Annexation Area on the East Hill.

Section 2 describes the drainage planning area, which includes 17 drainage basins within the City's current corporate limits jurisdiction totaling approximately 28 square miles. It lies within the larger-scale Duwamish-Green Water Resource Inventory Area (WRIA) No. 9 as designated by Washington State Department of Ecology. The location, extent, and components of the drainage planning and basin areas are shown on Figure ES-1 as follows:

- Lower Mill Creek (Basin A)
- Springbrook Creek (Basin B)
- Horseshoe Acres/Green River (Basin C)
- Mill Creek/Auburn (Basins D and E)
- Green River (Basins F and M)
- Upper Mill Creek (Basin G)
- Soos Creek/Meridian Valley (Basin H)
- Garrison Creek (Basins I and J)
- Bingamon Creek (Basin K)
- Lake Fenwick (Basins L)
- Midway Creek (Basins N)
- McSorley Creek (Basin O)
- Johnson Creek (Basin P)
- GRNRA (Basin Q)



City of Kent Drainage Basins

- A: Lower Mill Creek
- B: Springbrook Creek
- C: Horseshoe Acres - Green River
- D: Mill Creek / Auburn
- E: Mill Creek / Auburn
- F: Green River
- G: Upper Mill Creek
- H: Soos Creek / Meridian Valley
- I: Garrison Creek
- J: Garrison Creek
- K: Bingamon Creek
- L: Lake Fenwick
- M: Green River
- N: Midway Creek
- O: McSorely Creek
- P: Johnson Creek
- Q: Green River Natural Resource Area
- Panther Lake Potential Annexation Area

N

0 1
Miles

Figure ES-1
DMP Study Areas

The major goals and objectives of the DMP are presented in Section 2, and are summarized as follows:

- Define drainage problems and recommend solutions that will reduce planning area flood hazards and associated public safety risks, provide economic incentives for continued growth, improve water quality, improve or restore fish passage, and enhance stream and wetland habitats; integrate Low Impact Development (LID) components into implementation of those solutions where technically feasible
- Identify and update stormwater Capital Improvement Plan (CIP) project needs along with drainage components of Transportation Improvement Program (TIP; City of Kent 2006) projects, including their expected implementation costs and priorities
- Evaluate and recommend solutions to Mill and Springbrook Creek; Green River Valley floor flooding problems impacting roadway transportation corridors; and adjacent residential, commercial, and industrial properties
- Identify opportunities for habitat restoration along the City's stream and river corridors including potential land acquisition or easement needs to implement those actions
- Document federal- and state-mandated permits and stormwater management regulations and compliance/reporting needs as the basis for supplemental public education/involvement, water quality improvement actions and monitoring, development review and inspection, and O&M program activities and associated costs
- Establish expected total stormwater projects and programs funding needs, and evaluate alternative drainage utility rate structures and rate adjustment options to adequately fund implementation actions
- Integrate public involvement into the drainage planning process though a Citizen's Advisory Committee (CAC) and public meetings, and disseminate plan findings, recommendations, implementation costs, and utility rate implications to the public

The public involvement process used for plan development as well as meeting summaries from the five CAC meetings held are also documented in Section 2 and Appendix A, respectively. The CAC formulated a recommendations letter (Appendix A) to document their comments on key DMP findings for City Council consideration in the plan adoption process.

A summary of federal, Washington State (State), and City regulations, which are the basis for DMP evaluation and its implementation, is provided in Section 3. Those that have the most significant implications on the City's drainage management planning and required compliance actions include federal and state water quality regulations under the Clean Water Act (CWA). Those include the National Pollutant Discharge Elimination System (NPDES) Phase II Permit (Ecology 2007a) compliance, operations, and reporting requirements; Total Maximum Daily Load (TMDL) requirements; and resultant pollutant load allocations for water quality-impaired water bodies within the City. The collective regulations also define minimum design standards and set the framework for environmental permitting needs for the City's CIP projects recommended for implementation in the DMP.

Section 4 characterizes the drainage planning area and associated trunk storm drain (TSD) systems including a description of the data sources used for estimating stormwater runoff potential and for assessing drainage system capacities. Drainage area delineation and characterization was completed initially at a subbasin scale (294 subbasins delineated covering approximately 18,000 acres in the DMP planning area). Subsequently, drainage subcatchments breakdowns within those subbasins were completed (1,842 subcatchments were delineated that range in size from less than 0.5 acre to 155 acres, and that average approximately 10 acres in size). This smaller scale of basin subareas is needed to minimize incremental flow changes throughout the trunk drainage systems being analyzed.

Existing land cover was established using the City's geographic information system (GIS) by evaluating the impervious area database layers in combination with updates completed for new development areas using recent aerial photography. In pervious areas, both soils (till, outwash, and saturated) and vegetative land cover conditions (forest, pasture, and grass) were documented City-wide. Drainage subbasin and catchment areas were intersected with the updated land cover/soils GIS database, and results were tabulated as input for hydrologic analysis. Future land cover was estimated through interpretation of possible new or redevelopment parcel densities based on the City's Comprehensive Plan Land Use Map. Critical areas (e.g., wetlands, steep slopes, etc.) documented in the City's GIS were identified and excluded as potential development areas. Trunk drainage system characteristics (storm drain sizes, types, lengths, invert and rim elevations, etc.) were tabulated from the City's GIS database and from supplemental as-built drawing records research conducted by City staff for use in hydraulic capacity analysis. Where the resulting composite database was incomplete, topographic mapping and existing adjacent drainage system characteristics were considered, and engineering judgment was applied in assigning estimated values for analysis.

Although the City currently does not have regulations requiring the use of Low Impact Development (LID), LID guidelines will be incorporated into the update of the City's Surface Water Design Manual to be completed by August 2009. While the Comprehensive Plan recommends the use of LID within the City, the DMP does not directly incorporate those measures in the recommended planning-level solutions to drainage problems. However, appropriated LID measures will be incorporated where technically feasible with solutions design. As a conservative approach to the analysis and drainage infrastructure needs, it was assumed there would be no new LID components within the watersheds or retrofitting of existing drainage systems to incorporate LID measures. The City will further encourage use of LID in its watersheds through the update of the Surface Water Design Manual.

Drainage problems and relative priorities (high, medium, and low) assigned in conjunction with City staff for assessment and solutions development are presented in Section 5. A total of 20 drainage problem areas were initially identified from records compiled by City staff including input from the City's O&M Department staff. An additional 21 drainage problem areas (some overlapping with the City-identified problem areas) were identified from input received at a public open house conducted on January 23, 2008. Site visits to key problem areas were conducted to better understand site conditions and to identify the problem type (i.e., flooding, water quality, and/or fish passage/habitat), extent (i.e., affecting public roads and/or structures, private property, or undeveloped areas), and potential causes of problems. Site reconnaissance was also conducted during the December 3, 2007 flooding event (approximately 2-year event magnitude on Mill Creek) to validate identified Mill Creek and Springbrook Creek flooding problems and to collect high water mark data that was used to calibrate hydraulic models. Bridge and culvert geometries, sedimentation levels at crossings, and adjacent hydraulic conditions were also field verified for crossings of Mill Creek, Springbrook Creek, and along the GRNRA diversion channel loop from/to Mill Creek. Documented drainage problems were reviewed with the CAC for input on priorities for evaluation and solutions development with consideration of problems rating criteria established by the CAC.

Hydrologic analysis for estimating selected flood flow events was completed at the drainage catchment level for all identified subbasin TSD systems within the DMP planning area as reported in Section 6. Analysis was also conducted at a larger, subbasin scale for the Mill Creek/Springbrook Creek/Garrison Creek stream systems (receiving waters). The catchment level runoff analysis was conducted using the MGSFlood continuous simulation hydrologic model (MGS 2008) as adapted for City-specific precipitation characteristics with shortened (15 minute) analysis time steps. Estimated catchment runoff hydrographs for existing land use conditions were routed through regional detention ponds and resulting hydrographs were combined. Statistically based peak flow estimates were computed at selected analysis points and outfalls throughout the various TSD systems analyzed.

At the basin-wide scale, stream flow estimates were prepared using the Hydrologic Simulation Program Fortran (HSPF) continuous simulation hydrologic model. For that analysis, composite subbasin area runoff characteristics were determined, and the resulting runoff response to long-term continuous precipitation records was simulated for each subbasin. A series of stream/storage routing reaches were established to model the hydrologic effects of existing floodplains and regional storage flow controls. After calibration of runoff results to available historical flow data, statistically based peak flood flow estimates were computed at various analysis points along the stream systems. Hydrologic analysis of expected future conditions was also completed for the Mill Creek system to evaluate the expected performance and benefits of recommended project improvements. The methods, assumptions, and results of those analyses are presented in Section 6.

Hydraulic evaluation of TSD systems was conducted to determine their conveyance capacities as the basis validating improvement needs and developing solutions (where capacity was found to be deficient). That analysis was conducted for selected subbasin TSD systems within Basins A, B, C, F, G, H, I, J, L, and Q. The remaining basins (D, E, K, M, N, O, and P) typically did not have reported drainage problems, were not highly developed, and/or did not have major TSD system infrastructure in place, and no indications of future substantial growth-related demand for improvements were projected within the City's Comprehensive Plan. For each subbasin drainage system analyzed, a screening-level hydraulic backwater modeling analysis was conducted to estimate hydraulic grade elevations (flood levels) along each TSD system with outfall to receiving waters (i.e., river, stream, or lake). Those systems were evaluated for capacity to convey design event (25-year) estimated peak flows without overflow or flooding, along with related opportunities to improve flow control, water quality, and/or fish passage/habitat.

Priority receiving waters (Mill and Springbrook Creeks) were also analyzed to confirm the extent of existing flooding problems (either documented or identified from analysis) and to evaluate proposed project improvements. For those analyses conducted along the Mill Creek and Springbrook Creek (valley floor) stream alignments, prior Hydraulic Engineering Center Step-Backwater (HEC-2) hydraulic models available from Federal Emergency Management Agency (FEMA) and follow-on floodplain mapping evaluations were converted to HEC River Analysis System (HEC-RAS) hydraulic models. The HEC-RAS model is now the accepted hydraulic model by FEMA. The resulting HEC-RAS models were then updated to current conditions based on field reconnaissance results and City-furnished as-built drawing records for hydraulic structures at selected stream crossings. After calibration of predicted flood levels to available flood flows and surveyed high water mark data from the December 3, 2007 event, the resulting models were used to generate stream hydraulic profiles and to identify associated creek system flooding potential. Those models were also used to evaluate the expected functionality and flood reduction benefits of proposed stream system improvements for existing flood flow conditions. The methods, assumptions, and results of stream system hydraulic analyses completed are summarized in Section 6.

Section 7 documents City-wide drainage management solution opportunities and evaluates drainage infrastructure improvement alternatives to address priority drainage problems within the TSD and receiving water drainage systems evaluated. Solution priorities focused on:

- Reducing flood levels, duration, and recurrence frequency and associated public safety risks
- Providing water quality improvement and associated benefits for water quality standards compliance
- Improving anadromous and resident fish passage and habitat enhancement within planning area receiving waters
- Providing stream corridor riparian restoration and public access points for water quality, fish, wildlife, and public education benefits

For TSD systems evaluated, improvement opportunities focus on system replacement, rehabilitation needs, and diversion options to upgrade hydraulic capacities and/or reduce conveyance design flow needs to achieve a minimum of 25-year event level-of-protection against flooding. In addition, water quality treatment opportunities and concepts are identified and evaluated to reduce pollutant loadings to receiving waters and in attempt to manage compliance with existing or anticipated future water quality regulatory standards. A total of 40 TSD or stream improvement project opportunities were identified and evaluated for technical, cost, and implementation feasibility. Those concepts were then reviewed with City staff and the CAC to get input and comments as the basis for project improvement recommendations that are presented in Section 7.

For various improvement opportunities identified along stream and river corridors, as summarized in Section 8, solutions were considered that will provide multi-objective flood reduction and environmental restoration benefits across the spectrum of identified solution priorities. Those target projects (affecting approximately 120 acres collectively) are associated with lower and upper Mill Creek, Springbrook Creek, Mill Creek (Auburn), the Green River, the GRNRA, Meridian Valley Creek, and McSorley Creek. A number of private properties are potentially at risk to creek flooding at locations where significant habitat restoration benefits can be achieved. Implementation of restoration projects on those parcels (beyond existing City rights-of-way) will require that the City work cooperatively with those property owners to secure easement rights, or alternatively, purchase those parcels (or subdivided components). Another concept that should be explored is the potential for transfer of development rights, particularly where preservation could be achieved for ecologically highly valued (undeveloped) parcels in close proximity to environmentally sensitive receiving waters.

The City currently faces new, more stringent stormwater regulations and standards as a result of federal water quality mandates (U.S. Environmental Protection Agency [EPA] rules under the CWA) as permitted and administered by Ecology. Those regulations include the NPDES Phase II Stormwater Permit and the TMDL requirements for State 303(d)-listed (water quality impaired Category 5) water bodies.

The NPDES permit, as issued and administered by Ecology, sets out a series of required programmatic stormwater management requirements and actions required of regulated small municipal separate storm sewer system (MS4) providers including (but not limited to):

- City code policy/ordinance modifications
- Application of more stringent stormwater manual standards
- Development and implementation of a stormwater management program (SWMP) meeting permit requirements
- Stormwater program public education/outreach and public involvement/participation activities and effectiveness evaluation
- Stormwater facilities mapping and illicit discharge detection and elimination (IDDE)
- Supplemental new, redevelopment, and construction phase water quality control regulation and inspection
- More intensive O&M actions
- Measuring effectiveness of program actions and water quality control practices
- Annual tracking and reporting requirements

Supplemental water quality monitoring needs are also expected in the next NPDES permit cycle. Under TMDL regulation, City water bodies on the 303(d) list are subject to water body, pollutant-specific load allocations, and associated compliance monitoring requirements. TMDL loading allocation is currently assigned to Lake Fenwick (for total phosphorus), but TMDL assessments are in progress on various other City 303(d)-listed water bodies (e.g., Green River and Big Soos Creek). Further load allocation reduction requirements and compliance monitoring under those TMDLs are expected in the next 3 to 5 years.

The City is already addressing many of these requirements under its existing stormwater program, but other needs and higher standards apply. This will require supplemental Public Works Engineering and O&M Department staffing and equipment procurements. To define those needs, a gap analysis was conducted comparing the City's current water quality and O&M program activities, staffing, and available equipment against the anticipated needs under the NPDES Phase II Stormwater Permit and existing/anticipated TMDL requirements. Sections 2 and 9 present the framework for these new, higher standards and associated (mandated) stormwater program actions. It also documents findings of the gap analysis, highlighted by recommended stormwater program modifications and expected supplemental programs costs.

The City currently funds drainage management program actions, O&M, and capital improvement expenditures through a City-wide Stormwater Utility and through other periodic, project-specific, or program grant funding opportunities when successfully secured (typically grants are competitive and provide only a small component of required stormwater program funding). To conduct a stormwater programs financial assessment for the DMP, the City independently contracted with the FCS Group to assess the current drainage utility rate structure and evaluate potential drainage utility rate modifications needed to satisfy the updated stormwater program (cumulative) funding needs. Those funding needs include required expenditures for:

- Recommended stormwater CIP projects implementation
- TIP projects drainage improvement components
- Lifecycle repair and replacement of aging stormwater infrastructure
- Required stormwater program activities implementation and administration
- Repair and replacement of levees along the Green River

The methods, assumptions, and findings of the financial analysis are presented separately in the FCS Group report, but the highlights of that evaluation and recommendations are documented in Section 10, and are summarized as follows:

- The current basin-specific stormwater utility rate structure should be considered for replacement with a City-wide, uniform rate structure per equivalent service unit (ESU)
- Drainage Utility debt service should be considered for use (through revenue bonds issued within target debt/revenue limits) to spread capital project expenditures over a longer period within their expected lifecycle (20 years recommended)
- A new ESU rate should be considered for adoption (rate options are shown in Section 10), with provisions for annual inflation and implementation cost escalation, to adequately fund the recommended stormwater program and its estimated implementation costs
- An updated capital facilities charge (charge options are shown in Section 10) should be considered for adoption reflecting recovery of the existing facilities investment cost

together with growth-related capital improvement cost components for future customers

Drainage improvement needs in the planning area were assessed with consideration of drainage problem areas and assigned priorities. Table ES-1 summarizes the recommended TSD and stream system improvements, the problems they address, their estimated implementation cost (all in May 2008 dollars), and their targeted priorities (high, medium, and low). Forty stormwater CIP projects with an estimated total implementation cost of approximately $68 million are recommended in this DMP. In addition, City staff estimated that the drainage component costs for the City's current TIP are approximately $50 million. Although not addressed by the DMP, City staff have also estimated that the City's supplemental (unfunded) component of levee improvements required along the Green River to be approximately $42 million—for a total expected capital facilities expenditure need of approximately $160 million.

City staff recommend a 10-year phased CIP program, resulting in an average annual capital cost expenditure of approximately $16 million (variable per year considering assumed cost escalation and inflation). Estimated annual stormwater program costs, as shown in Table ES-2, currently total approximately $4.5 million. With supplemental program expansion needs, the annual costs are expected to increase. The financial analysis presented in Section 10 documents the rate structure options to fully fund the recommended stormwater CIP program (inclusive of TIP drainage component), the anticipated City Green River levee improvement commitment and funding shortfall, and the expanded stormwater program needs.

Table ES-1
Recommended CIP Drainage Improvements, Estimated Implementation Costs, and Targeted Priorities

Basin/ Project No.	Problems Addressed	Project Improvements Description	Estimated Construction Cost ($)	Estimated Implementation Cost ($)	Implementation Priority
Phase 1 – Basin A – Lower Mill Creek					
A-1	LMC-4, PM-14	Subbasin A15E – Mill Creek TSD, Restoration at Senior Center – Titus Street to Smith Street			High
		Alt. 1 – Parallel Culvert Alignment, Remove Excess Sediment	716,000	895,000	
		Alt. 2 – Daylight Channel, Establish Riparian Vegetation Buffer around Mill Creek	1,268,000	1,585,000	
A-2	LMC-3,4,5, PM-13	Subbasin A15E – Mill Creek Restoration – Smith Street to James Street	925,000	1,181,000	High
A-3	LMC-3,4,5, PM-10,13	Subbasin A14E – Mill Creek Relocation/Restoration – James Street to Chandler Bay Drive			High
		Alt. 1 – Relocate and Restore Mill Creek Channel through Wetlands East of Mill Creek	3,338,000	4,672,000	
		Alt. 2 – Widen and Restore Existing Mill Creek Channel along East Bank	2,245,000	2,949,000	
A-4	None Identified	Subbasin A14W - Mill Creek Culvert Replacement - Burlington Northern Railroad			Medium
		Alt. 1 – Open Trench Culvert Replacement Coordinated with 228th TIP	350,000	437,000	
		Alt. 2 – Bore and Jack Replacement Culvert without Interrupting Rail Service	962,000	1,203,000	
A-5	LMC-6, PM-12	Subbasin A13W - TSD Improvements – Partial Subbasin A13W Diversion to GRNRA			High
		Alt. 1 – Install Box Culvert in South 228th Street to Conveyance Channel with Box Culvert Crossing Improvements	5,421,000	6,551,000	
		Alt. 2 – Install 72-inch Culvert in South 228th Street and in Frontage along 68th Avenue South, West to Presettling Pond	4,597,000	5,746,000	
		Alt. 3 – Regrade Channel to 68th Avenue South, 72nd Culvert and TSD, Conveyance Channel Box Culvert Improvements	2,612,000	3,864,000	
		Alt. 4 – North along Union Pacific Railroad/Bike Trail/PSE Easement to GRNRA Diversion Weir – Not Further Evaluated			
A-6	LMC-6	Subbasin A13W – TSD Improvements – 4th Avenue North, Smith Street to near South 228th Street	4,538,000	5,672,000	Medium
A-7	LMC-6, PM-12,21	Subbasin A14E – Mill Creek Culverts Replacement, Relocation/Restoration – 76th Avenue Corridor			High
		Alt. 1 – Full Improvements	4,295,000	5,649,000	
		Alt. 2 – Partial Improvements (not including Mill Creek restoration downstream of private crossings)	1,717,000	2,227,000	

Basin/ Project No.	Problems Addressed	Project Improvements Description	Estimated Construction Cost ($)	Estimated Implementation Cost ($)	Implementation Priority
A-8	None Identified	Subbasin A04W – TSD Improvements – South 190th Street and South 196th Street	2,072,000	2,590,000	Low
		Total – Basin A	**19,458,000**	**25,726,000**	
Phase 1 – Basin B – Springbrook Creek					
B-1	None Identified	Multiple Subbasins – Springbrook Creek Channel Flood Containment Berms – North of South 212th Street	671,000	988,000	High
B-2	SBC-1	Subbasin B04W – TSD Improvements – South 196th Street and 84th Avenue South	3,690,000	4,612,000	High
B-3	None Identified	Subbasin B03E – TSD Improvements – North Side of South 180th Street	1,469,000	1,836,000	Low
		Total – Basin B	**5,830,000**	**7,436,000**	
Phase 2 – Basin C – Horseshoe Acres/Green River					
C-1	None Identified	Subbasin C02 – TSD Improvements – South of Kent-Des Moines Road, East of State Route 167	272,000	341,000	Low
C-2	None Identified	Subbasin C05 – TSD Improvements – 1st Avenue South and 3rd Avenue South Extensions	388,000	485,000	Low
C-3	None Identified	Subbasin C07 – TSD Improvements – 79th Avenue South, South 266th Street to Detention Pond			Low
		Alt. 1 – TSD Improvements from South 266th Street to Detention Pond	196,000	245,000	
		Alt. 2 – TSD Conveyance Service Extension in 79th Avenue South	118,000	148,000	
C-4	PM-1,6,9	Subbasin C08 – TSD Improvements – Central Avenue South, South 259th Street, Extensions, and Pump Station			Medium
		Alt. 1 – No Pump Intake TSD Improvements	2,618,000	3,272,000	
		Alt. 2 – 60-inch Diameter Pump Intake TSD Improvement	1,988,000	2,485,000	
		Alt. 3 – 72-inch Diameter Pump Intake TSD Improvement	1,987,000	2,483,000	
		Alt. 4 – TSD Conveyance Service Extensions in Maple Lane South, South 266th Street	498,000	623,000	
		Alt. 5 – Pump Station and Force Main Upgrade at Existing Outfall (22 Cubic Feet Per Second Pump Addition in Existing Extra Pump Bay)	440,000	550,000	
		Total – Basin C	**3,899,000**	**4,875,000**	
Phase 2 – Basin F – Green River					
F-1	LDS-1	Subbasin F01 – TSD Improvements – Outfall Pump Station (allowance)	1,800,000	2,225,000	Medium
		Total – Basin F	**1,800,000**	**2,225,000**	
Phase 1 – Basin G – Upper Mill Creek					
G-1	None Identified	Subbasin G05E – TSD Improvements – 110th Place Southeast, Southeast 256th Street, 109th Avenue Southeast	1,640,000	2,051,000	Medium

Basin/ Project No.	Problems Addressed	Project Improvements Description	Estimated Construction Cost ($)	Estimated Implementation Cost ($)	Implementation Priority
G-2	None Identified	Subbasin G05E – TSD Improvements – 104th Avenue Southeast, Southeast 260th Street to Southeast 256th Street	2,790,000	3,488,000	Medium
G-3	UMC-1	Subbasin G05E – Upper Mill Creek Diversion to Detention Dam – East of 104th Avenue Southeast	409,000	563,000	High
G-4	UMC-1	Subbasin G05E – Upper Mill Creek Detention Dam, Outlet Modifications – 104th Avenue Southeast			High
		Alt. 1 – Raise Dam for Added Storage, Replace Outlet Works and Restrict Outflow, Reconstruct Spillway	1,753,000	2,341,000	
		Alt. 2 – Upper Mill Creek Diversion Micro-tunnel (60-inch Diameter) South to South 277th Street Conveyance, West to New Green River Outfall	5,800,000	7,250,000	
G-5	None Identified	Subbasin G04E – TSD Improvements – 97th Place South to Outfall	231,000	288,000	Medium
G-6	None Identified	Subbasin G03E – TSD Improvements – Southeast 248th Street, 100th Avenue Southeast	135,000	169,000	Medium
G-7	None Identified	Subbasin G02E – TSD Improvements – Canyon Drive Southeast to Outfall	96,000	120,000	Medium
		Total – Basin G	**7,054,000**	**9,020,000**	
Phase 2 – Basin H – Soos Creek/Meridian Valley					
H-1	PM-7,18	Subbasin H19 – Meridian Valley Creek Restoration – Meridian Valley Country Club			Medium
		Alt. 1 – Meridian Valley Creek Local Stream Erosion Improvements South of Southeast 243rd Street	35,000	43,000	
		Alt. 2 – Meridian Valley Creek Stream Restoration Improvements, Southeast 240th Street to Southeast 256th Street	891,000	1,214,000	
H-2	MVC-2	Subbasin H11 – Meridian Valley Creek TSD Conveyance Improvements – 132nd Avenue Southeast to 136th Avenue Southeast	706,000	883,000	Medium
H-3	MVC-3	Subbasin H131 – TSD Improvements – 145th Place Southeast and 146th Avenue Southeast	243,000	304,000	Low
H-4	LMT-2	Subbasin H30 – TSD Improvements – 132nd Avenue Southeast to Lake Meridian Outfall	1,268,000	1,585,000	Medium
H-5	BSC-1	Subbasin H133 – Big Soos Creek Bridge Replacement – Southeast 256th Street	1,646,000	2,058,000	High
H-6	SC-1, PM-11	Subbasin H15 – Soosette Creek Culvert Replacement – 144th Avenue Southeast	229,000	292,000	High
H-7	EFSC-1,2	Subbasin H113 – East Fork Soosette Creek Culvert Replacements – Southwest of Southeast 276th Street	115,000	143,000	Low
H-8	WFNB-1,2	Subbasins H61, H62 – West Fork North Branch Soosette Creek Channel Widening – South of Southeast 256th Street	517,000	646,000	Low

Basin/ Project No.	Problems Addressed	Project Improvements Description	Estimated Construction Cost ($)	Estimated Implementation Cost ($)	Implementation Priority
H-9	WFWB-1,2,3,4	Subbasin H50 – West Fork West Branch Soosette Creek Culvert Replacements – 116th Avenue Southeast	336,000	470,000	Low
H-10	None Identified	Subbasin H09 – North Fork Meridian Valley Creek Restoration Repair – South of Southeast 240th Street	120,000	150,000	Medium
H-11	None Identified	Subbasin H11 – North Fork Meridian Valley Creek Restoration – South 236th Place Culvert Replacement	164,000	205,000	High
		Total – Basin H	**6,270,000**	**7,993,000**	
Phase 2 – Basin I – Garrison Creek					
I-1	GC-1	Subbasin I1 – Lower Garrison Creek Sediment Removal at South 218th Street, Upstream Erosion Controls	49,000	61,000	Medium
		Total – Basin I	**49,000**	**61,000**	
Phase 2 – Basin L – Lake Fenwick					
L-1	None Identified	Subbasin L01 – TSD Improvements – Conveyance, Erosion Protection, Water Quality Treatment	2,950,000	3,688,000	Medium
L-2	LF-2	Subbasin L01 – Lake Fenwick Constructed Wetland Annual Vegetation Harvesting (5 years)	75,000	100,000	Medium
L-3	LF-1	Subbasin L01 – Lake Fenwick Hypolimnetic Aeration System Improvements	280,000	400,000	Medium
L-4	PM-2,3,4,5	Subbasin L01 – TSD Improvements – Conveyance, Erosion Protection, Water Quality Treatment	112,000	150,000	Low
		Total – Basin L	**3,417,000**	**4,338,000**	

Basin/ Project No.	Problems Addressed	Project Improvements Description	Estimated Construction Cost ($)	Estimated Implementation Cost ($)	Implementation Priority
Phase 1 – Basin Q – GRNRA					
Q-1	None Identified	Subbasin Q05 – TSD Improvements – 54th Avenue South and South 226th Street	2,104,000	2,630,000	Low
Q-2	GRNRA-1	Subbasin Q01 – Restore Diversion Weir, Pre-settling Ponds Sediment Removal, Replace GRNRA Fencing	1,064,000	1,330,000	High
Q-3	GRNRA-2	Subbasin Q01 – GRNRA Outlet Improvements – Lagoon Outlet to Mill Creek Confluence			High
		Alt. 1 – Replace Culvert at South 212 Street, Widen Boeing Ditch, Excavate Low Flow Channel Downstream	1,441,000	1,801,000	
		Alt. 2 – New Channel along South 212th Street and New Culvert Crossing, Excavate Low Flow Channel Downstream (Not Evaluated)			
		Alt. 3 – Tie GRNRA Outlet to New TSD in 64th Avenue South, link to Existing 48-inch TSD, Excavate Low Flow Channel Downstream	1,336,000	1,669,000	
		Alt. 4 – Pump Station and Force Main with New Outfall to Green River for Lagoon Drawdown (30 Cubic Feet Per Second Pump Station Assumed)	1,800,000	2,250,000	
		Total – Basin Q	**4,504,000**	**5,629,000**	
		Phase 1 Projects Total – Basins A, B, G, and Q	**36,846,000**	**47,811,000**	
		Phase 2 Projects Total – Basins C, F, H, I, and L	**15,435,000**	**19,492,000**	
		Phase 1 and 2 Projects Total	**52,281,000**	**67,303,000**	
		Estimated Green-Duwamish ERP Projects (next 5 years)	**400,000**	**500,000**	High
		Total Estimated CIP Project Costs (June 2008)	**52,681,000**	**67,803,000**	

Grey lettering = Alternatives improvements considered or evaluated, but not recommended

Table ES-2
Recommended Stormwater Programs Estimated Supplemental and Existing Program Costs

NPDES Reference	Description	Annual Cost ($)	Capital Cost ($)
Water Quality			
S5.C.4.b	Erosion control inspectors		
	2- FTE	160,000	
	0.5 – FTE (Environmental Conservation Supervisor)	45.000	
	2 – FTE (Engineering Department)	180.000	
	2010 – NPDES Phase II and TMDL monitoring	90,000	80,000
	Total Recommended Supplemental – Water Quality	**475,000**	**80,000**
	Total Existing – Water Quality	**208,000**	
O&M			
S5.C.5.a.ii	Maintenance of stormwater facilities		
	15 – FTE	1,125,000	
	1 – TV truck	7,500	175,000
	2 – Service trucks	10,000	70,000
S5.C.5.b	Annual inspection of stormwater treatment and flow control facilities		
	6 – FTE	450,000	
	1 – Vactor truck	10,000	375,000
	1 – Tool truck	5,000	50,000
	2 – Service trucks	10,000	70,000
S5.C.5.d	Inspection of catch basins and disposal of decant water		
	2 – Temporary employees	32,000	
	2 – Service trucks	5,000	35,000
	Total Recommended Supplemental – O&M	**1,654,500**	**775,000**
	Total Existing – O&M	**4,265,000**	

Notes:

FTE = full-time employee

TV = television

2 INTRODUCTION

2.1 Background

This DMP update has been prepared to serve as a comprehensive guide to the City's storm drainage capital improvement needs and surface water management program within the City's current corporate limits, covering approximately 28 square miles of a mostly urban area centered around State Route 167 (SR 167) within King County, Washington. The City of Kent lies between the Cities of Renton and Tukwila to the north, the City of Auburn to the south, the City of Covington to the east, and the Cities of SeaTac and Des Moines to the west as shown in Figure 2-1. With its extensive commercial development intermixed with light industrial and high density residential land uses along the periphery of the Green River, and with the major highway corridors and utilities aligned through it, the City is a critical hub to commerce and economic development within the greater Puget Sound region. As such, flood hazard reduction and water resources protection are critical components to maintaining the economic health and sustainable environmental features within the City.

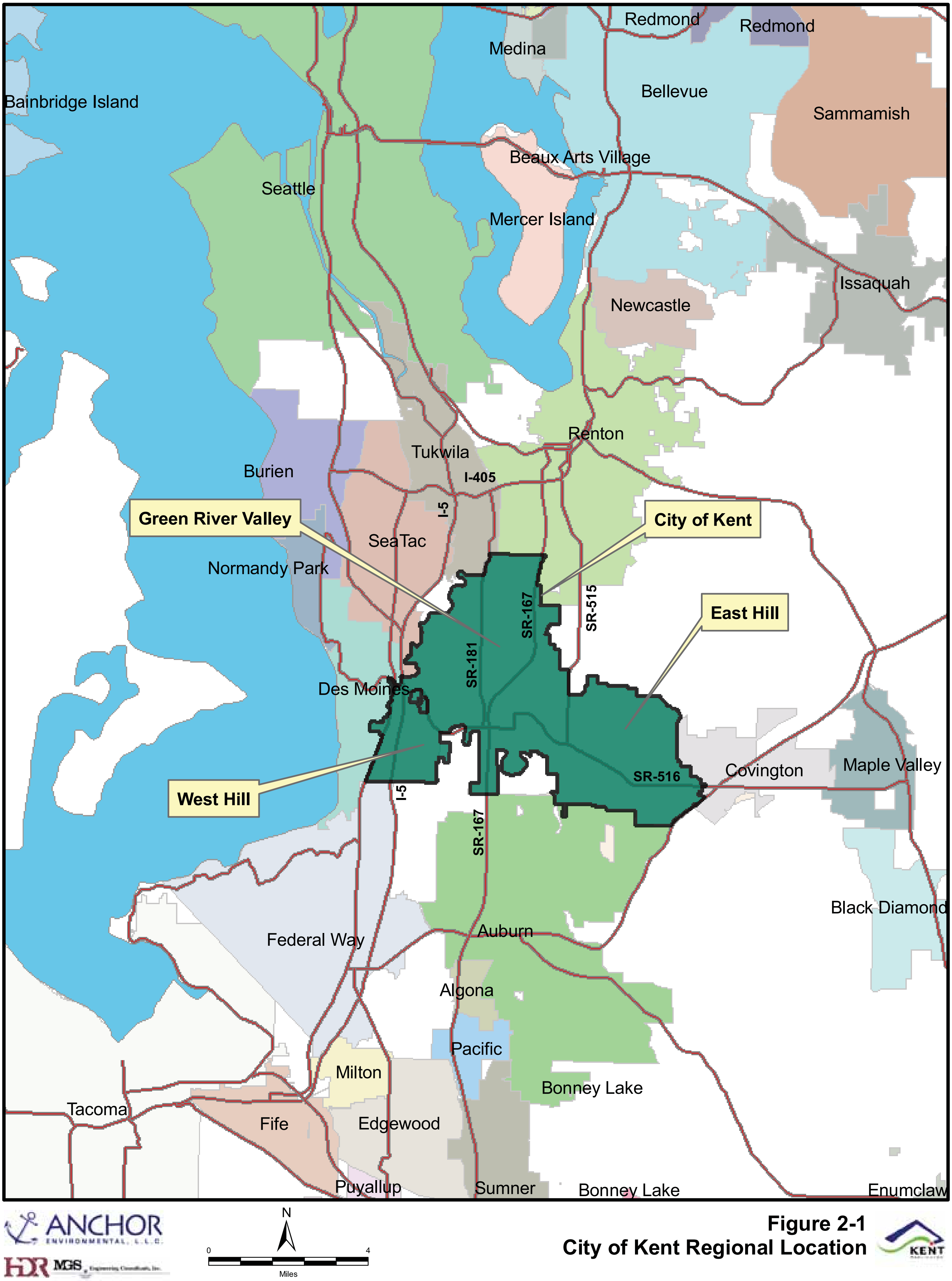
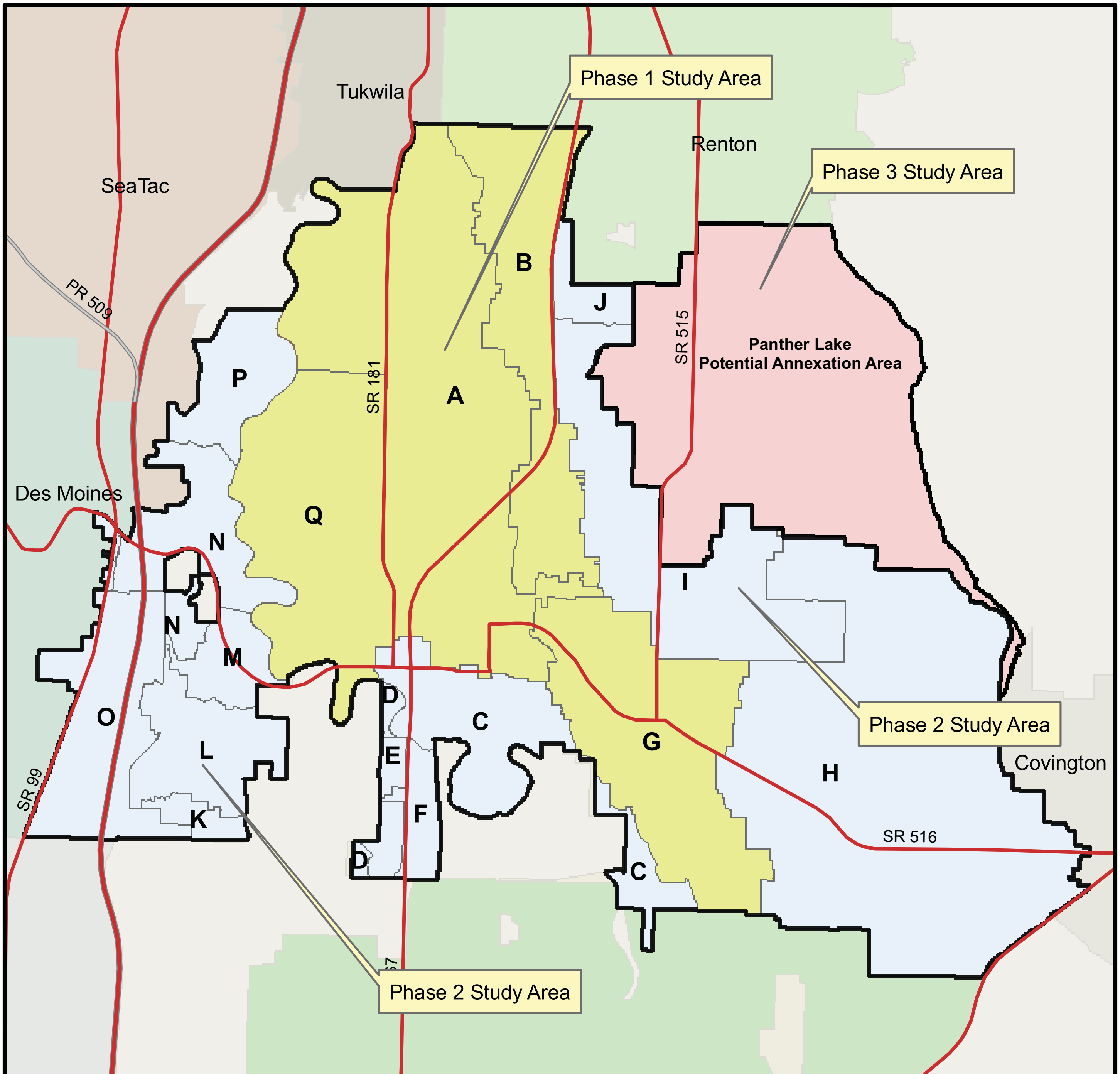


Figure 2-1
City of Kent Regional Location

2.2 Drainage Planning Area and Needs

The City-wide drainage planning area, as shown in Figure 2-2, includes the Green River Valley and surrounding East and West Hill communities. It extends approximately to Big Soos Creek to the east, beyond Interstate 5 (I-5) to the west (McSorley and Massey Creek headwaters), to South 180th Street to the north (near the Mill Creek/Springbrook Creek confluence), and generally to the Green River to the south. Within that area, the City has identified 17 drainage basins with multiple stormwater drainage systems and outfalls to receiving waters. Those receiving water drainage systems include the Green River, Mill Creek (Kent and Auburn), Springbrook Creek, Garrison Creek, Big Soos Creek, Meridian Valley Creek, Lake Meridian Outlet, Soosette Creek, McSorley Creek, Massey Creek, Midway Creek, Johnson Creek, Olsen Creek, Bingamon Creek, and Lake Fenwick.



City of Kent Drainage Basins

- A: Lower Mill Creek
- B: Springbrook Creek
- C: Horseshoe Acres - Green River
- D: Mill Creek / Auburn
- E: Mill Creek / Auburn
- F: Green River
- G: Upper Mill Creek
- H: Soos Creek / Meridian Valley
- I: Garrison Creek
- J: Garrison Creek
- K: Bingamon Creek
- L: Lake Fenwick
- M: Green River
- N: Midway Creek
- O: McSorely Creek
- P: Johnson Creek
- Q: Green River Natural Resource Area
- Panther Lake Potential Annexation Area

N

0 1

Miles

Figure 2-2
DMP Study Areas

The City's Public Works Department, Environmental Engineering Section is responsible for:

- City-wide surface water management planning
- Drainage infrastructure management and CIP projects design, permitting, and construction management
- SWMPs development, implementation, and compliance monitoring/reporting

The City's prior DMP was prepared more than 20 years ago (URS Engineers et al. 1985). Subsequent area-specific drainage plan update for Meridian Valley Annexation Area (R.W. Beck 1999) and a Mill Creek Stormwater Management Analysis Update (R.W. Beck 2000) have also been prepared. City staff recognized the need to update those prior plans and consolidate stormwater management recommendations through a formal update of the DMP, as was initiated in July 2007. This DMP is a companion document and component of the City's Comprehensive Plan (City of Kent 1995), which was updated in 2004, with minor changes adopted in 2006 for consistency with the GMA.

The primary needs associated with this DMP update include:

- Characterize the City's existing watersheds and drainage basins
- Document the existing major drainage systems infrastructure capacity to convey flood flows and document associated deficiencies
- Evaluate and recommend drainage system improvements needed to respond to identified existing drainage problems as well as potential growth-induced drainage improvement needs as determined by analysis
- Identify supplemental stormwater program actions to maintain compliance with federal and state drainage management mandates as well as City-specific stormwater standards
- Identify and recommend sites for fish and wildlife habitat improvement projects
- Identify a minimum 6-year financing plan, including funding sources, to fund the needed capital facilities

The DMP update was conducted in two phases (see Figure 2-2). The Phase 1 study area addresses primarily the Green River Valley drainage systems and upland areas tributary to Lower Mill and Springbrook Creeks inclusive of:

- Basin A – Lower Mill Creek

- Basin B – Springbrook Creek
- Basin G – Upper Mill Creek
- Basin Q – GRNRA

The Phase 2 study area evaluates the remainder of the Green River Valley and East and West Hill drainages including:

- Basin C – Horseshoe Acres/Green River
- Basins D and E – Mill Creek/Auburn
- Basins F and M – Green River
- Basin H – Soos Creek/Meridian Valley
- Basins I and J – Garrison Creek
- Basin K – Bingamon Creek
- Basin L – Lake Fenwick
- Basin N – Midway Creek
- Basin O – McSorley Creek
- Basin P – Johnson Creek

When implemented, the recommended DMP actions will reduce flood hazards and public safety risks, improve water quality, facilitate fish passage and enhance habitat use, and will provide opportunities for additional public use and education activities that will ultimately benefit the City's surface water resources.

2.3 Drainage Master Plan Purpose and Goals

The primary purpose and specific goals of the DMP update are as follows:

1. Goal No. 1 – Define drainage problems and recommend solutions that will:
    - Reduce planning area flood hazards and associated public safety risks
    - Provide economic incentives for appropriately located and sensitively designed projects that protect critical drainage features
    - Improve water quality
    - Improve or restore fish passage
    - Enhance stream and wetland habitats
    - Integrate feasible Low Impact Development (LID) components with projects implementation

2. Goal No. 2 – Identify and update stormwater CIP project needs, financing plan, and funding sources, inclusive of:
    - Conveyance capacity improvements for existing watershed conditions and planned growth
    - Storage capacity improvements that will reduce downstream flood hazards and mitigate the effects of future growth
    - Water quality improvements and/or enhanced use of existing facilities that will reduce pollutant loadings to receiving water and facilitate *Western Washington Phase II Municipal Stormwater Permit* (the NPDES Phase II Permit; Ecology 2007a) and TMDL program compliance
    - Fish passage and instream/riparian corridor enhancement improvements consistent with fisheries management objectives
    - Drainage improvement components of TIP projects
3. Goal No. 3 – Evaluate and recommend solutions to Mill and Springbrook Creek; Green River Valley floor flooding problems impacting roadway transportation corridors; and adjacent residential, commercial, and industrial properties and their access inclusive of:
    - Opportunities for habitat restoration benefits
    - Options for passive public access and public education/involvement
    - Land acquisition and/or easement needs
4. Goal No. 4 – Document federal- and state-mandated permits, associated stormwater management regulations, and compliance/reporting needs as the basis for:
    - Supplemental public education/involvement and assessment of effectiveness
    - Water quality improvement actions and future monitoring needs
    - Increased levels of development review and inspection
    - More intensive O&M activities
5. Goal No. 5 – Establish expected total stormwater project implementation costs and programs funding needs to allow:
    - Evaluation of alternative drainage utility rate structures and rate adjustment options to adequately fund implementation actions

6. Goal No. 6 – Integrate public involvement into the drainage planning process through:
    - Formation of a CAC and meetings/presentations to secure their input, comments, and support for DMP recommendations
    - Public meetings to receive input on drainage problems and recommended DMP improvement projects and program actions
    - Dissemination of plan findings, recommendations, implementation costs, and utility rate implications to the public

2.4 Public Involvement Process

The public involvement process for this DMP development and review was independently led by the City's public involvement consultant, Norton-Arnold & Company (Norton-Arnold), at the direction of City staff. That process consisted of a focused CAC with broad City-wide area and stakeholder representation, providing presentations and DMP inputs on various topics, and requesting input and comment on materials presented. A total of five CAC meetings were held between March 11 and May 6, 2008, to present DMP input and findings to the committee regarding:

- Drainage problems and priorities
- Solution opportunities/concepts, targeted benefits, and expected costs
- Stormwater programs expansion needs and expected costs
- Total estimated DMP funding needs and allocation
- Stormwater utility rate structure alternatives and rate adjustment needs to fully fund DMP recommendations

The Anchor team provided input to the public involvement process and attended the five meetings. Presentations to the CAC were made at all meetings except the last. Response was also provided to comments and questions that were raised by the committee members.

Meeting summaries prepared by Norton-Arnold from the five CAC meetings are included in Appendix A. The CAC also formulated a recommendations letter (also included in Appendix A) to document their comments on key DMP findings for City Council consideration in the plan adoption process.

City staff and Norton-Arnold also organized and led two open house/public meetings to encourage public input (beyond the CAC) on drainage problems and proposed drainage system improvement projects. Those meetings were held on January 23 and April 8, 2008. Supplemental problems identified by community residents and stakeholders were added to the list of priority problems being addressed in the DMP. Public meeting summaries prepared by Norton-Arnold are also included in Appendix A.

2.5 Drainage Master Plan Organization

The remainder of this DMP is organized as follows:

- Section 3 summarizes the drainage planning regulatory framework including regulations, standards, policies, and programs, and their relationship to the DMP.
- Section 4 describes and characterizes the study area drainage basins and drainage systems under evaluation.
- Section 5 documents drainage problem areas and their relative priority for assessment and solutions development.
- Section 6 presents the methods, assumptions, and results of hydrologic and hydraulic analysis of drainage systems as the basis for improvement recommendations and benefits assessment.
- Section 7 highlights the TSD and stream system improvement opportunities along with recommended solutions to priority drainage problems.
- Section 8 discusses City-wide river and stream habitat restoration opportunities, discusses potential restoration action types, and identifies private parcels where easements or acquisitions may be needed to implement those actions.
- Section 9 presents recommended stormwater program modifications (water quality and O&M) anticipated to be needed to respond to current or anticipated future NPDES Phase II Permit and TMDL program requirements.
- Section 10 summarizes the findings of utility rate analysis conducted independently (by FCS Group) to provide options and recommendations to City staff and City Council regarding rate structure and rate level modification needs.

2.6 Authorization

Authorization for the DMP preparation was provided by contract agreement between the City and Anchor dated July 9, 2007. Phase 1 services were initially authorized with the contract execution. Phase 2 services were authorized incrementally (by task groupings) in December 2007 and January 2008.

3 DRAINAGE PLANNING REGULATORY FRAMEWORK

This section presents federal, State, and City regulations, standards, policies, and programs that apply to the City's DMP update. A brief background and basic requirements of those stormwater management regulations is provided (Pierce County 2008), and potential effects on DMP implementation actions are noted.

3.1 Federal Regulations and Programs

Local stormwater management regulation that stems from federal requirements includes the federal CWA, Endangered Species Act (ESA), and the National Flood Insurance Program (NFIP). The following sections describe those requirements.

3.1.1 Clean Water Act National Pollutant Discharge Elimination System

Amendments to the federal CWA completed in 1987 resulted in EPA action to issue stormwater discharge regulations. EPA developed the NPDES Permit Program to address water quality compliance for:

- Stormwater discharges associated with industrial activity
- Municipal separate MS4 providers through a two-phase permit process

The Phase I permit applies to large- and medium-size municipalities with populations greater than 100,000. The NPDES Phase II Permit is applicable to smaller jurisdictions with populations of greater than 10,000 and for certain census-defined urban areas. The City of Kent is a Phase II community.

In Washington, the responsibility for implementation of the NPDES permit program lies with Ecology. The NPDES Phase II Permit, as required under paragraph 402(p)(3) of the CWA, requires regulated small MS4 permittees to develop an SWMP that effectively prohibits non-stormwater discharges into storm sewers that discharge to surface waters, and controls must be applied to regulated stormwater discharges that reduce the discharge of pollutants to the "Maximum Extent Practicable (MEP)."

The permit implements "six plus two" minimum requirements for an SWMP as required by the EPA Phase II rules.

The six stormwater program minimum requirements are:

- Public education and outreach
- Public involvement and participation
- IDDE
- Construction site stormwater runoff control
- Post-construction stormwater management for new development and redevelopment
- Pollution prevention and good housekeeping for municipal operations

The two additional NPDES Phase II Permit requirements are:

- Compliance with approved TMDL or water cleanup plan, or equivalent analysis
- Evaluation and assessment of program compliance

The NPDES and State Waste Discharge General Permit for Discharges from Small MS4 Providers in Western Washington (Phase II Permit) became effective on February 16, 2007. It is currently undergoing an appeals process, but is in effect in its current form pending outcome of that appeals process.

Section 9 summarizes the current City NPDES Phase II Permit status and program gaps needing to be filled to maintain continued permit compliance.

3.1.2 Clean Water Act Section 303(d) List and Total Maximum Daily Load

Under the CWA (Section 303), states are required to establish standards to protect the water quality of waters of the United States. In response to CWA Section 303(d), Ecology has prepared a list of water bodies that are not meeting or not expected to meet water quality standards. The most recent list of water quality-impaired water bodies, designated as Category 5 waters, was approved by EPA in November 2005.

Under the CWA, if a water body is not compliant with standards for a particular pollutant, then a TMDL for that pollutant must be calculated. The TMDL is the maximum amount of a pollutant that can be discharged to the water body without violating the water quality standards for it. The loading limits for all pollutant sources discharging to the impaired water body are adjusted downward until the TMDL can be achieved.

Section 9 summarizes the current status of TMDLs within the City and the expected actions that are needed to maintain compliance with existing and forthcoming TMDL requirements.

3.1.3 Clean Water Act Sections 10 and 404 Permits

Placement of fill in waters of the United States is regulated under Sections 10 and 404 of the CWA. Those waters typically include rivers and streams (within the ordinary high water limits) and non-isolated wetlands that are hydraulically connected to regulated streams. Section 10 applies to work in navigable waters below the mean higher high water tidal elevation including structures, dredging and disposal, excavation and filling, and other related actions. Section 404 applies to all other similar proposed actions affecting waters of the United States, with regulation provided either under one or numerous nationwide permits, or under an individual permit (which require broader review) where the limitations of nationwide permits are exceeded. Other regional (state and tribal) conditions may apply to Sections 10 and 404 permit approvals. For the City, Sections 10 and 404 permits are administered by the U.S. Army Corps of Engineers (Corps), Seattle District. These regulations will apply, in particular, to stream relocation and restoration projects recommended in the DMP.

3.1.4 Endangered Species Act

Under the ESA, the U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) Fisheries have issued a list of endangered and threatened species and have designated critical habitat for the listed species. Federally listed species include the Chinook salmon (*Oncorhynchus tshawytscha*), listed as threatened in March 1999, and the Dolly Varden bull trout (*Salvelinus malma malma*), listed as threatened in October 1999. Steelhead (*O. mykiss* ssp.) are also listed as threatened. Coho salmon (*O. kisutch*) are listed as a species of concern.

Based on the WRIA 9 mapping, Chinook salmon (fall run) use is limited to the Green River and primarily the mainstem of Big Soos Creek. Potential Dolly Varden bull trout use is shown for the Green River. Steelhead use is shown for the Green River and Big Soos Creek. Those mapping designations and the City salmonid populations survey indicate extensive Coho salmon use of Big Soos Creek and its major tributaries (including Meridian Valley Creek), valley tributaries, and the Green River.

Section 9 of the ESA prohibits the "take" of endangered species. The "take" of a species can include "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct." Harm may occur with significant habitat modification where it results in the killing or injury to listed species. Under Section 7 of the ESA, proposed actions that could have an effect on listed species that require a permit from a federal agency, or that are federally funded, require the involved federal agency to consult with USFWS or NOAA Fisheries. This normally requires preparation of a Biological Assessment. After consultation, the applicable federal agency issues a Biological Opinion regarding the effects of the action. If the finding is that the action could jeopardize the continued existence of the species, then the action cannot be permitted. If, however, the finding is to the contrary, then the applicable federal agency issues an "incidental take statement" that allows the action to be permitted.

This regulation and process can have a significant effect on stormwater management plans and targeted improvements. Since water quantity, quality, and critical fish habitat can be affected by solutions to flooding and drainage problems, the improvements need to be addressed in a manner that protects listed species. These regulations will apply, in particular, to stream relocation and restoration projects recommended in the DMP.

3.1.5 National Flood Insurance Program

The NFIP was initiated in 1968 under the National Flood Insurance Act. The NFIP is administered by the Federal Insurance Administration under FEMA. One of the primary purposes of the NFIP is to make affordable flood insurance available to residents and businesses in communities that adopt approved floodplain management regulations. FEMA oversees a program of mapping flood hazards along selected flooding sources under the NFIP. Those hazards are shown on FEMA's Flood Insurance Rate Maps (FIRMs) and form the basis for local critical areas zoning of flood hazards. Revisions to FIRMs require certification letters (e.g., approval of a Letters of Map

Revision). Requirements for FIRM certifications can include changes in floodplains and floodway limits and flood elevations associated with stream channel and hydraulic structure modifications.

The City participates in the NFIP under conditions of a flood hazard ordinance and regulations modeled after minimum federal standards. Communities that do not participate in the NFIP have limited eligibility for federal flood disaster relief and other forms of projects with federal funding participation. An optional feature of the NFIP is participation in the Community Rating System (CRS), where actions that extend beyond minimum NFIP requirements can result in reductions in flood insurance premiums for community policy holders. The City is in the process of preparing an application to the CRS program.

3.2 State Regulations, Programs, Permits, and Standards

Local stormwater management needs are influenced heavily by regulations at the State level including water quality standards and certifications (e.g., Section 401), various acts (e.g., GMA, Shoreline Management Act [SMA], State Environmental Policy Act [SEPA], and Watershed Planning Act), codes (e.g., State Hydraulic Code), standards (e.g., Ecology Stormwater Management Manual for Western Washington [SWMMWW]), and initiatives (e.g., Puget Sound Partnership [PSP]). The following sections describe State requirements applicable to the DMP planning and implementation actions.

3.2.1 State Water Quality Standards and Section 401 Water Quality Certification

The discharges of stormwater to surface water and groundwater within Washington are regulated under water quality standards contained in Washington Administrative Code (WAC) 173-201A and 173-200, respectively. WAC 173-201A sets standards for each regulated parameter for the various classes of surface waters. WAC 173-200 also calls for designation of special groundwater protection areas (e.g., aquifer protection areas, wellhead protection areas, or sole source aquifers).

In July 2003, Ecology adopted a new set of water quality standards, but EPA did not initially fully approve those revised standards (EPA notified Ecology in March 2006 of formal disapproval of parts of the 2003 standards). Ecology subsequently developed supplemental revisions to the 2003 adopted water quality standards in response to EPA's disapproval of the State's standards. After public hearings were held in August 2006, Ecology issued the revised final standards on November 20, 2006 (replacing the standards adopted in 2003). Those standards became effective on December 23, 2006. Under these new standards, Ecology classifies fresh waters by actual use (e.g., fish habitat, swimming, or water supply) instead of by class (e.g., Class AA, A, B, C, or Lake Class).

The water quality standards need to be considered for implications on proposed actions or activities in most storm drainage assessments and improvement projects. They are also the primary basis for water quality programs such as NPDES and TMDL. Where certain project thresholds are exceeded by a proposed action, a Section 401 Water Quality Certification is the approval mechanism used by Ecology to document concurrence with a project's ability to maintain State water quality standards with its long-term operation. For short-term construction effects, an NPDES Stormwater General Permit is typically required (when more than 1 acre of disturbance occurs) inclusive of a Stormwater Pollution Prevention Plan (SWPPP), a Stormwater Site Plan, and a Temporary Erosion and Sedimentation Control Plan. These requirements will likely apply to most of the CIP projects recommended in the DMP.

3.2.2 Growth Management Act and Drainage/Comprehensive Plans Consistency

Under the State GMA, local governments were directed to prepare and adopt comprehensive plans and regulations to better manage growth. The City Comprehensive Plan was originally adopted in April 1995 and was most recently modified in May 2006. GMA goals that apply to storm drainage planning include encouraging residential and employment growth and higher use intensities in urban corridors with existing public facilities and services, and protecting the quality and quantity of drinking water by limiting development pressure and impacts on environmentally sensitive areas.

The City's Comprehensive Plan guides the Zoning and Subdivision Codes, which govern land use activities, which in turn influence stormwater runoff potential and drainage system infrastructure facility needs. The suitability of stormwater facility improvements is often affected by critical area designations along water resource features and often requires additional evaluation for siting of improvements. Findings of the drainage planning process can also provide important guidance for land use planning decisions and for periodic Comprehensive Plan updates.

The GMA requires that comprehensive plans be internally consistent and that municipalities take actions and make budget decisions in conformity with their individual plans. Therefore, drainage plans and their associated recommended CIP projects are required to be consistent with the City's Comprehensive Plan.

3.2.3 Shoreline Management Act

The State Shoreline Management Act (SMA) establishes policy guidelines on how Shorelines of the State can be used, and it provides preference to uses that protect the quality of those waters and the natural environment, depend on proximity to the shoreline (water dependent uses), and preserve and enhance public access or increase recreational opportunities for the public along shorelines.

Shorelines of the State include all marine waters, rivers, and streams with a mean annual flow greater than 20 cubic feet per second (cfs; i.e., Green River and lower reaches of Big Soos Creek), lakes larger than 20 acres (i.e., Lake Meridian), and upland areas 200 feet landward from mean high water. Shorelines of the State are further defined as biological wetlands, river deltas, and some or all of the 100-year floodplain, including all wetlands within the floodplain, when associated with the listed water.

The SMA compliance authority is split between local and State governments. The SMA is typically administered by municipalities under a permit program in accordance with adopted Shoreline Master Programs (SMPs) and use regulations that are modeled around State guidelines. The City SMP will be applied to those capital projects where SMA jurisdiction applies as part of environmental permitting for their implementation.

3.2.4 State Environmental Policy Act

The SEPA was enacted in 1971 under Revised Code of Washington (RCW) Chapter 43.21C. It provides the framework for agencies to consider the environmental consequences of a proposal before taking action. It also gives agencies the ability to condition or deny a proposal due to identified likely significant adverse impacts. The SEPA is implemented through the SEPA rules, WAC Chapter 197-11.

Environmental review is required for any proposal that involves a government "action," as defined in the SEPA rules (WAC 197-11-704), and that is not categorically exempt (WAC 197-11-800 through 890). Project actions involve an agency decision on a specific project, such as a stormwater improvement project. Non-project actions involve decisions on policies, plans, or programs, such as the adoption of a comprehensive plan or development regulations, or a 6-year stormwater capital improvements plan.

One agency is identified as the "lead agency" under the SEPA rules (WAC 197-11-924 to 938), and this lead agency is responsible for conducting the environmental review for a proposal and documenting that review in the appropriate SEPA documents (i.e., Determination of Non-significance, Determination of Significance/Environmental Impact Statement (EIS), adoption, or addendum).

City authority and procedures and policies for local regulation under SEPA are contained in City Code Chapter 11.03. The SEPA rules must be used in conjunction with City regulations. The City has prepared a programmatic SEPA Checklist for the DMP to document environmental assessment of non-project actions proposed in the DMP. Specific CIP projects are anticipated to require independent SEPA review as part of environmental permitting for their implementation.

3.2.5 Watershed Planning Act

Under RCW 90.82, the State legislature has set out a framework for developing local solutions to watershed issues on a watershed basis. This provides a process to allow citizens within a watershed to collaborate with resource agencies to determine how best to manage local watershed issues. The process uses a three-phased planning approach:

Phase 1 – Organizational Phase, Phase 2 – Assessment Phase, and Phase 3 – Planning Phase. Ecology provides grant funding assistance for watershed plan development.

3.2.6 State Hydraulic Code

The State Hydraulic Code (RCW 77.55) regulates any activity affecting the bed or changes in flow of the State's fresh waters with the goal to protect fish and wildlife and associated habitat. The Hydraulic Code is administered by Washington Department of Fish and Wildlife (WDFW). The Hydraulic Project Approval (HPA) is used by WDFW to condition projects such that a project is designed, scheduled, managed, sequenced, and constructed to minimize adverse effects on fish and wildlife.

HPAs typically apply to stormwater projects permitting during implementation of recommended drainage improvements (e.g., stream crossings and outfall improvements). In many of those cases, the bed of waters of the State are altered with those improvements or the magnitude or timing of flows discharged to streams are modified (e.g., detention or treatment facilities). The City anticipates that HPAs will be required as part of environmental permitting (through Joint Aquatic Resources Permit Applications [JARPAs]) on the recommended DMP projects that fall within the Hydraulic Code criteria for regulation.

3.2.7 Ecology Stormwater Management Manual for Western Washington

In 2005, Ecology issued a revision to the 2001 SWMMWW standards to update design criteria and procedures, apply recent research, and to clarify statements and correct errors in the 2001 manual. The SWMMWW is a guidance manual that includes stormwater requirements for new development and redevelopment, stormwater pollution prevention planning, and erosion and sediment control from construction sites. The manual is divided into five volumes as follows:

- Volume I – Minimum Technical Requirements and Site Planning
- Volume II – Construction Stormwater Pollution Prevention
- Volume III – Hydrologic Analysis and Flow Control Design/Best Management Practices (BMPs)
- Volume IV – Source Control BMPs
- Volume V – Runoff Treatment BMPs

The intent is for local jurisdictions to use the manual or an Ecology-approved equivalent manual in their SWMP and practices. Application of the SWMMWW (or Ecology-approved equivalent stormwater management manual) is a requirement of the NPDES Phase II Permit. The City is currently planning to update their standards and drainage manual to be consistent with the Ecology SWMMWW.

3.2.8 Puget Sound Partnership

The PSP is a recently formed coalition of government representatives, tribes, scientists, businesses, and citizens working cooperatively at the direction of Governor Gregoire and the State legislature to restore and protect the health of Puget Sound. The primary charge of this organization is to create an Action Agenda that leads to a clean and healthy Puget Sound ecosystem. This action agenda that is currently being developed will coordinate federal, State, local, tribal, and private resources. Ron Sims, King County's Executive, is the South Central Puget Sound PSP Ecosystem Coordination Board representative and chair (the City is within his regional representation).

Stormwater is one of the most significant concerns with non-point source pollution that enters Puget Sound. The actions of the PSP will likely have significant effects and ramifications on the City's stormwater program and project implementation actions. State grant funding opportunities for projects will likely funnel through the PSP as the program develops, and environmental permitting could ultimately be affected by PSP future actions.

3.3 City Policies, Regulations, Programs, and Standards

The City's stormwater management needs are directly affected by City-specific comprehensive planning policies, City code regulations, stormwater programs driven by State and federal regulations, and development review and design standards for City-wide drainage improvement. The following sections describe City requirements applicable to DMP planning and implementation actions.

3.3.1 City Comprehensive Plan and City-wide Planning Policies

Under the Washington State GMA, local governments were directed to prepare and adopt comprehensive plans and regulations to better manage growth. The City

Comprehensive Plan was originally adopted in April 1995, and was most recently modified in May 2006. The three GMA goals that apply to storm drainage planning include encouraging growth and densities in urban areas, protecting the environment and enhancing quality of life including water quality and availability, and ensuring public facilities are adequate to serve growth under established minimum standards.

The City's Comprehensive Plan guides land use regulations, which in turn influence stormwater runoff potential and drainage system infrastructure facility needs. The suitability of stormwater facility improvements are often affected by critical area designations along water resource features and often require additional evaluation for siting of improvements. Findings of the drainage planning process can also provide important guidance for land use planning project decisions and for periodic Comprehensive Plan updates.

The City's Comprehensive Plan Goals and Policies are documented in Section 3.4. The Goals and Policies that are most closely aligned with the DMP are the Environmental Sensitive Design and Construction Goals and Policies as follows:

- Goal CD-20 – Encourage environmental sensitivity and LID principles in the design and construction of all projects
- Goal CD-22 – Promote LID and limited disturbance of natural hydrologic systems so that water quantity and quality are protected throughout the development process and occupation of the site

These policies are applicable to DMP solutions for the promotion of healthy water bodies while maintaining natural stream and enhancement opportunities.

3.3.2 City Code Regulations

The City codes are bound by the State WAC. The City has incorporated the regulations of the State and federal government into City Code Chapter 7, Utilities; specifically City Code Section 7.05, Storm and Surface Water Utility and City Code Section 7.07, Surface Water Drainage Code.

These codes are the operating authority of the City to implement the recommendations of the DMP, state the mechanism of authority to maintain infrastructure, and also authorize the City to implement the Drainage Utility and Connection Charges. Upon approval of the DMP, these sections will be considered for amendment in order to implement the DMP.

3.3.3 City Stormwater Programs and Services

The City stormwater programs and services and recommended modifications to meet current and anticipated stormwater regulations, standards, and permits are described in Section 9.

3.3.4 City Surface Water Design Manual

The City currently manages drainage review for development and redevelopment through the Surface Water Design Manual (City of Kent 2002). That document is an addendum to the 1998 King County Surface Water Design Manual (KCSWDM) and includes all changes and deletions to the KCSWDM adopted by the City. It is used for guidance in drainage review and design of stormwater facilities within the City. An update to this manual is planned in the near future to establish consistency and equivalency with the Ecology SWMMWW, as is driven by the NPDES Phase II (stormwater) Permit compliance needs.

3.4 Drainage Master Plan Goals and Policies

The following DMP update Goals and Policies were prepared by City staff and are included to document consistency with the City's Comprehensive Plan and the GMA.

The DMP will guide the drainage facility capital improvement needs to reduce flood risks, improve water quality, enhance fish passage and instream/riparian habitats, and efficiently serve planned growth. The DMP establishes goals and policies related to infrastructure improvements to provide a comprehensive guide to the City's capital improvement program and surface water management program

When implemented, the DMP will reduce flood hazards and public safety risks, improve water quality, facilitate fish passage, enhance habitat, and will provide opportunities for public use and education activities that ultimately benefit the City's surface water resources.

The City integrated a public involvement process through the development of a CAC and public meetings. The CAC formulated recommendations on key findings for consideration during the adoption process. The CAC findings have been incorporated into the goals and policies for the DMP.

Goal 1 – As the City continues to grow and develop, ensure that an adequate supply and range of public services and capital facilities are available to provide satisfactory standards of public health, safety, and quality of life.

- Policy 1.1 – Assess impacts of residential, commercial, and employment growth on public services and facilities in a manner consistent with adopted levels-of-service.
- Policy 1.2 – Ensure that public services and capital facilities needs are addressed in updates to Capital Facilities Plans and Capital Improvement Programs, and development regulations as appropriate.
- Policy 1.3 – To ensure financial feasibility, provide needed public services and facilities that the City has the ability to fund, or that the City has the authority to require others to provide.
- Policy 1.4 – Periodically review the Land Use Element to ensure that public services and capital facilities needs, financing, and levels-of-service of the Capital Facilities Element are consistent and adequate to serve growth where it is desired.
- Policy 1.5 – Coordinate the review of non-City managed capital facilities plans to ensure consistency with the City Comprehensive Plan.
- Policy 1.6 – Ensure that the planning, design, and construction and operation of public facilities projects will not result in conflicts or substantial inconsistencies with other Comprehensive Plan policies.

Goal 2 – Base standards for levels-of-service upon appropriate provision of public services and facilities as outlined in the operating comprehensive plans of the City and other **providers** of services and facilities to the City and its Potential Annexation Area (Panther Lake Potential Annexation Area).

- Policy 2.1 – Establish levels-of-service appropriate to the core mission of City departments in their provision of services and access of facilities to the public.
- Policy 2.2 – When appropriate and beneficial to the City, its citizens, businesses, and customers, pursue national organizational accreditation for all City agencies providing public services and facilities. Such accreditation should be linked with performance standards applied by City agencies.
- Policy 2.3 – Coordinate with other jurisdictions and providers of services and facilities to ensure that the provision of services and facilities are generally consistent for all City residents, businesses, and others enjoying City services and facilities.

Goal 3 – Encourage effective non-capital alternatives to maintain or improve adopted levels-of-service. Such alternatives could include programs for community education and awareness, energy conservation, or integration of methods and technologies to improve service delivery.

Goal 4 – Ensure that appropriate funding sources are available to acquire or bond the provision of needed public services and facilities.

Goal 5 – Ensure that public utilities services throughout the City, its Potential Annexation Area (Panther Lake Potential Annexation Area), and other areas receiving such services are adequate to accommodate anticipated growth without significantly degrading the levels-of-service for existing customers.

- Policy 5.1 – Establish, maintain, and monitor effective provision of public utilities services and facilities.
- Policy 5.2 – Coordinate the planning and provision of public utilities services and facilities with other agencies providing such services to the City and to the homes and businesses in its Potential Annexation Area (Panther Lake Potential Annexation Area).
- Policy 5.3 – Consider existing demand units in assessing levels-of-service for future provision of services and facilities.

Goal 6 – Foster recognition of the significant role played by natural features and systems in the appropriate siting, design, and provision of public utility services.

- Policy 6.1 – Educate City staff, developers, and other citizens on the interaction between natural features and systems, such as wetlands, streams, and geologically hazardous areas, and the provision of public utility services.

Goal 7 – Coordinate with individuals and organizations to create a long-term, sustainable strategy for local and regional natural resource protection.

- Policy -7.1 – Continue to evaluate operating plans, programs, regulations, and public facility designs to determine their effectiveness in contributing to the conservation and recovery of species listed under the ESA.
- Policy CF-7.2 – Continue to participate in regional and WRIA planning efforts to support the conservation of listed species.
- Policy CF 7.3 – Continue to participate in local- and county-wide flood control efforts to support the repair and maintenance of flood control facilities.

Goal 8 – Support environmental quality in capital improvement programs, implementation programs, and public facility designs to ensure that local land use management and public service provision is consistent with the City's overall natural resource goals.

- Policy 8.1 – Protect and enhance environmental quality via maintenance of accurate and up-to-date environmental data associated with public services and facilities.
- Policy 8.2 – Provide public service agencies with general and site-specific environmental information to identify possible on- and off-site constraints and special development procedures as early in the facility planning process as is possible.
- Policy 8.3 – Indemnify the City from damages resulting from development in naturally constrained areas. To the extent possible or feasible, require accurate and valid environmental information.
- Policy 8.4 – Continue a periodic storm drainage/environmental inspection program to ensure constant maintenance and upkeep of storm systems and ongoing compliance with general environmental processes.
- Policy 8.5 – Ensure that decisions regarding fundamental site design are made prior to the initiation of land surface modifications. Grade and fill permits, which do not include site development plans, may be issued by the City where such activities do not disturb sensitive areas, such as wetlands.

- Policy 8.6 – Require site restoration if land surface modification violates adopted policy or if development does not ensue within a reasonable period of time.
- Policy 8.7 – As additional land is annexed to the City, assign zoning designations and plan for appropriate public facilities locations and capacities in a manner that will protect natural resources and environmentally sensitive areas.
- Policy 8.8 – Continue to support waste reduction and recycling programs in City facilities and in the City at large to meet State and King County waste reduction and recycling goals.
- Policy 8.9 – Work cooperatively with tribal, federal, state, and local jurisdictions, as well as with major stakeholders to conserve and work toward recovery of ESA-listed threatened and endangered species.

Goal 9 – Protect and enhance natural resources for multiple benefits, including recreation, fish and wildlife resources and habitat, flood protection, water supply, and open space.

- Policy 9.1 – Maintain the quantity and quality of wetlands via current land use regulation and review, and increase the quality and quantity of the City's wetlands resource base via incentives and advance planning.
- Policy 9.2 – Protect wetlands not as isolated units but as ecosystems and essential elements of watersheds. Base protection measures on wetland functions and values, impact on water supply quality and quantity, and the effects of on- and off-site activities.
- Policy 9.3 – When jurisdictional boundaries are involved, coordinate wetland protection and enhancement plans and actions with adjacent jurisdictions and the Muckleshoot Indian Tribe.
- Policy 9.4 – Maintain rivers and streams in their natural state. Rehabilitate degraded channels and banks via public programs and in conjunction with proposed new development.
- Policy 9.5 – On a regular basis, evaluate the adequacy of the existing public facilities operating plans, regulations, and maintenance practices in relation to goals for water resource and fisheries and wildlife resource protection. When necessary, modify these plans, regulations, and practices to achieve resource protection goals.
- Policy 9.6 – Protect the quality and quantity of groundwater used for water supply.
- Policy 9.7 – Update the City Critical Areas Maps as new information about aquifer recharge areas and wellhead protection areas becomes available.

- Policy 9.8 – In accordance with GMA regulations, update public facilities operating plans and regulations to identify, protect, and preserve wildlife species and areas of local significance.
- Policy 9.9 – Protect the habitat of native and migratory wildlife by encouraging open space conservation of beneficial habitat through public capital improvement projects.

Goal 10 – Ensure that public facilities development on lands adjacent to the shorelines of the Green River are compatible with shoreline uses and resource values, and support the goals and policies of the City's Shoreline Master Program.

- Policy 10.1 – Minimize the loss of vegetation with development and operation of new public facilities. Continue to recognize the value of trees and other vegetation in protecting water quality.
- Policy 10.2 – Promote and support a systematic approach to enhancing the City-owned facilities through carefully planned plantings and ongoing maintenance of street trees, public landscaping, and greenbelts. Require the use of native and low water use vegetation.
- Policy 10.3 – Require protection of ecologically valuable vegetation, when possible, during all phases of public facilities development. In cases where development necessitates the removal of vegetation, require an appropriate amount of native or low water use landscaping to replace trees, shrubs, and ground cover, which were removed during development.
- Policy 10.4 – Record and protect established greenbelts associated with public facilities to preserve existing natural vegetation in geologically hazardous areas, wetlands, and other habitat areas, as well as along stream banks and where visual buffers between uses or activities are desirable.

Goal 11 – Regulate development of public facilities in environmentally critical areas to prevent harm, to protect public health and safety, to preserve remaining critical areas, and enhance degraded critical areas in the City.

- Policy 11.1 – Encourage appropriate enhancement of existing environmental features such as rivers, streams, creeks, and wetlands.

Goal 12 – Implement and maintain an SWMP that ensures compliance with the requirements of the NPDES Phase II Permit, which is part of the NPDES Program administered by Ecology.

- Policy 12.1 – Reduce the discharge of pollutants to the MEP
- Policy 12.2 – Use all known, available, and reasonable methods of prevention, control, and treatment to prevent and control pollution of waters of the State.
- Policy 12.3 – Implement an education program aimed at residents, businesses, industries, elected officials, policymakers, planning staff, and other employees of the City. The goal of the education program is to reduce or eliminate behaviors and practices that cause or contribute to adverse stormwater impacts.
- Policy 12.4 – Provide ongoing opportunities for public involvement through advisory councils, watershed committees, participation in developing rate-structures, stewardship programs, environmental activities, or other similar activities.
- Policy 12.5 – Implement an ongoing program to detect and remove illicit connections, discharges, and improper disposal, including any spills not under the purview of another responding authority, into the MS4 owned or operated by the City.
- Policy 12.6 – Develop, implement, and enforce a program to reduce pollutants in stormwater runoff from new development, redevelopment, and construction site activities.
- Policy 12.7 – Develop and implement an O&M program that includes a training component and has the ultimate goal of preventing or reducing pollutant runoff from municipal operations.
- Policy 12.8 – Develop a comprehensive long-term stormwater monitoring program. The monitoring program will include two components: stormwater monitoring and targeted SWMP effectiveness monitoring.
- Policy 12.9 – Produce an annual report that includes the City's detailed Stormwater Management Plan, tracking elements, and documentation of compliance with the NPDES Phase II Permit.

Goal 13 – Encourage environmental sensitivity and LID principles in the design and construction of all projects.

- Policy 13.1 – Encourage participation in LID and environmentally sensitive builder programs.
- Policy 13.2 – Adopt development standards that minimize environmental impacts of development through an appropriate balance of regulations and incentives.

Incentives could be tied to compliance with criteria applied throughout the development process.

- Policy 13.3 – Set public facility projects of the City as an example by incorporating techniques of LID design, construction, and O&M.

Goal 14 – Promote LID and limited disturbance of natural hydrological systems, so that water quantity and quality are protected throughout the development process and occupation of the site.

- Policy 14.1 – Establish site design criteria for allowing natural hydrological systems to function with minimum or no modification.
- Policy 14.2 – Promote the use of rain gardens, open ditches or swales, and pervious driveways and parking areas in site design to maximize infiltration of stormwater and minimize runoff into environmentally critical areas.
- Policy 14.3 – Promote inclusion of passive rainwater collection systems in site and architectural design for non-potable water (gray-water) storage and use, thereby saving potable (drinking) water for ingestion.

4 STUDY AREA DRAINAGE BASINS, CLIMATE, AND DRAINAGE SYSTEMS

This section describes the City-wide drainage basins and subareas evaluated under the DMP update including definition of drainage subbasins and their characterization as applicable to hydrologic analysis of stormwater runoff potential (see Section 6). It also highlights rivers, streams, creeks, and other tributaries as receiving waters for runoff from TSD systems evaluated for improvement needs within the various drainage basins and subbasins.

4.1 Available Database Reviewed for Drainage Master Plan Evaluation

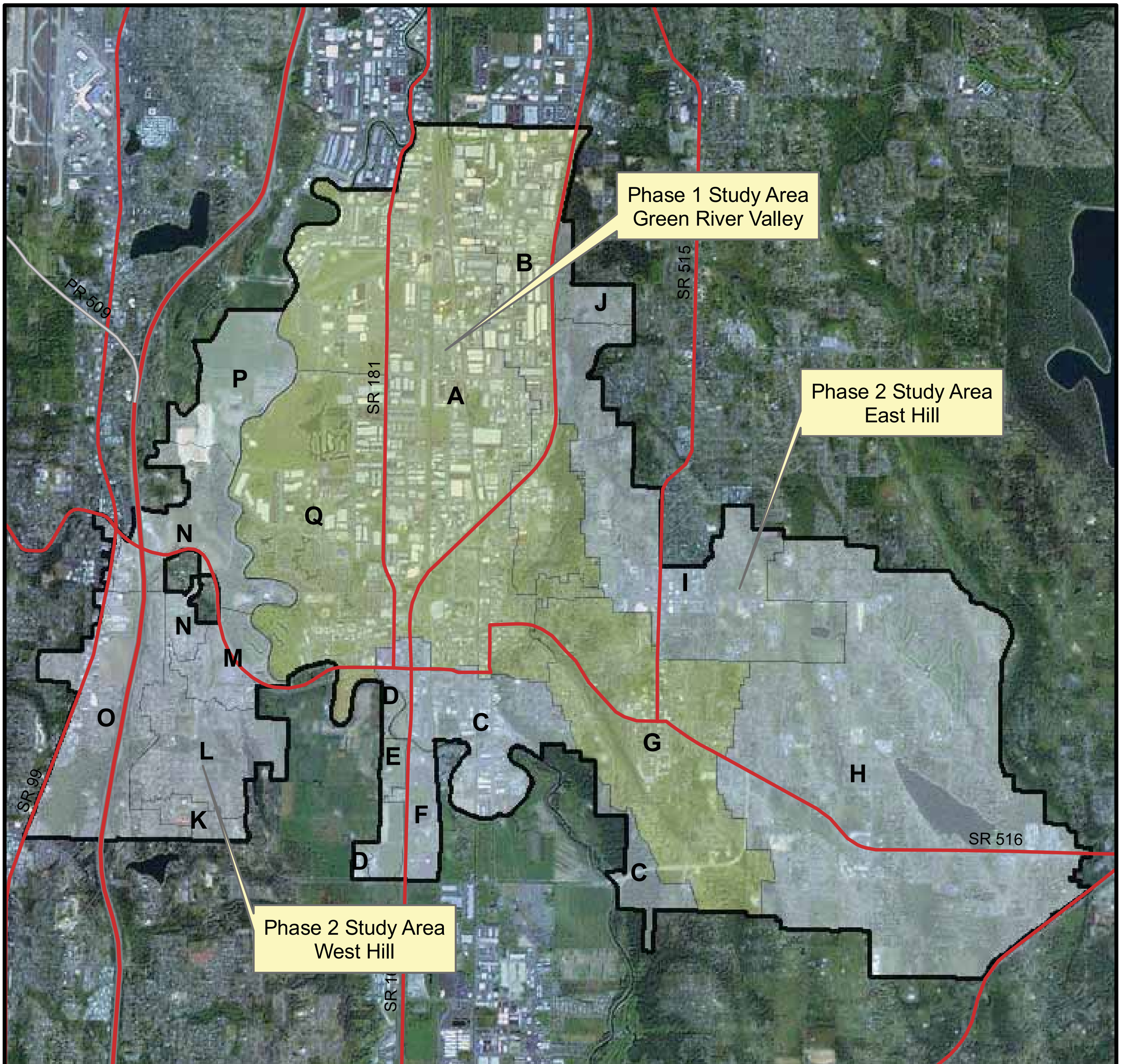
The City maintains an extensive GIS database record, which was the primary source of existing conditions information used in DMP development. Those records include, but are not limited to, aerial photography, topographic mapping (2-foot contour interval), inventoried/recorded drainage system infrastructure (e.g., storm drain and catch basin records), existing and comprehensive plan land use, impervious area cover, soils, and critical areas inclusive of mapped wetlands and steep slopes. In addition, the City maintains a quarter-section map book layout of drainage facilities with reference to record drawings, which was provided for Anchor's use. For site-specific areas where additional detailed information was needed, specific record drawings were researched and were provided by City staff. In limited areas (mainly for selected creek sections and hydraulic structures), supplemental surveys were conducted by the City survey crew and that database was furnished to the Anchor team for use in drainage systems analysis.

Other outside agency sources of information were accessed in development of the DMP including Ecology, WDFW, and the Natural Resource Conservation Service (NRCS) records (NRCS 2001).

The Anchor team initially conducted an overview of the City's GIS database records for information useful to drainage plan development. A total of 17 City-wide drainage basins are identified within those records in the drainage planning area (corporate limits) totaling approximately 18,000 acres (approximately 28 square miles). Those basins are shown in Figure 4-1, and are assigned letter designations (A through Q) along with names based on receiving waters that they drain to. In addition, that review identified a total inventoried storm drainage system length of approximately 285 miles (of pipeline). Although open drainage systems were not tabulated, an extensive system of open drainage channels exists throughout the planning area; however, less open drainage systems and more storm drain systems exist in the more intensely developed areas). Based on discussions with City staff, the major drainage systems to be evaluated for the DMP update were identified, and a review of data gaps in the inventoried drainage system was conducted jointly by City and Anchor team staff.

4.2 Planning Area Phases, Drainage Basins, and Subareas Definition

The DMP drainage analysis was conducted in two phases as shown in Figure 4-1. Phase 1 includes those portions of the Green River Valley that drain to both Lower Mill Creek and Springbrook Creek (Basins A and B), inclusive of the GRNRA (Basin Q) as part of the Lower Mill Creek drainage system. It also includes the Upper Mill Creek drainage basin (Basin G) that connects to Lower Mill Creek downstream from Earthworks Park at the Lower Mill Canyon stormwater detention facility. The Phase 2 planning area includes the remainder of the drainage basins, inclusive of the other Green River Valley drainage systems (Subbasins C, D, E, and F) that outfall directly to the Green River or Mill Creek/Auburn near its Green River confluence. The West Hill and East Hill areas (Subbasins H, I, J, K, L, M, N, O, and P; Figure 4-1) are also included with the Phase 2 analysis. Beyond hydrologic analysis conducted for all drainage basins and subareas, hydraulic analysis of drainage systems was limited to selected Phase 1 and 2 TSD systems as is summarized in Section 6.



City of Kent Drainage Basins

- A: Lower Mill Creek
- B: Springbrook Creek
- C: Horseshoe Acres - Green River
- D: Mill Creek / Auburn
- E: Mill Creek / Auburn
- F: Green River
- G: Upper Mill Creek
- H: Soos Creek / Meridian Valley
- I: Garrison Creek
- J: Garrison Creek
- K: Bingamon Creek
- L: Lake Fenwick
- M: Green River
- N: Midway Creek
- O: McSorely Creek
- P: Johnson Creek
- Q: Green River Natural Resource Area

ANCHOR ENVIRONMENTAL, L.L.C.

HDR MGS Engineering Consultants, Inc.

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Figure 4-1
Drainage Basins and Planning Phases

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Drainage basin boundaries included in the City GIS were initially reviewed for verification or possible adjustment needs. This included consideration of inputs from City staff knowledge and history in those basins and field reconnaissance as needed. Subsequently, drainage basin subareas delineations were completed within all drainage planning areas to define subbasin areas that were tributary to each outfall at its connection to receiving water. To do so, the City's topographic mapping was used in combination with drainage system records and limited field reconnaissance. For all 17 basins, a total of 294 subbasins were delineated with areas ranging from 1 to 731 acres and averaging approximately 60 acres. Figures 4-2 through 4-16 show the resulting drainage basin and subbasin boundaries as the outcome to that assessment. Drainage areas for those subbasins at drainage system outfalls are included in Section 6 tables.

Beyond subbasin delineation, smaller drainage subcatchment areas were delineated within each subbasin as was used for hydrologic analysis in development of runoff flow estimates throughout the developed drainage systems. Subcatchment areas are shown in Appendix D figures along with tables that define the associated drainage areas. Overall, 1,842 drainage subcatchment areas were defined ranging in size from less than 0.5 acre to 155 acres, and averaging approximately 10 acres (the maximum subcatchment sizes for most subbasins is less than 50 acres).

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Figure 4-2
Drainage Basin A and Subbasins
Lower Mill Creek

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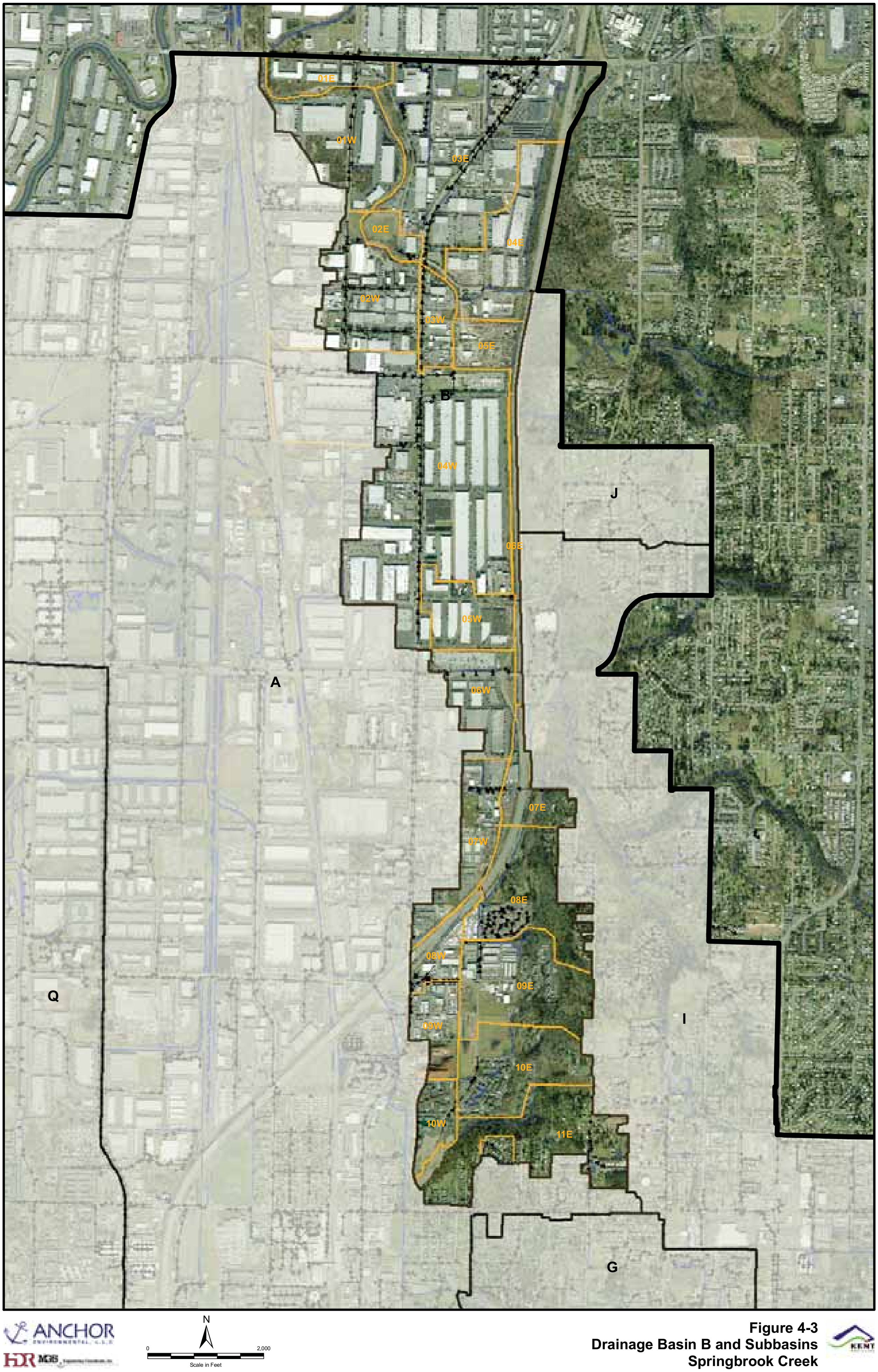
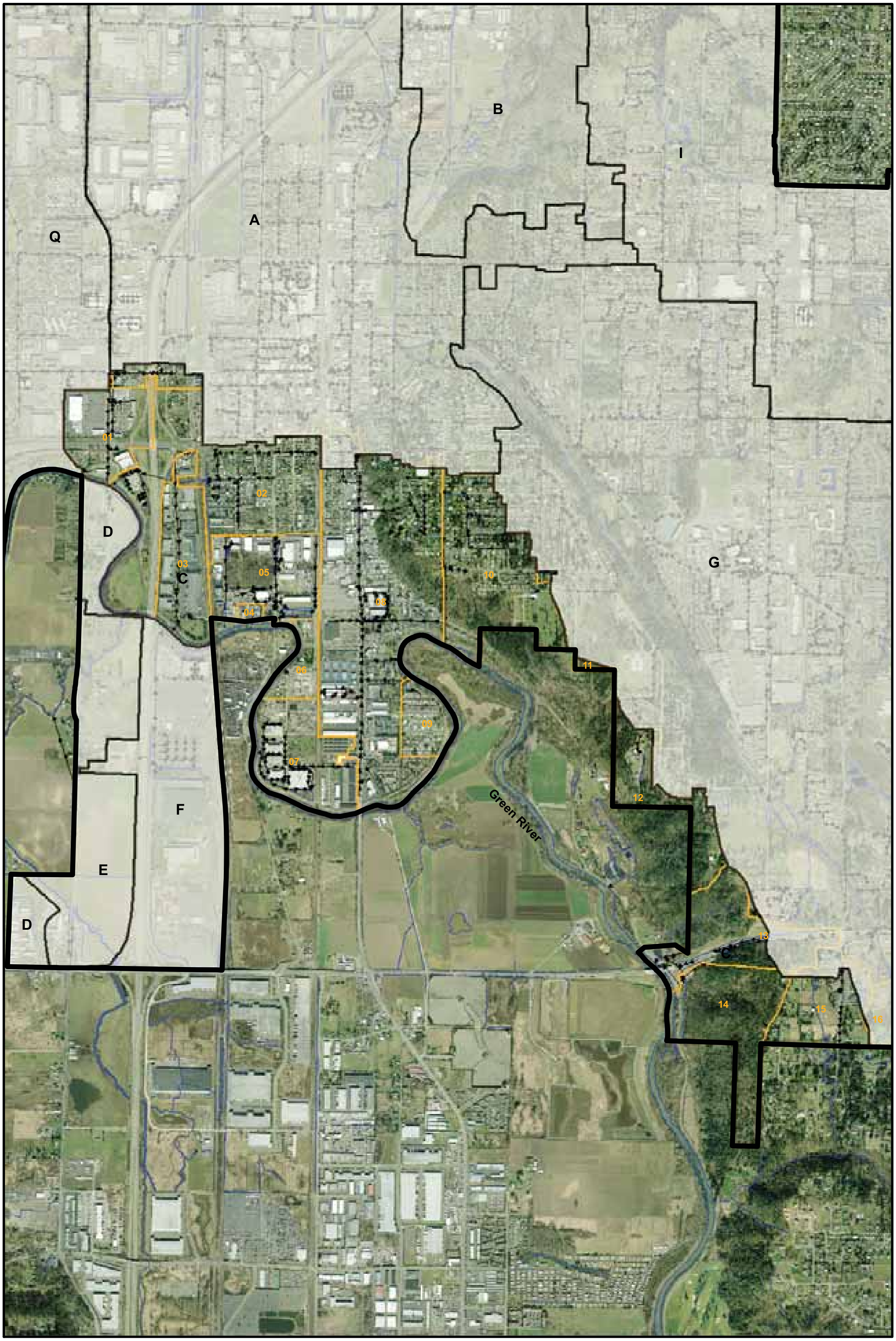


Figure 4-3
Drainage Basin B and Subbasins
Springbrook Creek



N

0 2,000

Scale in Feet

Figure 4-4
Drainage Basin C and Subbasins
Horseshoe Acres - Green River

Figure 4-5
Drainage Basins D, E, and F and Subbasins
Lower Mill Creek - Auburn and Green River

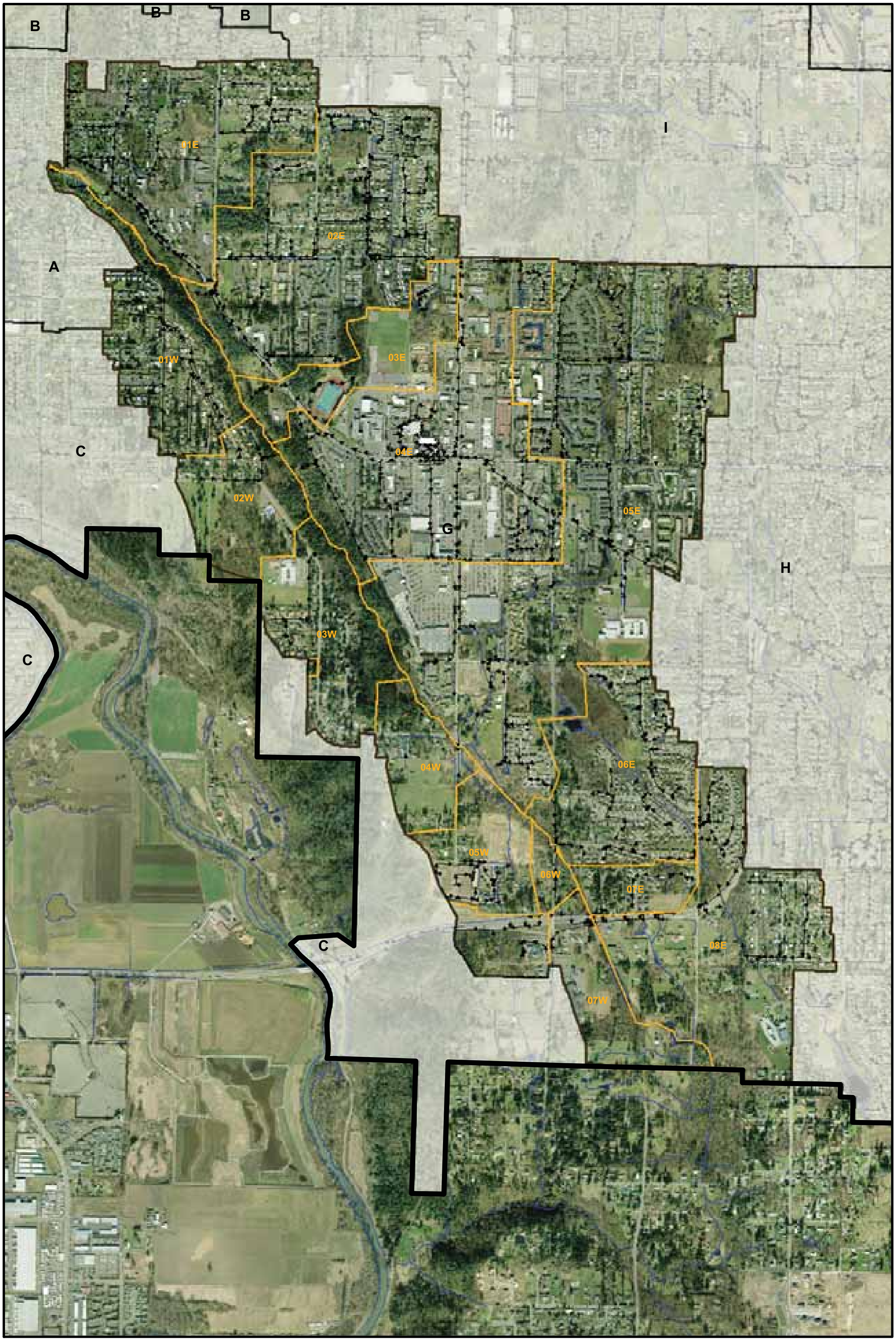


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Figure 4-6
Drainage Basin G and Subbasins
Upper Mill Creek

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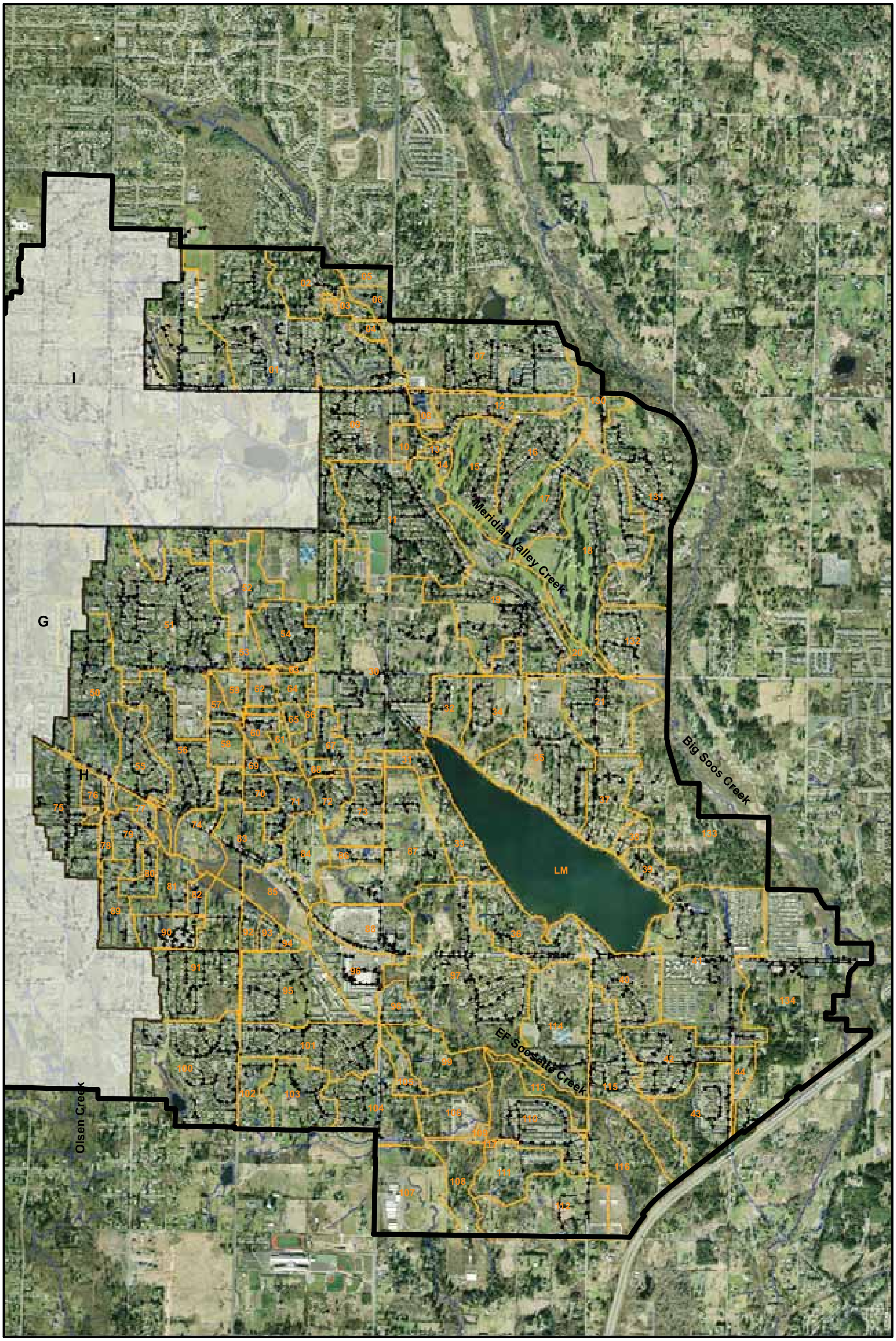

Figure 4-7
Drainage Basin H and Subbasins
Meridian Valley - Soos Creek

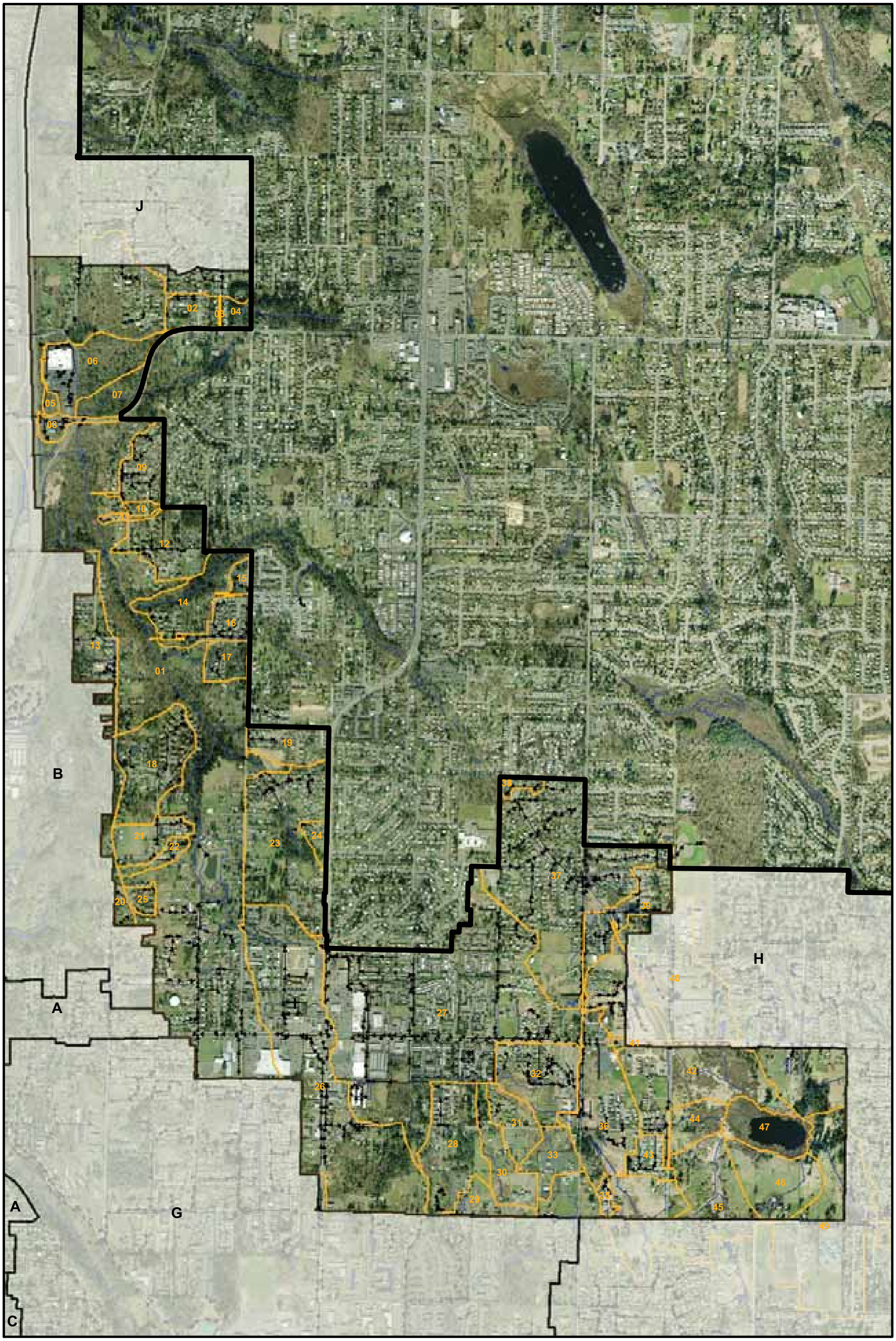

Figure 4-8
Drainage Basin I and Subbasins
Garrison Creek

Figure 4-9
Drainage Basin J and Subbasins
Upper Springbrook Creek

Figure 4-10
Drainage Basin K and Subbasins
Bingamon Creek

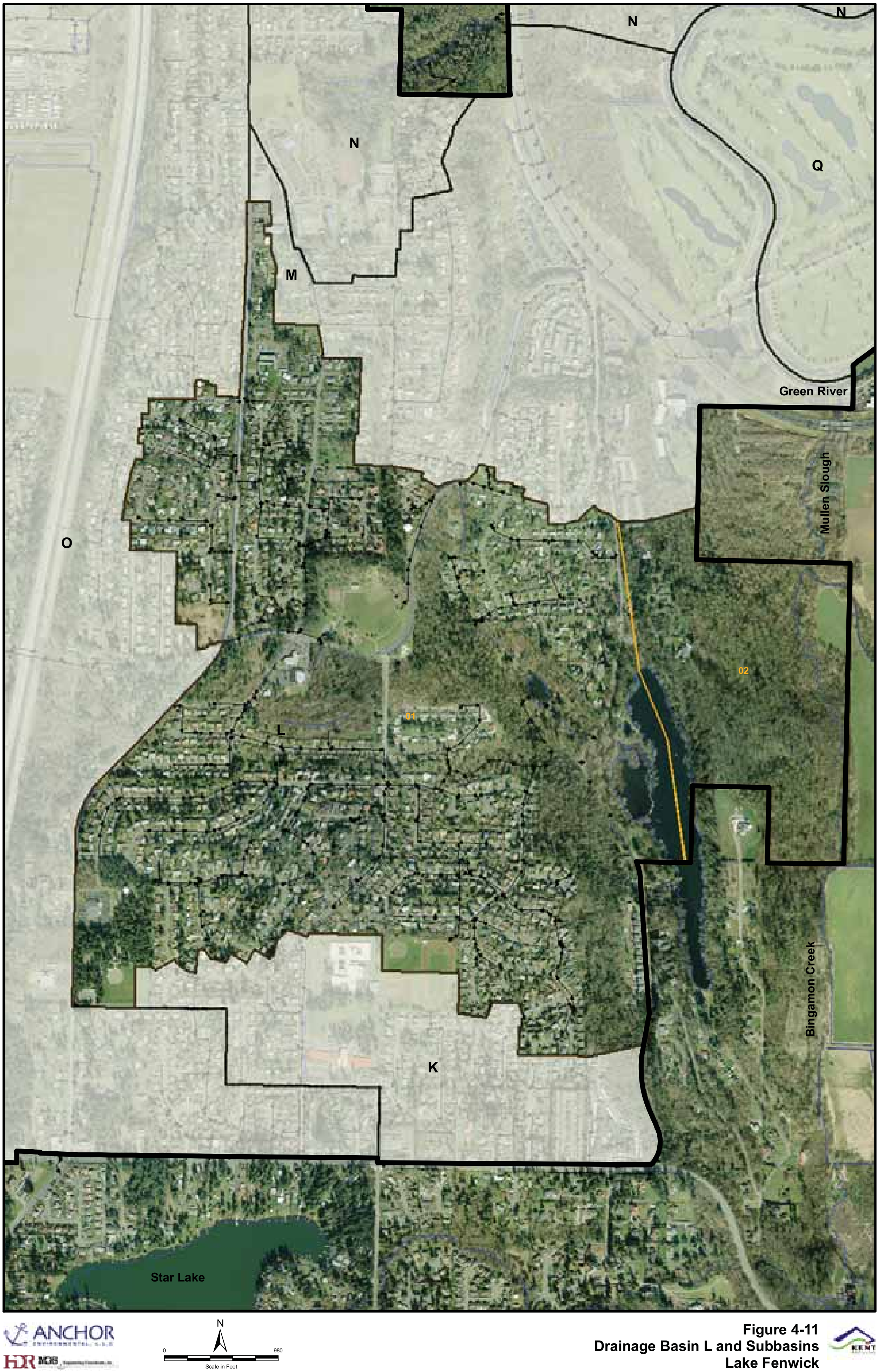

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Figure 4-11
Drainage Basin L and Subbasins
Lake Fenwick

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0 1,000

Scale in Feet

Figure 4-12
Drainge Basin M and Subbasins
Green River

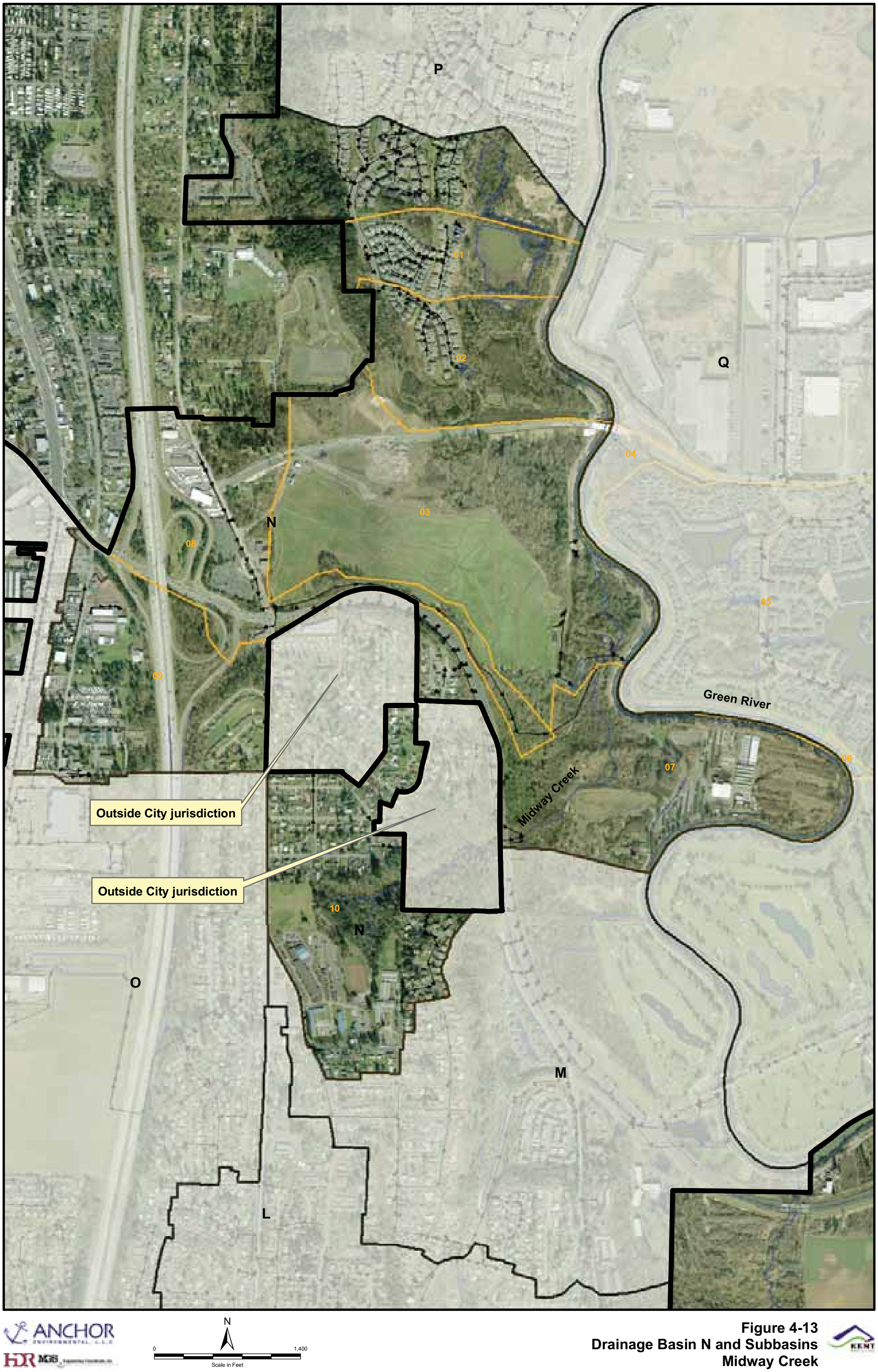

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Figure 4-13
Drainage Basin N and Subbasins
Midway Creek

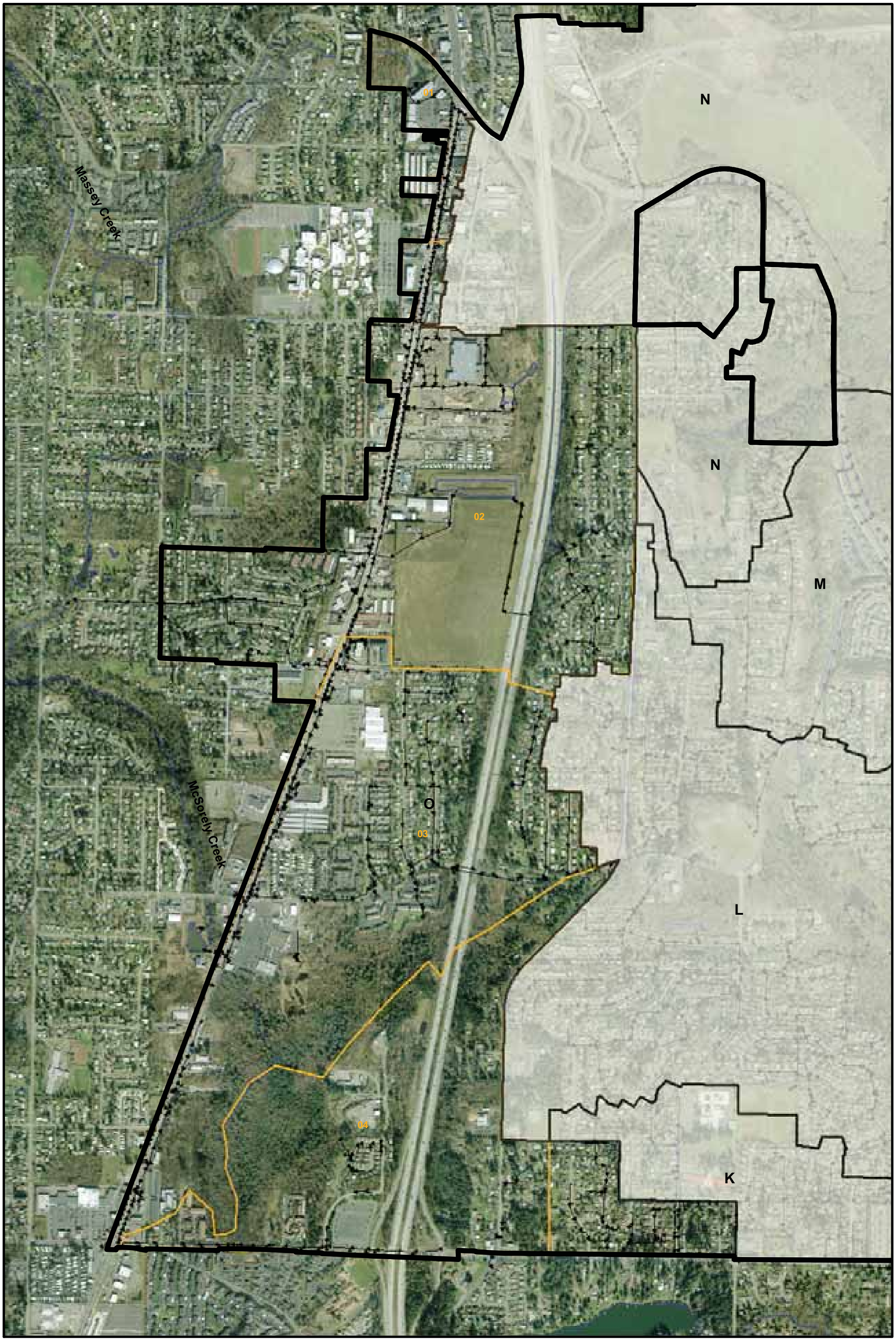

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Figure 4-14
Drainage Basin O and Subbasins
McSorley Creek

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Figure 4-15
Drainage Basin P and Subbasins
Johnson Creek

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0
1,000
Scale in Feet

Figure 4-16
Drainage Basin Q and Subbasins
Green River Natural Resource Area

4.3 Planning Area Drainage Subarea Characterization

4.3.1 Existing Land Cover

The City's GIS database layers were reviewed for contents and extent of land cover coverage within the planning area. In particular, impervious area cover was assessed since it is a key parameter needed in stormwater runoff evaluation. The City GIS provides impervious area cover in the form of roads, buildings, sidewalks, trails, etc., as separate data coverage layers. Those coverage layers were combined to form a composite GIS impervious area coverage layer. Review of aerial photographs was also conducted in comparison to that data layer. It was found that there were numerous updates needed to that GIS coverage based on more recent developed areas. This update appropriately accounted for the increase in impervious area compared to that shown in the GIS database. Therefore, each drainage basin was evaluated and the impervious area coverage layer was updated to reflect the added impervious area using the City's aerial photography coverage. Figure 4-17 illustrates the resulting City-wide impervious area coverage used for stormwater runoff assessment under existing conditions.

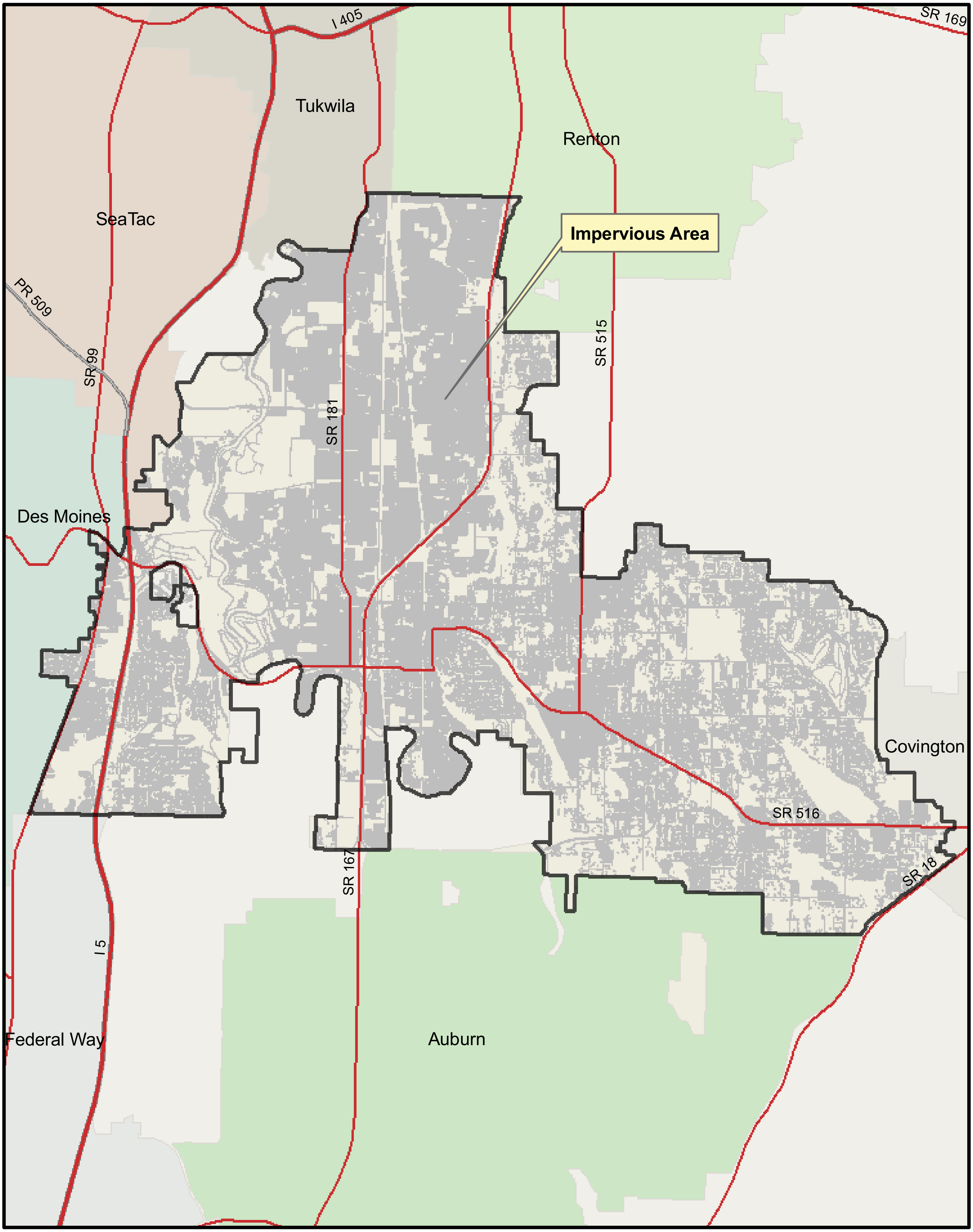

Figure 4-17
Impervious Areas
Roads, Buildings, and Parking Areas

For hydrologic modeling used in stormwater runoff assessment, it is important to also distinguish between other pervious land covers, namely forest, grass, and pasture conditions. This was completed using aerial photography interpretation and creating supplemental GIS coverage layers for those pervious land cover conditions. Forested areas were interpreted where a significant expanse of tree coverage exists. Otherwise, pasture was used in native areas where tree cover was limited, and grass was assumed in other developed pervious areas where tree cover has been removed and typically replaced by lawn.

Drainage subbasins and subcatchment areas were intersected using GIS for the resulting existing impervious and pervious land cover conditions within each subbasin and subcatchment. The results of that evaluation are summarized in Appendix B tables, and the associated percentage impervious area cover for each drainage subbasin is summarized in Section 6 tables.

4.3.2 Comprehensive Plan Land Use and Land Cover

The City's Comprehensive Plan (City of Kent 2004) was used as the basis for assessment of expected changes in future land use cover for consideration in hydrologic analysis and to maintain consistency of the DMP with that plan. Figure 4-18 shows the various City-wide Comprehensive Plan land use designations. Those designations and their allowable land uses were compared with aerial photography coverage and other critical areas designations to assess the extent of undeveloped parcels available for development and those parcels where redevelopment could occur. That assessment was extensive, being done at the parcel level for the approximately 18,000 parcels included in the City's GIS database. The parcels considered as available for development or redevelopment (City-wide) are shown in Figure 4-19.

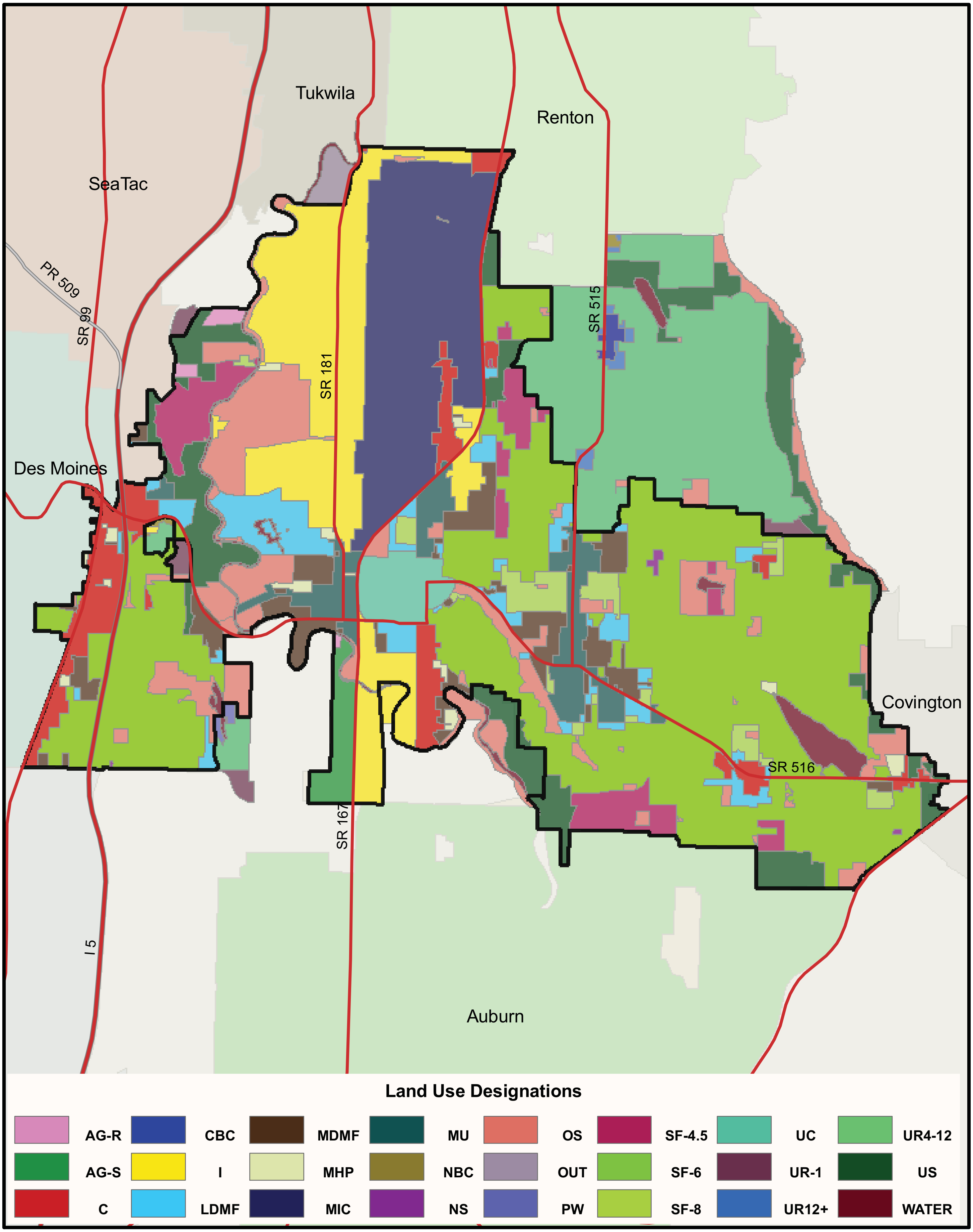

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Figure 4-18
Comprehensive Plan Land Use
City of Kent

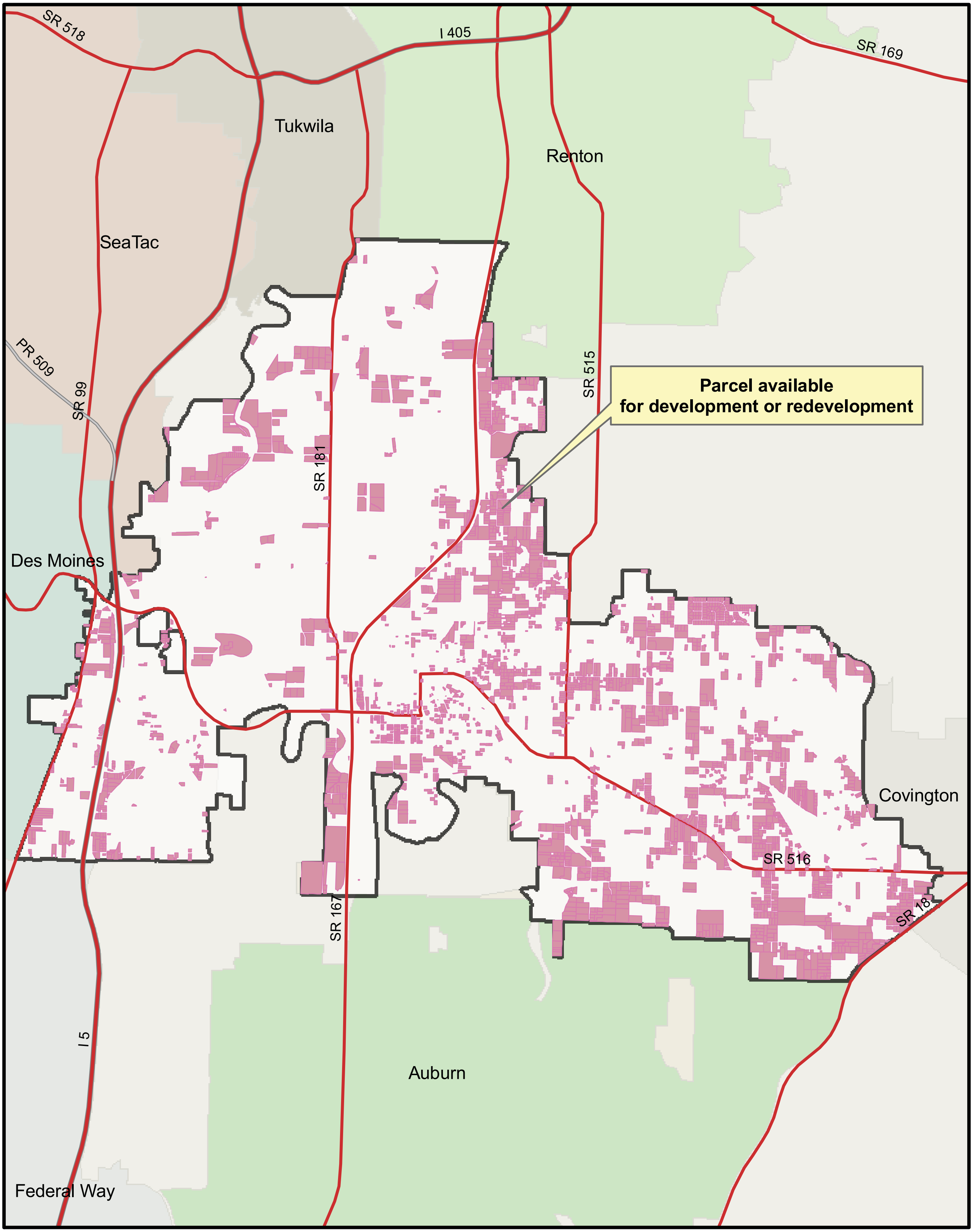

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Figure 4-19
Future Condition Land Cover
Parcels Available for Development/Redevelopment

Generally, those parcels in existing commercial or industrial use with high impervious coverage (typically greater than 80 percent by observation) were left unchanged for future conditions since the impervious area coverage on them is already very high, and any redevelopment of them would likely maintain or lower the impervious area on them. Detention controls to current standards would also be required under a redeveloped mitigated condition as discussed in Section 6. For commercial and industrial zoned parcels with lower existing impervious cover and for multi-family zoned parcels, impervious area coverage assumptions of 80 percent and 65 percent were used for future conditions land cover consistent with the City's TIP assumptions (taken from TIP analysis spreadsheets furnished by City staff).

For single family residential areas, land use densities associated with the zoned Comprehensive Plan land use designation were compared to existing development conditions on those parcels, including consideration of critical areas, and engineering judgment was used to assign an estimated number of potential lots that could be achieved with redevelopment. Impervious areas changes for residential areas were then assigned by applying a unit impervious area of 3,500 square feet per redevelopment lot, and crediting back any existing structures at 2,500 square feet per lot. These impervious areas were chosen through a review of recent development activity. The total impervious area was then applied and accounted for in GIS intersections with drainage subbasins to identify the expected future impervious cover conditions for each. This was not done at a subcatchment level since future land cover was only analyzed for stream systems hydrologic modeling using subbasin-level land cover.

These future land cover estimates were made solely for the DMP hydrologic analysis. The City's 2002 Surface Water Design Manual is currently still the governing reference for any future development or redevelopment standards within the City.

4.3.3 Soils and Geologic Units Hydrologic Classification

Pervious land cover soils conditions within the planning area were assessed using the City's GIS database in consideration of soils geologic mapping coverages. For hydrologic analysis, soils were classified as either outwash, till, or saturated. Based on broad-scale assessment, the Green River Valley floor remaining pervious area was assigned a saturated soils condition (typically fine-grained soils in pasture, wetlands, or other water bodies). Saturated soils were also identified for the West and East Hill areas. Limited outwash areas were also mapped from the soils mapping coverage. The remainder of the West and East Hill pervious land areas were assigned a till hydrologic soils characteristic. Figure 4-20 shows the resulting hydrologic soils classifications used for analysis.

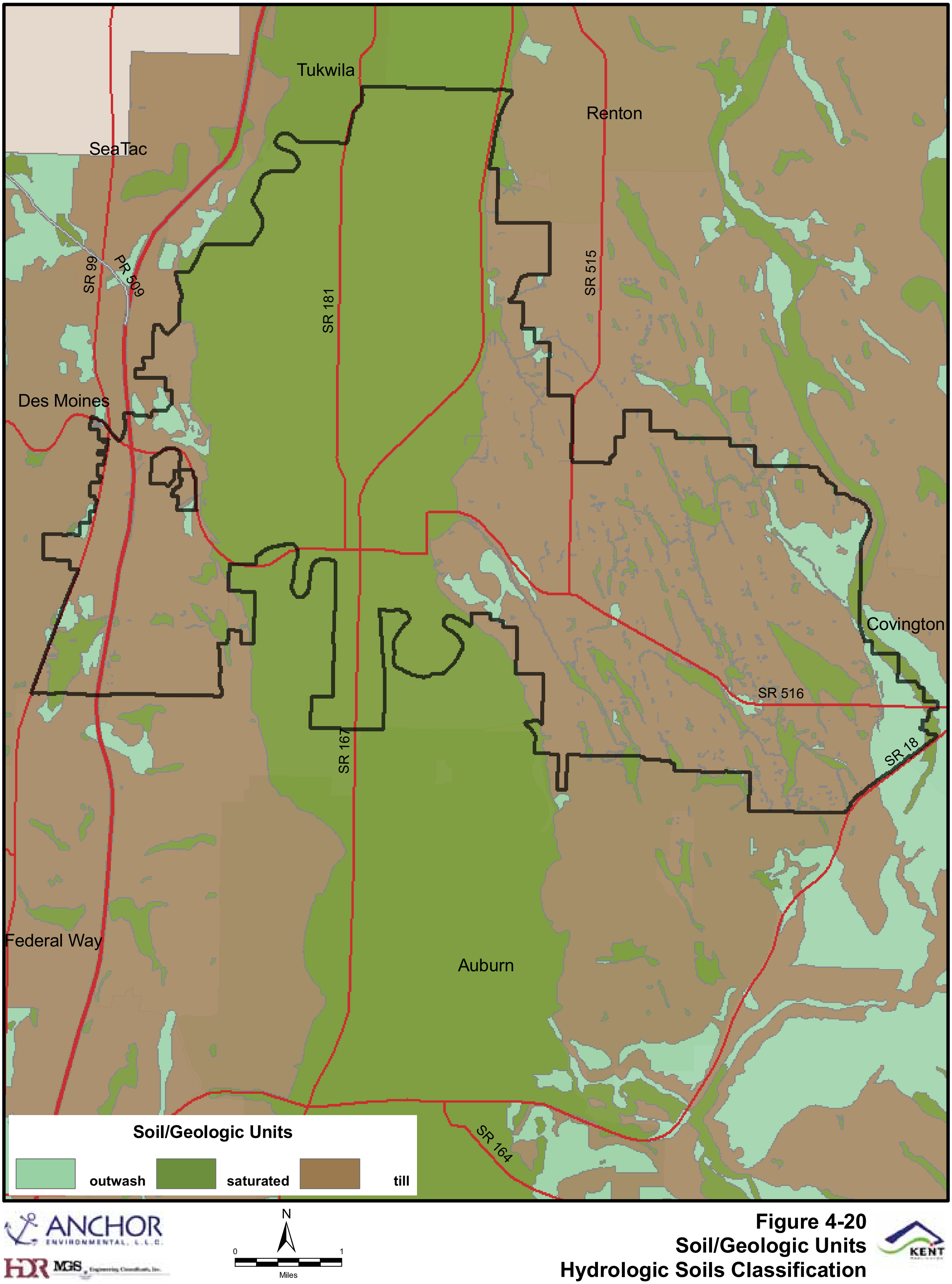

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Figure 4-20
Soil/Geologic Units
Hydrologic Soils Classification

4.3.4 Wetlands and Other Critical Areas

Wetland and other critical areas (limited to steep slope areas with average slopes greater than 30 percent for this analysis) were identified from City GIS coverage within the planning area. Those areas were considered in land cover assessment as described above and reflected in hydrologic analysis of stormwater runoff potential as described in Section 6. Figures 4-21 and 4-22 show the respective wetland and steep slope areas considered within the planning area drainage analysis.

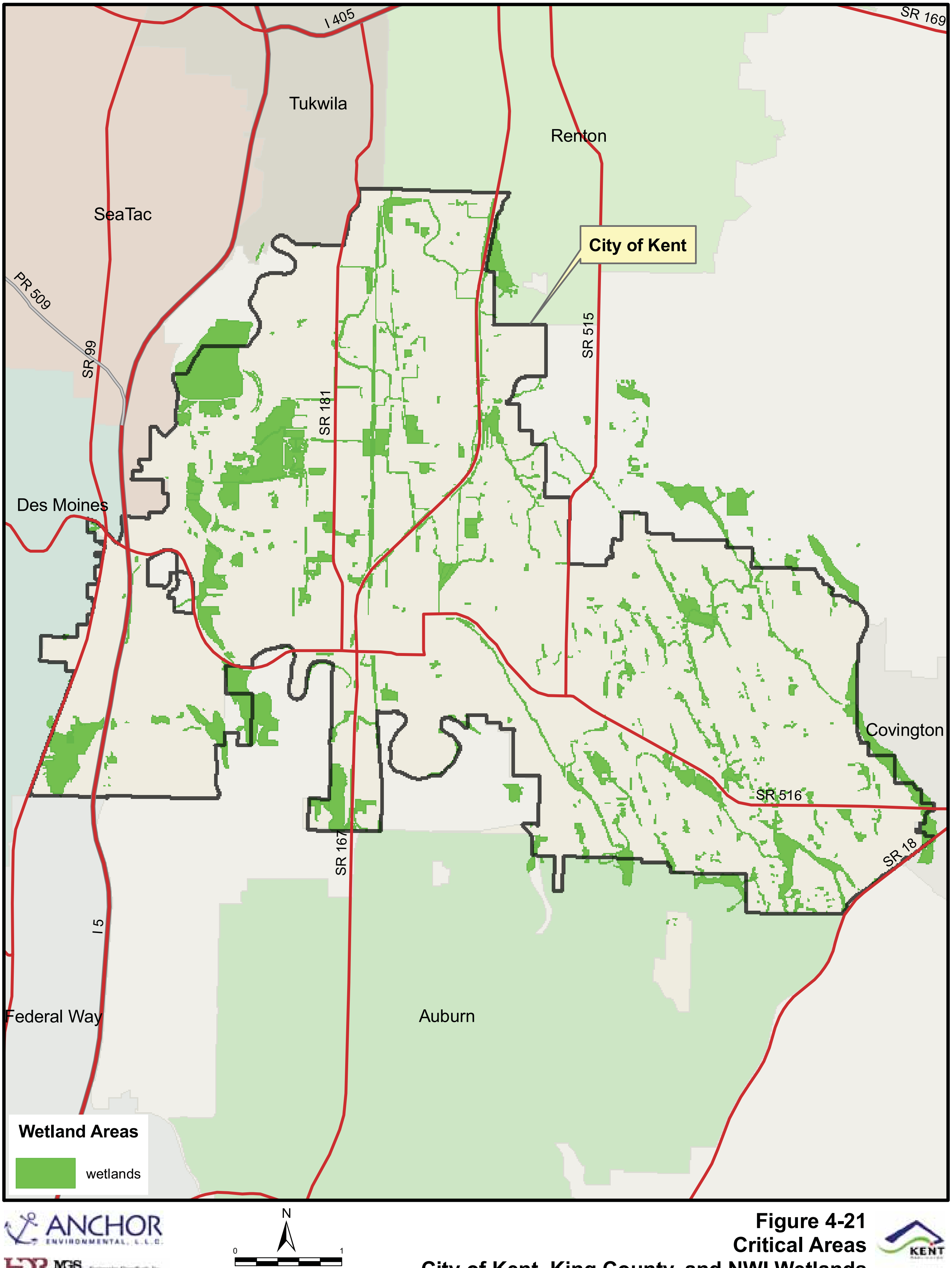

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Figure 4-21
Critical Areas
City of Kent, King County, and NWI Wetlands

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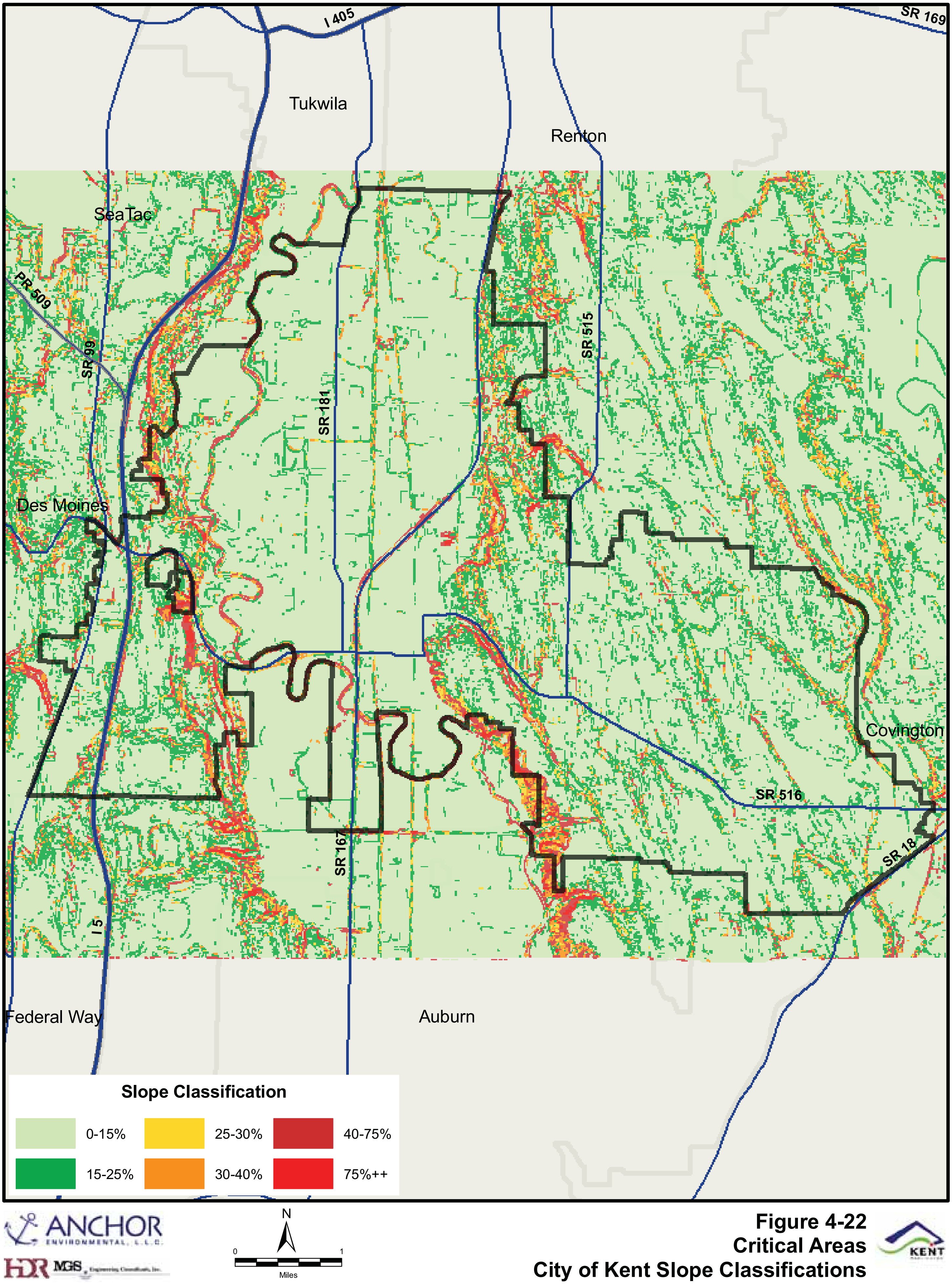


Figure 4-22
Critical Areas
City of Kent Slope Classifications

4.4 Drainage Planning Area Climatic Characteristics Affecting Flooding

The climate in western Washington, influenced by the Pacific Ocean, has a predominantly marine climate characterized by cool, dry summers and mild, wet winters. Local and regional variations in precipitation are influenced primarily by the orographic effects of the Olympic Mountains and the Cascade Range. Precipitation totals in the City average approximately 38 inches per year in the West Hill and Green River valley areas to 42 inches per year in East Hill.

Climatic characteristics for the City were summarized from review of statistically based data collected from a network of local and regional weather stations. Average temperatures in the study area range from average high temperatures of 78 degrees Fahrenheit in July to average low temperatures of 34 degrees Fahrenheit in January. Monthly precipitation averages nearly 6 inches in November, December, and January while declining to about an inch in July and August. Precipitation may occur as snow; however, it rarely accumulates for more than a few days. The average annual snow fall is approximately 4 inches. On average, approximately 75 percent of the annual rainfall occurs between October and March.

In most parts of western Washington, floods generally occur in late fall and winter as a result of significant and prolonged rainstorms. These floods may be augmented by water from snowmelt if rain falls on snow. However, given the elevation range within the City, peak flood flows typically result from more intense rainfall events where antecedent rainfall has saturated the soils and shallow groundwater aquifers, above glacial till layers or bedrock, resulting in rapid runoff response.

4.4.1 Climate Change Considerations

Climate is the long-term average of temperature and precipitation in a region; whereas, weather is a description of current conditions. In western Washington, latitude, terrain, and close proximity to the Puget Sound and the Pacific Ocean influence both weather and climate. Climate change is the alteration of the precipitation and temperature patterns over a long period of time. Though global climates have changed several times in the past, scientists have determined that human activity is impacting current shifts in global climate patterns, including the Puget Sound Region, by the emission of greenhouse gases. Greenhouse gases in the earth's atmosphere trap heat similar to how glass traps heat in a greenhouse. Ecology (2007b) has estimated the Pacific Northwest's average annual temperature has increased 1.5 degrees Fahrenheit during the 20th century and is expected to rise another 1.9 degrees Fahrenheit before 2030.

In the spring of 2006, a Climate Change Technical Committee (Committee) was formed as a part of the regional water planning framework in the Puget Sound Basin, which focused on Snohomish, King, and Pierce Counties. The Committee collaborated with the Climate Impacts Group from the University of Washington to draft technical memorandums and a final report on climate change and the potential impacts to regional water supplies and flooding potential. The study found that large river systems (Sultan, South Fork of the Tolt, Cedar, Green, and White Rivers) will have earlier spring peak flows in the future as a result of earlier spring snowmelt. Potential climate change impacts to Puget Sound Lowland streams have not been identified as some models predict more precipitation in the Puget Sound Lowlands and other models predict less. The Committee's final report stated that the understanding of impacts of climate change are limited at this time (Palmer 2007), suggesting that the scientific community is more confident in changes to temperature than in predicted changes to the precipitation patterns. While snowmelt may occur earlier in the future as a result of climate change, the Green River has a significant level of control due to the management of Howard Hanson Dam.

With unknown changes in precipitation patterns in the Puget Sound Lowlands and the influence of Howard Hanson Dam, impacts from future climate change are currently unknown. The City will continue to monitor the science of climate change as additional information and scientific processes improve the understanding of potential effects on precipitation and snowmelt that affect changes in flooding risks in the Puget Sound Lowlands.

4.5 Rivers, Streams, and Creek Systems Characteristics

The receiving water drainage systems within the City are shown in Figure 4-23 as aligned with the drainage basins being analyzed in the DMP update. Characterization of these systems for DMP hydrologic and hydraulic analysis of flood flows and flood elevations was primarily limited to the Green River, Lower and Upper Mill Creek, and Springbrook Creek as described in the following subsections. However, flood flow estimates were also developed or evaluated for other receiving waters (e.g., Big Soos Creek, Soosette Creek, Meridian Valley Creek, and Garrison Creek) at selected locations where drainage problem areas are identified. The characterization of selected receiving waters in this section is limited to a brief discussion of river or stream conditions and flooding potential and issues.

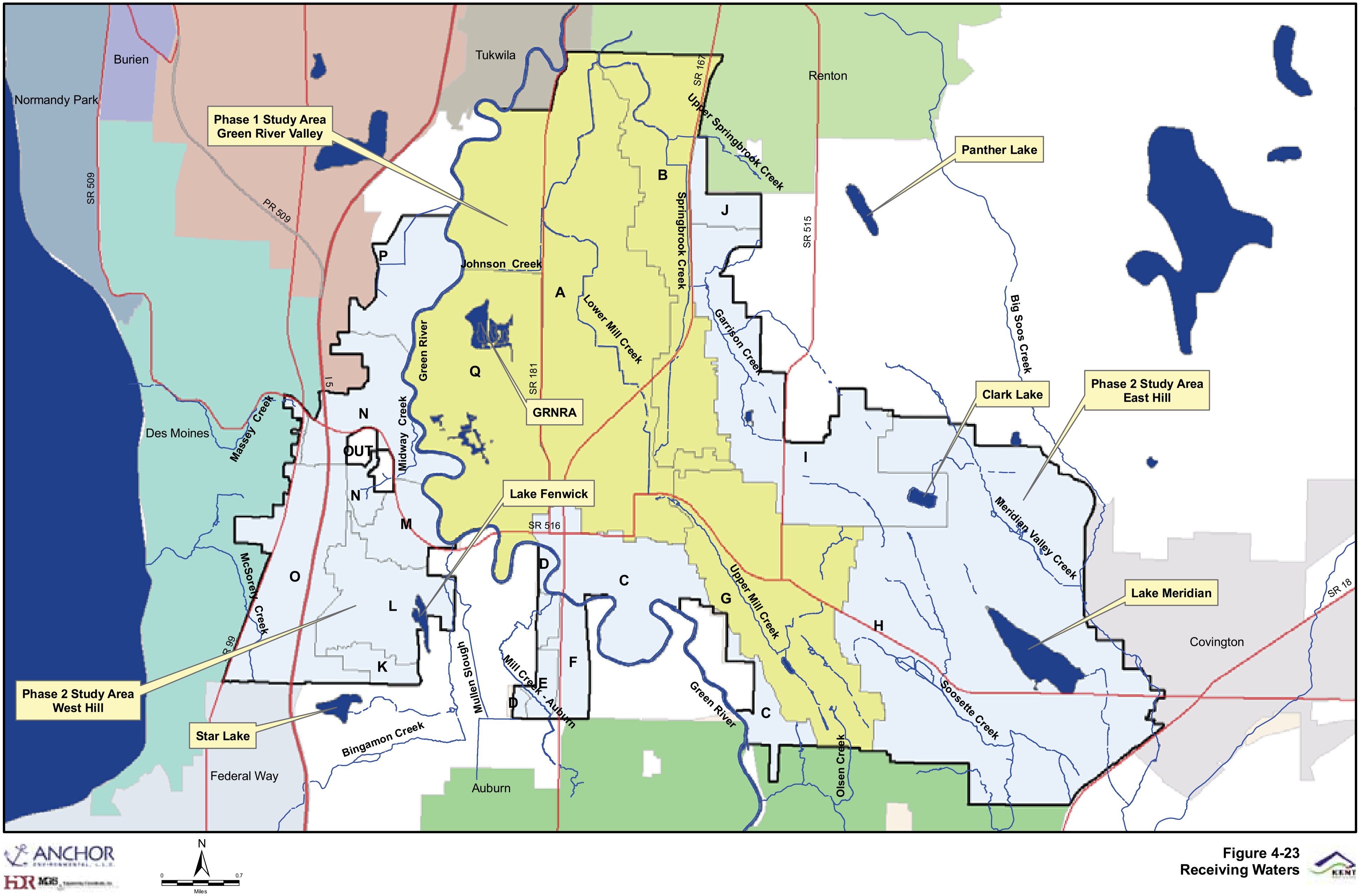


Figure 4-23
Receiving Waters

4.5.1 Green River

Within the City corporate limits, the Green River extends through the Phase 1 and 2 valley floor study areas and is the ultimate receiving water for stormwater runoff discharge from Basins C, D, E, F, K, L, M, N, and P (all but Basin C and F discharge to a receiving water initially before connecting to the Green River as shown in Figure 4-23). The north planning area limit (north end of Subbasin A) is located at approximately river mile 14.5 of the Green River, and the south planning area limit (south end of Subbasin C) is located at approximately river mile 28.0, for a total reach length of approximately 13.5 miles. The river gradient in this reach is very low at approximately 2.3 feet per mile. The river channel banks contain extensive levee systems on one or both banks in this reach, and regulatory flood elevations along this reach have been mapped by FEMA. A recent re-mapping program has been completed without consideration of levees due to issues with their certification. That evaluation is under review and appeal by the City at the current time. Improvements need to be made to Green River levees, which are not considered as part of the DMP evaluation except for expected supplemental funding needs associated with those improvements as provided by City staff and included in Section 10.

Within this reach, the major tributary stream connections include Midway Creek, Mullen Slough, and Mill Creek/Auburn. All these tributaries are un-regulated connections with the Green River and are affected by backwater flooding conditions induced at high Green River flood stages. Some of the drainage systems within the planning area discharge directly to the Green River, typically by pumps and/or low flow gravity bypasses at their outfalls. Therefore, for hydraulic analysis, Green River flood elevation levels were considered at those outfall locations in Basins C and F.

4.5.2 Mill Creek

Mill Creek is contained entirely within the drainage planning area limits. Its headwaters are in Basin G (Upper Mill Creek), and its channel extends at a moderate to steep gradient through the Mill Creek Canyon downstream to Earthworks Park adjacent to East Smith Street and Titus Street (a reach length of approximately 1.9 miles). Two regional stormwater detention facilities exist in this reach, Upper Mill Creek Dam and Lower Mill Creek Canyon Dam (at Earthworks Park). Those facilities were evaluated extensively with the DMP to better understand their effects on flood flow regulation and on stream and flood storage improvement needs and opportunities along both Upper and Lower Mill Creek. The Lower Mill Creek drainage system extends from the Lower Mill Canyon Dam outlet works, through the downtown corridor, and ends just upstream of South 180th Street at its confluence with Springbrook Creek (a reach length of approximately 5.5 miles). The average gradient on Lower Mill Creek is approximately 5.5 feet per mile. It has been re-aligned and hydraulically restricted by past Green River Valley floor development actions.

More than 30 bridges exist along this reach, some of which are restrictive to flood flows, and are evaluated for replacement needs in the DMP. Frequent and extensive flooding problems along Lower Mill Creek are well documented and are a significant concern for resolution to City representatives, residents, and stakeholders (in particular, the downtown corridor near East James Street, and along the 76th Avenue South transportation and commercial development corridor).

Within the Lower Mill Creek reach, the GRNRA, constructed by the City in 1996, provides off-channel water quality benefit including pre-settling and constructed wetland treatment, over 300 acre-feet (by design) of regional detention storage, habitat features, wildlife viewing, and public access/educational benefits. The GRNRA is connected to Mill Creek by an inlet channel north of South 228th Street, and the outlet channel reconnects with Lower Mill Creek at its East Valley Highway crossing north of South 208th Street.

4.5.3 Springbrook Creek

The headwater to Springbrook Creek is Upper Garrison Creek in the East Hill area near Clark Lake. Lower Garrison Creek joins the Springbrook Creek channel after crossing under SR 167 north of South 212th Street. The south branch of Springbrook Creek (also referred to as Lower Garrison Creek) extends south and upstream of SR 167, with a high flow overflow connection to Lower Mill Creek downstream of James Street. The Springbrook Creek channel extends downstream to its confluence with Lower Mill Creek, and then continues into the City of Renton. The total length of Springbrook Creek evaluated in the DMP, from the north corporate limits, to its overflow confluence with Lower Mill Creek is approximately 4.6 miles. Its average stream gradient is slightly greater but comparable to Lower Mill Creek at approximately 6.0 feet per mile. It has also been significantly re-aligned and hydraulically restricted by past Green River Valley floor development.

Frequent and extensive flooding along Springbrook Creek also occurs at numerous locations, particularly in the downstream segments near South 196th Street and East Valley Highway. In some areas, low bank elevations contribute to its overflow problems. Nearly 20 roadway or other crossings of the creek exist within the reach evaluated, some of which contribute to restriction of flood flows and increased flood elevations.

4.6 Trunk Drainage Systems Characteristics

TSD systems within the City are well documented in the GIS database (typically size, type, age, etc.). Figures 4-2 through 4-16 show the extent of the GIS-mapped drainage systems within the 17 drainage basins included in the drainage planning area. As stated previously, more than 285 miles of inventoried drainage system exist within the planning area. Of that total, approximately 250 miles are greater than or equal to 12 inches in diameter, but only about 85 miles of it is greater than or equal to 18 inches in diameter. Therefore, although there are drainage systems ranging up to 96-inch diameter, a larger proportion of the City drainage system (approximately 70 percent) is less than 18-inch diameter. Much of the City drainage system infrastructure is older and in need of lifecycle replacement. The City maintains an active program of repair and replacement of existing drainage infrastructure, and the City upgrades segments of the system on an ongoing basis as part of its stormwater and TIP projects. The DMP evaluates improvement needs along major segments of the TSD system based on hydrologic and hydraulic analyses presented in Section 6.

5 DRAINAGE PROBLEM AREAS DOCUMENTATION AND PRIORITIES

5.1 Drainage Problem Identification and Concerns

This section provides documentation of the City's existing drainage problem areas, sources, and their relative priorities for assessment. In addition, other drainage system deficiencies were defined through hydraulic capacity analysis as is documented in Section 6. These problems form the framework for drainage systems evaluation conducted in the DMP.

The City initially identified approximately 20 frequent drainage problem areas City-wide in consideration of resident and other stakeholder drainage complaints, past problems definition through prior drainage planning assessments (R.W. Beck 1999 and 2000), and in consideration of the City's O&M records and staff input. Those problem areas were reviewed to define their specific location, receiving water, type of problem, and potential source. That review included City GIS database records (aerial photographs, topographic mapping, drainage system facilities, etc.) and field reconnaissance investigations conducted by Anchor team staff for the majority of the problem areas. Problem areas were assigned identifiers consistent with abbreviated receiving water designations, and multiple problems in a receiving water were sequentially numbered (e.g., LMC-1, LMC-2, etc., for Lower Mill Creek).

To secure additional input from the public on City-wide drainage problems, a public open house was conducted on January 23, 2008, where significant additional input on drainage concerns was gathered. That input was synthesized into a supplemental list of public meeting-defined drainage problems. Those problems areas were designated as PM-1, PM-2, etc., and totaled 21 additional reported problems. Some of those problem areas overlapped and were consistent with prior City-defined drainage problems. The CAC was also consulted for input to collective drainage problem areas. Their priorities are discussed in Section 5.4.

5.2 Drainage Problem Review/Validation during December 2007 Flooding

Drainage problems were further reviewed during a December 3, 2007 flood event. During that event, the City received approximately 2.8 inches of precipitation within a 24-hour period, much of which occurred within a 12-hour period. The magnitude of that event was later determined to be an approximately 2-year runoff event for Mill Creek. During that event, in other nearby areas of the Puget Sound region, significantly higher rainfall amounts occurred and flood event frequencies were typically significantly higher. Flooding along Lower Mill Creek and Springbrook Creek during that event crossed many arterial roadways causing significant traffic disruption, shutdown of some road corridors and transportation-dependent businesses (e.g., East James Street, along the 76th Avenue corridor, South 196th Street), and some structures were subject to flooding (e.g., along Kennebeck Lane adjacent to Lower Mill Creek in the downtown corridor). A field investigation was conducted by the Anchor team and by City staff during that event, photography documentation was collected, and high water marks were flagged at numerous locations along Lower Mill Creek, typically immediately upstream and downstream from roadway crossings. Those high water elevations were surveyed by a City survey crew as validation of the extent of flooding during that event. Stream gage records for that day were also documented for later analysis. Other local drainage problem areas were also reviewed and photographed on that day for further evidence of the nature and extent of identified flooding problem areas. Appendix C includes representative photographs of flooding conditions documented during that event.

5.3 Drainage Problem Priorities for Evaluation

Review of the documented problems showed that those areas along the Lower Mill Creek and Springbrook Creek corridors had the most prevalent flooding problems and were of highest concern (considering City staff, public, and CAC inputs). Three primary areas of flooding concern were along Mill Creek in the downtown corridor below the Earthworks Park Dam (Lower Mill Creek Canyon Dam) downstream to SR 167, along the Mill Creek 76th Avenue corridor (South 228th Street to South 212th Street), and along Springbrook Creek in the area of South 196th Street and 84th Avenue South (East Valley Highway). Other concerns focused on the ability of the Upper Mill Creek storage facilities (Lower and Upper Mill Creek Canyon Dams and associated storage reservoirs) to control downstream flooding along Lower Mill Creek; frequent flooding of certain roadway crossings (e.g., Big Soos Creek at Southeast 256th Street and Soosette Creek Tributary at 144th Avenue Southeast); local drainage, erosion, and potential water quality problems in the East and West Hill neighborhoods; and problems associated with no existing public drainage system infrastructure in selected neighborhoods throughout the City.

The Anchor team worked with City staff to assign relative priorities (high, medium, and low) for drainage problems assessment in the DMP analysis. The priorities were assigned based on the following criteria for each priority:

- High priority – Significant, frequent, and longer duration flooding including flooding of structures, risks to public safety, major public roadway transportation and emergency vehicle access impacts, economic impacts to the business community, and major water quality issues; generally associated with receiving water systems and major TSD deficiencies
- Medium priority – Intermediate levels of and less frequent shorter duration flooding; typically more localized but still affecting public collector roadways or neighborhood access; potential water quality impacts; and fish passage or habitat improvement needs; generally associated with lateral drainage systems as components of the trunk drainage system
- Low priority – Typically neighborhood nuisance type flooding problems as a result of no existing public drainage infrastructure or reliance on private drainage systems such as minor ditch and/or driveway culvert deficiencies

5.4 Citizen's Advisory Committee Input to Drainage Problems Documentation and Priorities

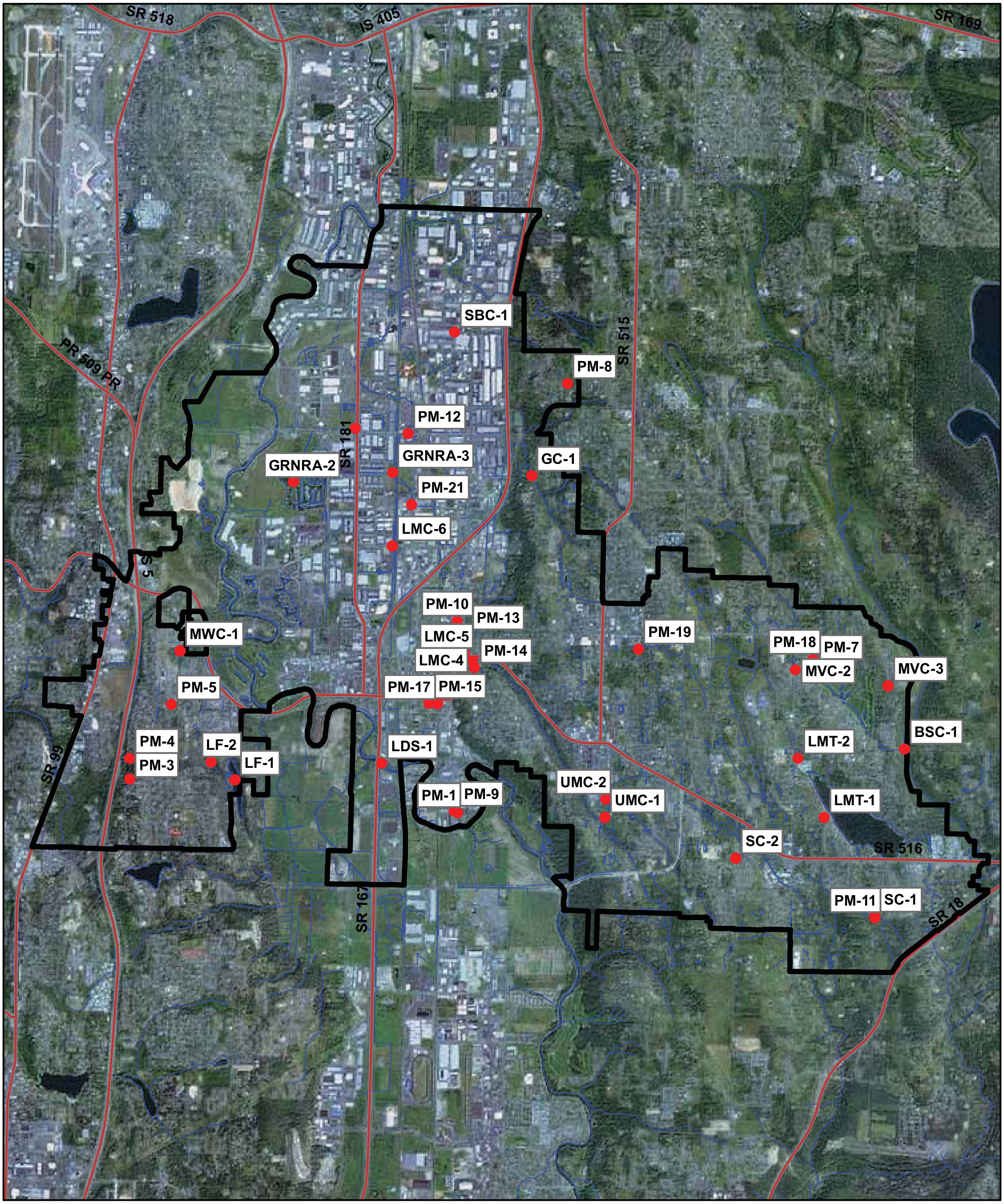
Drainage problems and relative priorities were presented to the CAC at their first meeting on March 11, 2008. The CAC was consulted on their opinion regarding the adequacy of the problems definition after summaries of problem areas and potential causes were presented and reviewed with them. The CAC was also asked to express any concerns with problems as defined, particularly regarding their importance and assigned relative priorities for DMP assessment. Feedback was recorded and is summarized in the meeting notes included in Appendix A for that meeting. The CAC generally wanted to have priorities defined by a more specific set of criteria including the following:

- Priority 1 – Serious demonstrated public safety risk
- Priority 2 – Proven serious economic impact
- Priority 3 – Major repeated traffic interruption
- Priority 4 – Other traffic interruption (water quality and habitat effects)
- Priority 5 – Citizen complaints or other irritating events

At the second and third CAC meetings held on March 25 and April 11, 2008, an additional prioritization of solution concepts to the identified problems was presented to the CAC using those criteria (as adapted for solutions review). Meeting notes summarizing the results of those meeting discussions are also included in Appendix A.

5.5 Summary of Prioritized Drainage Problems

Table 5-1 presents a summary of the drainage problems and their assigned relative priorities as discussed above. Figure 5-1 shows the locations of those problem areas as keyed by the problem identifier shown in the table.



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Miles

● Problem Area

PM-X Problem identified through public meetings

Figure 5-1
Priority Problem Areas Within Drainage Planning Area

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Table 5-1
Identified Drainage Problem Areas and Priorities

Problem No.	Problem ID	Subbasin	Location	Receiving Water	Problem Description	Potential Problem Source	Priority
1	LMC-3	A20W, A15E	James Street and Mill Creek	Lower Mill Creek	Frequent flooding of roadway	High Mill Creek tailwater with downstream channel capacity restriction	High
2	LMT-1	H	Southeast 266th Street near 137th Avenue Southeast	Lake Meridian	Drainage easement need	No drainage system	Low
3	MVC-2	H	132nd Avenue Southeast storm drain between Southeast 240th and Wilson Playfield	Meridian Valley Creek	Roadway flooding	TSD capacity	Medium
4	LMC-4	A22W, A15E, G	Lower Mill Creek at Senior Center	Lower Mill Creek	Creek channel overflow; flooding at/near Senior Center	Creek channel and crossings restrictive capacity	High
5	MWC-1	N	Midway Creek at South 243rd Street	Midway Creek/Green River	Roadway flooding near creek	Green River backwater	Low
6	SC-1	H	Soosette Creek East Tributary at 144th Avenue Southeast	Soosette Creek	Frequent roadway flooding at creek crossing	Culvert capacity limitation	Medium
7	MVC-3	H	Meridian Firs	Big Soos Creek	Public/private drainage system interconnection	Under-sized private system at connection to public system	Low
8	LMC-5	A22W, A15E, G	Lower Mill Creek at Mill Creek Middle School	Lower Mill Creek	Creek channel overflow, flooding at/near school	Creek channel and crossings restrictive capacity	High

Problem No.	Problem ID	Subbasin	Location	Receiving Water	Problem Description	Potential Problem Source	Priority
9	SC-2	H	Television sites on East Hill, 116th to 132nd Avenue Southeast; Southeast 272nd to 282nd Street	Soosette Creek	Localized roadway/site flooding	Stormwater system sizing/condition deficiencies	Medium
10	LMT-2	H	Lake Meridian Estates Park	Lake Meridian	Localized roadway/site flooding	Under-sized and failing stormwater conveyance pipeline	Low
11	BSC-1	H	Southeast 256th bridge at Big Soos Creek crossing near 148th Avenue Northeast	Big Soos Creek	Roadway flooding	Restrictive bridge section	High
12	GC-1	B07W, B07E, I	Garrison Creek upstream of Springbrook Creek (218th Street and Garrison)	Garrison Creek/Springbrook Creek	Roadway flooding	Sediment accumulation at existing bridge, possibly with capacity deficiency	Medium
13	SBC-1	B	Hexcel site; 81st Avenue South south of South 196th Street	Springbrook Creek	Roadway and commercial site localized flooding	Pump station capacity limitation; cast iron flap gate on outfall	High
14	LMC-6	A13W-1, A13W-2	West side of Union Pacific Railroad near South 228th Street	Lower Mill Creek	Frequent flooding of railroad ditch	76th Avenue outfall crossings restriction and sedimentation (interconnected by TSD)	Medium

Problem No.	Problem ID	Subbasin	Location	Receiving Water	Problem Description	Potential Problem Source	Priority
15	GRNRA-1	Q, LMC	Boeing/Pacific Gateway lagoon discharge channel along South 212th Street and West Valley Highway	Lower Mill Creek	Conveyance restrictions along Boeing/Pacific Gateway lagoon discharge channel	Restrictive channel capacity and high invert elevation	High
16	GRNRA-2	Q, LMC	GRNRA lagoon	Lower Mill Creek	Frequent high lagoon levels	Downstream elevated tailwater	High
17	GRNRA-3	Q, LMC	GRNRA diversion channel	Lower Mill Creek	Diversion controls not fully functioning per design	Diversion weir missing weir plate; Lower Mill Creek discharge rating accuracy	High
18	UMC-1	G	Upper Mill Creek detention systems	Upper Mill Creek	Adequacy of storage for Lower Mill Creek flood flow regulation	Insufficient regional storage for larger flood events	High
19	UMC-2	G05E	South 264th culvert east of 104th Avenue Southeast	Upper Mill Creek	Pedestrian access limitations; hydraulic capacity inadequate	Culverts too short for pedestrian access crossing south side of road	High
20	LDS-1	F	Union Pacific pump station southeast of Green River crossing of SR 167, north of South 262nd	Green River	Localized roadway/site flooding	Pump station capacity limitation combined with limitations in operation for Green River discharges	Medium
21	PM-1	C	Green River Estates	Green River	Parking lot floods, no apparent outlet; sink hole	Private system; may discharge to Central Avenue system that is pumped to the Green River	Low
22	PM-2	O	260th and Military Road	Lake Fenwick	Driveway washes out	Roadway drainage released to altered private drainage system	Low

Problem No.	Problem ID	Subbasin	Location	Receiving Water	Problem Description	Potential Problem Source	Priority
23	PM-3	O	26201 Military Road	Lake Fenwick	Run on from culvert	Does not appear to be a ditch on the west side of the road	Medium
24	PM-4	O	South side of 259th Place between Military and I-5	Lake Fenwick	Floods	Additional runoff from development may be the source	Medium
25	PM-5	L	251st Street and 38th Avenue	Lake Fenwick	Floods	No City infrastructure; private system undersized	Low
26	PM-6	C	1510 Maple Lane – Walnut Grove Mobile Park	Green River	Parking lot floods	No City infrastructure	Low
27	PM-7	H	24323 135th Avenue Southeast	Meridian Valley Creek	Floods; bank erosion	Structure in channel; possibly sanitary sewer	Medium
28	PM-8	J	20423 98th Place South	Garrison Creek	Yard and driveway floods	Inadequate private system	Low
29	PM-9	C	Central and South Central Place	Green River	Local flooding	Appears to be the same as PM-1	Low
30	PM-10	A	George Street	Mill Creek	Floods between George and James Street along Mill Creek and west to Central Avenue	Mill Creek	High
31	PM-11	H	Soosette Creek East Tributary at 144th Avenue Southeast	Soosette Creek	Frequent roadway flooding at Creek crossing	Culvert capacity limitation	High
32	PM-12	A	76th Avenue South and South 212 Street	Mill Creek	Mill Creek flooding	Backwater flooding from Mill Creek combined with local site drainage	Medium
33	PM-13	A	606 Kennebeck Avenue North	Mill Creek	Mill Creek floods	Mill Creek	High
34	PM-14	A	East Titus Street	Mill Creek	Water comes down the hill into backyards	Lack of local infrastructure; maybe road side ditch filled on Kensington	Low

Problem No.	Problem ID	Subbasin	Location	Receiving Water	Problem Description	Potential Problem Source	Priority
35	PM-15	C	2nd Avenue South and the area between Willis and Crow Streets	Green River	Local flooding	Appears that road side ditches have been filled	Low
36	PM-17	C	1st Avenue South; 100 to 300 yards south of East Willis Street	Green River	Local flooding along railroad right of way	No outlet to depression; inadequate infiltration rates	Low
37	PM-18	H	Southeast 243rd Place; north of Meridian Valley Country Club	Meridian Valley Creek	Channel bed and bank erosion; manhole in channel same as PM-7	Manhole in channel	Medium
38	PM-19	I	Southeast 244th Street and 108th Avenue Southeast	Garrison Creek	Stormwater pond full	Wet pond	Low
39	PM-21	A	76th Avenue South	Mill Creek	Mill Creek flooding	Inadequate capacity of crossings, extensive sediment accumulation	High
40	LF-1	L	Within Lake Fenwick	Lake Fenwick	Control of Lake Fenwick dissolved oxygen and total phosphorus levels consistent with lake TMDL requirements	Existing hypolimnetic aeration system needs some upgrades to better control total phosphorus levels in the lake consistent with lake TMDL requirements	Medium

41	LF-2	L	Approximately 1,000 feet upstream of Lake Fenwick Inlet	Lake Fenwick	Stormwater treatment wetland – control of total phosphorus levels delivered to Lake Fenwick to assist in meeting lake TMDL requirements	Need for maintenance action to harvest wetland vegetation dieback annually to control total phosphorus releases to Lake Fenwick; look at other potential upstream development area treatment BMPs for total phosphorus control	Medium

Notes:
- BSC = Big Soos Creek
- GC = Garrison Creek
- GRNRA = Green River Natural Resource Area
- LDS = Local Drainage System
- LF = Lake Fenwick
- LMC = Lower Mill Creek
- LMT = Lake Meridian Tributaries
- MVC = Meridian Valley Creek
- MWC = Midway Creek
- PM = Public Meeting
- SBC = Springbrook Creek
- SC = Soosette Creek
- UMC = Upper Mill Creek

6 HYDROLOGIC AND HYDRAULIC ANALYSIS OF DRAINAGE SYSTEMS

This section describes the hydrologic and hydraulic analyses conducted in analyzing the drainage planning area stormwater runoff potential and in evaluating the capacity of the City's existing drainage infrastructure and proposed improvements to deliver runoff to receiving waters. It also describes similar analyses conducted for priority streams (Mill and Springbrook Creeks) to evaluate existing flooding problems and proposed solutions to them. More detailed documentation of this assessment is contained in Appendices D, E, and F.

6.1 Hydrologic Analysis of Trunk Drainage Systems

Hydrologic modeling analysis was used to evaluate stormwater runoff potential and to generate recurrence interval peak discharge estimates within the entire DMP planning area (294 drainage subbasins and associated drainage systems) based on drainage subareas delineation and characterization as presented in Section 4. The highlights of the analysis approach, methods, and assumptions are included below along with a summary of the results of that analysis.

6.1.1 Approach, Methods, and Assumptions

The approach to hydrologic analysis within drainage subbasin areas that are tributary to the City's TSD systems was focused around conducting analysis using a continuous simulation analysis approach consistent with City and Ecology requirements. A secondary goal was to maintain the flexibility to generate selected storm event runoff hydrographs as a hydrologic modeling output for use in steady or unsteady (time variable) hydraulic modeling of drainage systems capacity.

The MGSFlood (MGS 2008) model was selected for use due to its ability to meet those goals, efficiencies in evaluation of system improvement effects and benefits, and its relative simplicity in use. MGSFlood is a continuous rainfall-runoff computer model developed for stormwater facility design in western Washington. The program meets the requirements of the 2005 Ecology SWMMWW (Ecology 2005).

A project-specific version of the model was developed for the City DMP analysis. The program uses the HSPF (EPA 2001) computational algorithms to compute a continuous time series of runoff for multiple basins, computes flood magnitude-frequency statistics, and exports hydrographs that can be subsequently imported into the SWMM EXTRAN program. The program includes the ability to simulate runoff hydrographs from an unlimited number of subbasins and perform routing through stream channels and stormwater ponds. The program contains Extended Precipitation Time Series (Schaefer et al. 2001) developed for stormwater analysis in western Washington. The data have a time step of 15 minutes, are 158 years in length, and represent the rainfall characteristics of the City DMP planning area. The extended precipitation time series allows for accurate calculation of the runoff potential from floods of interest for stormwater management planning. The extended length allows for interpolation to compute 100-year recurrence interval flood flows rather than extrapolation, which is required with the use of shorter precipitation time series.

The MGSFlood model was used to compute runoff hydrographs and peak discharge magnitude frequency statistics for the extensive number of subbasins and smaller subcatchment drainage areas within the drainage planning area. The hydrologic statistics were used as input to hydraulic analysis to evaluate the capacity of the existing conveyance system and along with proposed upgrades to those drainage system segments identified as deficient. The MGSFlood program was ideal for this purpose because it is easy to use, provides accurate results, and allows for quick analysis of stormwater improvement options.

Key assumptions from the hydrologic analysis used to develop planning-level estimates of trunk drainage system recurrence interval flood flows are as follows:

- Existing land cover (impervious area) and pervious area soils conditions (see Section 4) were used; future land use was not evaluated for hydrologic analysis of local drainage systems because new development and redevelopment requires mitigation of peak flow effects through adequately sized detention storage facilities meeting current City standards
- Analyses were performed at a 15-minute simulation time step to allow capture of appropriate peak flows considering the relatively small drainage subbasin and subcatchment areas being analyzed
- Analyses included large regional detention storage systems for flow routing effects, but smaller on-site detention storage systems were not directly considered and those effects were not modeled; many of these systems were built

to lower design standards, and their performance and net effect is diminished for larger events where overflows may occur (also, many of these on-site detention systems are private with maintenance not directly provided under the City's O&M program)

- All impervious areas are assumed fully effective in generating stormwater runoff tributary to trunk drainage systems; losses to runoff in pervious areas are based on use of regional parameters included within the MGSFlood model considering the hydrologic soils characteristics of those pervious areas
- Peak flows for combined subcatchment flows at points of analysis within local drainage systems are additive without need for hydrologic routing analysis within those drainage systems (beyond regional detention systems, which are included).

6.1.2 Results

The results of the MGSFlood hydrologic analysis conducted for the trunk drainage systems to generate peak flood flow estimates are reported in Table 6-1. This analysis was conducted at the subcatchment level of drainage area definition (see Appendix D for more detailed analysis information) and was rolled up to the subbasin level for results presented in Table 6-1. Peak recurrence interval flood flow estimates reported here represent the predicted flood flows at TSD outfalls to their respective receiving waters as noted in the basin designations. Corresponding subbasin tributary areas and existing impervious land cover percentages are also reported (as referenced from Section 4).

Table 6-1
Subbasin Area Hydrologic Analysis Results for Trunk Drainage Systems – Existing Land Cover Conditions

Subbasin Identifier	Subbasin Area at Outfall (acres)	Subbasin Impervious Area Cover (percent)	Simulated Runoff Peak Flow Estimate at Outfall (cfs)					
			Q2E	Q5E	Q10E	Q25E	Q50E	Q100E
Basin A – Lower Mill Creek								
A01E	119	60	26	34	41	54	60	80
A01W	4.8	45	0.8	1.1	1.2	1.6	1.8	2.3
A02E	104	36	14	20	24	33	36	45
A02W	46	56	9.2	12	14	19	21	27
A03E	36	11	2.2	3.8	5.3	7.6	8.2	9.6
A03W	61	65	14	19	21	28	31	42
A04E	19	84	5.6	7.3	8.5	11	12	17
A04W	338	67	79	104	121	159	177	238
A05E	46	81	13	17	19	25	28	38
A05W	29	56	5.7	7.7	9.1	12	14	18
A06E	16	59	3.4	4.6	5.4	7.2	7.9	11
A06W	21	56	4.1	5.5	6.5	8.5	9.5	13
A07E	404	69	92	121	141	185	207	276
A07W	312	41	47	66	79	107	117	150
A08E	39	73	9.9	13	15	20	22	30
A08W	135	64	30	40	47	62	69	92
A09E	50	44	8.1	11	14	19	21	27
A09W	23	82	6.6	8.6	10	13	15	20
A10E	19	80	5.1	6.7	7.8	10	11	16
A10W	48	70	12	16	18	24	27	36
A11E	45	70	11	15	17	22	25	33
A11W	27	69	6.6	8.7	10	13	14	20
A12E	7.7	72	1.9	2.5	2.9	3.9	4.2	5.7
A12W	101	69	22	32	37	48	54	72
A13E	9.3	58	2.0	2.5	2.9	3.9	4.2	5.7
A13W	731	60	155	206	241	316	352	467
A14E	76	23	8.6	13	18	25	31	39
A14W	9.7	66	2.3	3.0	3.4	4.6	4.9	6.7
A15E	36	32	4.6	6.6	8.1	11	13	16
A15W	8.4	38	1.2	1.6	1.8	2.4	2.9	3.3
A16W	29	36	4.0	5.5	6.4	9.0	9.7	12
A17W	76	73	19	25	30	39	43	58
A18W	11	35	1.4	1.9	2.2	2.8	3.5	3.9

Subbasin Identifier	Subbasin Area at Outfall (acres)	Subbasin Impervious Area Cover (percent)	Simulated Runoff Peak Flow Estimate at Outfall (cfs)					
			Q2E	Q5E	Q10E	Q25E	Q50E	Q100E
A19W	4.9	47	0.8	1.1	1.2	1.7	1.9	2.4
A20W	21	63	4.6	6.1	7.0	9.2	10	14
A21W	54	39	8.6	12	16	22	26	33
A22W	12	45	2.1	2.8	3.2	4.4	4.9	6.6
Basin B – Springbrook Creek								
B01E	29	57	5.9	7.9	9.0	12	13	17
B01W	73	64	17	22	25	33	37	49
B02E	14	26	1.3	2.0	2.4	3.1	3.7	3.9
B02W	70	79	19	25	30	38	43	58
B03E	189	70	46	61	71	93	104	140
B03W	23	74	5.8	7.6	8.9	12	13	18
B04E	81	59	17	22	26	34	39	51
B04W	306	82	87	113	133	171	192	262
B05E	24	11	1.4	2.5	3.4	5.0	5.4	6.0
B05W	40	78	11	14	16	21	24	32
B06E	15	55	3.1	4.0	4.5	6.1	6.6	8.8
B06W	44	81	12	16	19	24	27	37
B07E	27	31	3.6	5.4	6.6	9.3	11	13
B07W	44	61	9.5	12	14	19	21	28
B08E	69	21	7.6	12	15	23	27	33
B08W	23	80	6.2	8.1	9.4	12	14	19
B09E	75	32	10	15	19	27	31	39
B09W	27	43	4.3	5.9	7.3	9.5	11	14
B10E	65	23	7.1	11	14	21	24	30
B10W	21	42	3.1	4.3	5.1	7.0	7.5	9.7
B11E	86	25	7.4	13	18	27	34	40
Basin C – Horseshoe Acres/Green River								
C01	47	69	11	15	17	23	25	34
C02	112	36	15	21	25	33	37	46
C03	53	62	12	15	18	23	26	34
C04	2.7	9.0	0.1	0.2	0.3	0.5	0.6	0.6
C05	89	43	14	19	22	30	33	42
C06	18	19	1.4	2.1	2.7	3.8	4.0	4.4
C07	61	43	9.7	13	16	21	23	30
C08	233	54	46	62	73	97	111	146
C09	23	47	3.9	5.3	6.2	8.4	9.1	12
C10	97	23	9.6	14	18	26	34	40

Subbasin Identifier	Subbasin Area at Outfall (acres)	Subbasin Impervious Area Cover (percent)	Simulated Runoff Peak Flow Estimate at Outfall (cfs)					
			Q2E	Q5E	Q10E	Q25E	Q50E	Q100E
C11	1.6	0.0	0.1	0.2	0.3	0.4	0.6	0.6
C12	42	4.8	3.1	6.1	8.4	13	16	19
C13	65	15	6.5	11	15	22	26	31
C14	69	4.3	4.8	9.4	13	20	25	29
C15	49	25	6.3	9.8	13	18	21	26
C16	85	4.0	5.0	10	14	21	26	29
Basin D – Mill Creek/Auburn								
D01	33	10	1.7	3.0	4.3	6.1	6.8	7.0
D02	22	20	1.9	2.9	3.7	4.8	5.7	6.3
Basin E – Mill Creek/Auburn								
E01	12	7.6	0.5	1.0	1.5	2.2	2.4	2.5
E02	27	6.3	1.1	2.2	3.3	4.7	5.2	5.4
E03	87	4.1	3.3	6.8	10	15	17	17
E04	22	16	1.6	2.6	3.4	4.8	5.3	6.0
Basin F – Green River								
F01	200	57	41	54	63	83	92	121
Basin G – Upper Mill Creek								
G01E	139	22	17	27	36	51	61	77
G01W	45	12	4.1	6.9	9.5	14	18	22
G02E	109	28	15	23	29	42	49	63
G02W	82	9.4	4.1	7.2	10	15	21	25
G03E	145	20	17	27	36	51	62	77
G03W	48	10	3.8	6.5	9.0	13	18	20
G04E	63	47	12	17	21	29	32	43
G04W	71	11	6.5	12	16	23	29	36
G05E	612	40	115	167	207	284	322	426
G05W	39	4.6	2.8	5.4	7.5	12	15	17
G06E	28	3.1	1.8	3.5	5.0	7.6	9.4	11
G06W	45	1.8	2.8	6.0	8.3	13	16	19
G07E	19	13	1.8	3.0	4.2	6.0	7.4	9.0
G07W	10	8.1	0.8	1.4	2.0	3.1	3.8	4.4
G08E	22	4.4	1.4	2.8	3.8	5.9	7.4	8.3
G08W	17	8.1	1.2	2.2	2.9	4.3	5.4	6.3
G09E	6.2	6.1	0.4	0.7	1.0	1.4	1.8	1.9
Basin H – Soos Creek/Meridian Valley								
H01	164	25	22	34	44	60	73	88
H02	31	17	3.6	5.9	7.9	11	14	17

Subbasin Identifier	Subbasin Area at Outfall (acres)	Subbasin Impervious Area Cover (percent)	Simulated Runoff Peak Flow Estimate at Outfall (cfs)					
			Q2E	Q5E	Q10E	Q25E	Q50E	Q100E
H03	6.0	21	0.8	1.2	1.6	2.2	2.7	3.2
H04	4.4	32	0.7	1.0	1.3	1.8	2.1	2.6
H05	7.7	21	0.9	1.4	1.8	2.5	3.3	3.6
H06	8.2	31	1.2	1.8	2.4	3.2	3.9	4.8
H07	100	29	14	21	28	38	46	56
H08	8.5	28	1.1	1.5	1.9	2.6	3.5	3.7
H09	50	40	8.8	12	16	21	25	31
H10	9.5	16	1.0	1.7	2.2	3.2	4.1	4.6
H11	101	27	14	21	28	38	47	58
H12	29	23	3.7	5.6	7.4	10	13	15
H13	3.3	39	0.5	0.7	0.8	1.1	1.4	1.5
H14	2.7	26	0.3	0.4	0.4	0.6	0.8	0.9
H15	38	17	3.6	5.7	7.6	11	14	16
H16	51	21	5.5	8.4	11	15	19	25
H17	37	19	3.2	4.8	6.2	8.7	12	14
H18	97	15	6.2	9.4	12	17	24	31
H19	93	26	11	17	22	29	37	44
H20	12	15	1.0	1.6	1.9	2.9	3.9	4.4
H21	53	30	7.7	11	15	20	24	30
H30	176	24	24	37	49	68	83	102
H31	7.7	24	1.0	1.6	2.1	3.0	3.6	4.5
H32	20	20	2.5	4.0	5.4	7.6	9.4	11
H33	28	21	3.6	5.5	7.5	10	13	16
H34	34	27	4.8	7.3	9.8	13	16	20
H35	76	25	11	16	22	30	36	44
H36	44	31	6.6	9.7	13	17	21	26
H37	32	25	4.4	6.6	9.0	12	15	18
H38	8.3	20	1.0	1.6	2.1	3.0	3.7	4.4
H39	13	23	1.7	2.6	3.4	4.8	5.9	7.0
H40	40	30	5.8	8.5	11	15	18	21
H41	116	39	19	26	33	44	53	64
H42	41	33	6.2	8.9	12	15	19	23
H43	41	19	4.1	6.1	8.1	12	16	17
H44	9.2	17	0.6	0.9	1.0	1.4	1.9	2.7
H50	67	31	10	15	20	28	33	42
H51	154	33	25	36	47	64	75	95
H52	36	9.0	3.2	5.9	7.8	12	15	17

Subbasin Identifier	Subbasin Area at Outfall (acres)	Subbasin Impervious Area Cover (percent)	Simulated Runoff Peak Flow Estimate at Outfall (cfs)					
			Q2E	Q5E	Q10E	Q25E	Q50E	Q100E
H53	10	27	1.4	2.2	2.8	3.8	4.6	5.7
H54	28	34	4.5	6.6	8.8	12	14	18
H55	35	31	5.2	7.7	10	14	16	21
H56	52	36	8.5	12	16	21	25	31
H57	7.0	20	0.9	1.3	1.8	2.5	3.1	3.7
H58	12	21	1.6	2.4	3.3	4.6	5.7	6.9
H59	8.7	14	0.9	1.6	2.1	3.1	3.8	4.4
H60	10	20	1.2	1.9	2.5	3.4	3.9	4.9
H61	11	17	1.3	2.0	2.7	3.8	4.8	5.5
H62	7.8	14	0.8	1.4	1.9	2.7	3.4	4.0
H63	2.0	51	0.4	0.6	0.8	1.0	1.1	1.5
H64	9.5	18	1.1	1.8	2.4	3.5	4.3	5.2
H65	4.6	26	0.6	1.0	1.3	1.8	2.2	2.7
H66	6.2	23	0.8	1.2	1.7	2.3	2.9	3.5
H67	16	25	2.1	3.2	4.3	5.9	7.1	8.8
H68	8.5	25	1.1	1.7	2.2	3.1	3.8	4.4
H69	5.1	33	0.8	1.1	1.4	1.9	2.3	2.7
H70	10	34	1.6	2.4	3.2	4.1	4.8	6.2
H71	17	31	2.4	3.5	4.7	6.2	7.3	9.1
H72	13	25	1.7	2.6	3.2	4.5	5.5	6.4
H73	27	28	4.0	6.0	7.9	11	13	16
H74	28	16	2.9	4.7	6.4	8.5	10	12
H75	49	41	8.9	13	16	22	25	32
H76	8.6	53	1.9	2.6	3.2	4.3	4.7	6.4
H77	7.9	19	1.0	1.5	2.0	2.9	3.6	4.3
H78	5.2	34	0.9	1.2	1.6	2.2	2.6	3.3
H79	15	35	2.5	3.6	4.7	6.3	7.5	9.5
H80	10	33	1.6	2.4	3.2	4.2	5.0	6.4
H81	21	9.5	1.9	3.3	4.5	6.4	8.0	9.3
H82	6.3	21	0.8	1.2	1.6	2.1	2.5	3.2
H83	29	20	3.4	5.4	7.2	9.9	12	15
H84	23	15	2.3	3.9	5.1	7.3	9.3	11
H85	26	9.8	2.1	3.5	5.1	6.3	7.2	8.6
H86	7.9	24	1.0	1.5	1.9	2.6	3.3	3.5
H87	74	16	8.1	13	18	25	30	37
H88	36	65	8.7	12	14	18	21	27
H89	20	26	2.7	4.1	5.5	7.5	9.3	11

Subbasin Identifier	Subbasin Area at Outfall (acres)	Subbasin Impervious Area Cover (percent)	Simulated Runoff Peak Flow Estimate at Outfall (cfs)					
			Q2E	Q5E	Q10E	Q25E	Q50E	Q100E
H90	18	51	3.8	5.3	6.5	8.9	9.8	13
H91	66	20	8.1	13	17	24	29	35
H92	8.5	24	1.1	1.7	2.3	3.1	3.8	4.6
H93	5.5	21	0.7	1.1	1.4	2.0	2.4	2.8
H94	4.0	18	0.5	0.7	1.0	1.4	1.8	2.1
H95	57	36	9.6	14	18	25	28	36
H96	32	61	7.5	9.9	12	16	18	23
H97	129	20	15	24	32	43	52	63
H98	11	52	2.5	3.4	4.2	5.8	6.3	8.5
H99	34	7.0	2.7	4.9	6.9	9.4	12	14
H100	83	28	12	18	23	31	37	46
H101	47	33	7.6	11	15	19	23	29
H102	18	11	1.7	3.0	4.0	6.0	7.6	8.7
H103	33	17	3.8	6.2	8.3	12	15	18
H104	44	24	5.6	8.6	11	16	19	23
H105	10	19	1.2	2.0	2.6	3.7	4.6	5.5
H106	26	17	2.8	4.5	6.2	8.4	10	13
H107	51	13	5.1	8.9	12	17	22	26
H108	25	8.2	2.0	3.7	5.0	7.4	9.5	10
H109	3.2	25	0.4	0.6	0.7	1.0	1.3	1.3
H110	49	28	6.9	11	14	19	21	27
H111	29	7.1	2.3	4.3	5.7	8.6	11	12
H112	56	11	5.3	9.3	12	18	23	27
H113	14	0.9	0.9	1.8	2.4	3.5	4.3	4.6
H114	61	24	7.8	12	16	22	27	32
H115	53	21	6.7	10	14	19	24	29
H116	56	7.9	4.7	8.6	12	17	22	23
H117	1.0	49	0.2	0.2	0.3	0.4	0.4	0.5
H130	20	13	1.9	3.3	4.4	6.5	8.3	9.3
H131	90	19	8.5	13	16	24	32	36
H132	36	22	3.3	4.8	5.9	7.6	9.4	11
H133	108	8.1	6.3	11	16	22	28	34
H134	155	19	12	16	20	27	35	47
H-LM	153	0.0	7.7	15	24	29	33	37
Basin I – Garrison Creek								
I01	344	17	36	60	79	114	138	168
I02	9.5	22	1.2	1.8	2.5	3.5	4.2	5.3

Subbasin Identifier	Subbasin Area at Outfall (acres)	Subbasin Impervious Area Cover (percent)	Simulated Runoff Peak Flow Estimate at Outfall (cfs)					
			Q2E	Q5E	Q10E	Q25E	Q50E	Q100E
I03	0.4	75	0.1	0.1	0.2	0.2	0.2	0.3
I04	4.6	8.1	0.4	0.7	1.0	1.5	1.9	2.3
I05	2.1	1.5	0.1	0.2	0.2	0.3	0.4	0.4
I06	28	15	2.6	4.3	5.8	8.5	11	13
I07	11	0.6	0.6	1.4	1.9	3.0	3.8	4.3
I08	5.0	59	1.1	1.4	1.6	2.2	2.4	3.2
I09	15	31	2.3	3.3	4.5	6.0	7.2	9.2
I10	2.2	19	0.3	0.4	0.5	0.8	1.0	1.2
I11	1.8	32	0.3	0.4	0.5	0.7	0.9	1.1
I12	25	24	2.5	3.7	4.7	6.4	8.2	10
I13	22	23	2.7	4.2	5.8	8.0	9.8	12
I14	23	10	1.8	3.2	4.3	6.5	8.4	9.6
I15	3.7	18	0.4	0.6	0.8	1.1	1.4	1.7
I16	12	43	2.1	2.9	3.7	5.0	5.6	7.4
I17	8.8	16	0.9	1.4	1.9	2.9	3.5	4.2
I18	33	22	4.1	6.2	8.6	12	15	18
I19	15	31	2.2	3.2	4.4	5.8	7.0	9.0
I20	8.7	18	1.0	1.5	2.1	3.0	3.7	4.7
I21	13	24	1.7	2.5	3.5	4.8	5.9	7.4
I22	4.6	27	0.6	0.9	1.2	1.7	2.0	2.5
I23	58	28	8.2	12	16	23	27	35
I24	4.2	23	0.5	0.8	1.1	1.5	1.9	2.4
I25	3.7	41	0.7	0.9	1.2	1.6	1.9	2.5
I26	118	48	23	33	41	56	63	85
I27	182	54	39	55	67	90	101	137
I28	33	24	4.1	6.3	8.5	12	15	18
I29	8.5	25	1.1	1.6	2.2	3.0	3.7	4.5
I30	17	25	2.0	3.1	4.1	5.8	7.0	8.6
I31	13	15	1.3	2.1	2.9	4.3	5.3	6.4
I32	28	23	3.3	5.1	6.8	9.4	12	14
I33	13	35	2.0	2.8	3.7	4.9	5.8	7.5
I35	2.5	40	0.4	0.6	0.8	1.1	1.3	1.7
I36	56	21	6.8	11	14	20	24	29
I37	102	27	14	21	28	38	46	59
I38	3.2	32	0.5	0.7	0.9	1.2	1.5	1.9
I39	19	30	2.8	4.2	5.6	7.5	9.1	11
I40	78	27	11	17	22	30	36	44

Subbasin Identifier	Subbasin Area at Outfall (acres)	Subbasin Impervious Area Cover (percent)	Simulated Runoff Peak Flow Estimate at Outfall (cfs)					
			Q2E	Q5E	Q10E	Q25E	Q50E	Q100E
I41	2.2	78	0.6	0.9	1.0	1.3	1.5	2.0
I42	49	11	4.3	7.4	10	14	16	20
I43	7.6	35	1.3	1.8	2.5	3.2	3.8	4.9
I44	11	0.1	0.7	1.4	1.9	3.0	3.7	4.0
I45	51	8.0	4.5	8.2	11	17	21	23
I46	26	1.6	1.9	3.8	5.1	8.0	10	11
I47	18	0.0	0.9	1.9	2.9	3.4	3.9	4.3
I49	72	30	11	16	21	29	34	43
Basin J – Garrison Creek								
J01	5.6	4.8	0.4	0.8	1.1	1.7	2.1	2.5
J02	24	12	2.0	3.6	4.6	6.9	8.6	9.4
J03	10	6.9	0.7	1.4	1.8	2.9	3.6	3.9
J04	46	12	4.1	6.9	9.3	14	17	20
J05	88	26	12	18	24	33	40	51
Basin K – Bingamon Creek								
K01	33	30	4.7	6.9	9.4	13	15	20
K02	54	37	8.8	13	17	23	26	35
K03	8.3	41	1.5	2.1	2.7	3.7	4.2	5.6
K04	18	24	2.3	3.6	4.9	6.8	8.3	11
K05	39	41	7.0	10	13	17	20	27
Basin L – Lake Fenwick								
L01	493	25	60	89	124	171	210	270
L02	95	8.1	4.7	10	15	23	28	31
Basin M – Green River								
M01	47	11	3.0	4.9	6.9	10	12	14
M02	32	7.5	1.8	3.3	4.9	6.2	6.8	7.3
M03	19	8.0	0.9	1.7	2.3	3.5	3.8	4.0
M04	176	34	25	36	46	63	75	97
M05	90	6.3	3.7	7.4	11	16	18	18
M06	28	21	2.4	3.6	4.6	6.1	7.1	7.6
Basin N – Midway Creek								
N01	35	21	3.5	5.3	7.5	10	12	15
N02	54	10	3.4	5.7	7.9	12	14	17
N03	151	6.3	6.7	12	18	27	34	41
N04	11	14	0.7	1.1	1.5	2.2	2.4	2.5
N05	199	43	31	42	49	65	73	91
N06	1.9	23	0.2	0.2	0.3	0.4	0.5	0.5

Subbasin Identifier	Subbasin Area at Outfall (acres)	Subbasin Impervious Area Cover (percent)	Simulated Runoff Peak Flow Estimate at Outfall (cfs)					
			Q2E	Q5E	Q10E	Q25E	Q50E	Q100E
N07	104	9.2	5.9	10	15	22	25	28
N08	80	40	13	19	24	33	39	51
N09	84	39	14	19	26	35	41	55
N10	91	27	12	17	24	33	41	53
Basin O – McSorley Creek								
O01	27	63	6.2	8.4	10	13	15	21
O02	348	36	53	77	101	139	165	218
O03	332	38	51	72	92	125	144	190
O04	226	24	26	40	53	73	87	108
Basin P – Johnson Creek								
P01	316	5.7	13	27	39	57	63	67
P02	206	28	25	37	49	68	80	102
Basin Q – GRNRA								
Q01	112	13	6.8	12	16	22	25	27
Q02	86	68	20	27	32	41	47	62
Q03	126	54	24	33	40	53	59	78
Q04	690	52	120	162	186	250	275	361
Q05	357	38	51	72	88	118	131	166

Notes:
QnE = subbasin peak flow rate of the n-year storm event, existing land use/cover
Results are based on use of the MGSFlood continuous simulation model with 15-minute time steps.

6.2 Hydrologic Analysis of Receiving Waters

Hydrologic modeling was also conducted at a watershed scale for Upper and Lower Mill Creek, and for Springbrook Creek and its Garrison Creek tributaries to predict flood flows throughout those systems and to allow hydrologic assessment of proposed solutions to correct creek system flooding problems. The highlights of the analysis approach, methods, and assumptions are included below along with a summary of results of that analysis.

6.2.1 Approach, Methods, and Assumptions

The analysis approach for this watershed-scale level of runoff analysis considered the needs to provide continuous simulation hydrologic response modeling while taking into account the water balance effects that occur within natural drainage systems (e.g., losses due to evapotranspiration, stream interflow effects, losses to shallow and deep groundwater, etc.). Prior hydrologic analysis had been conducted for the Mill Creek and Springbrook/Garrison Creek watersheds (NHC 1996) using the HSPF model, and recent analysis using that same tool was conducted for the Earthworks Park Dam (Lower Mill Creek Canyon Dam) safety improvements design (R.W. Beck 2006 and 2008). Because the HSPF model has all the capabilities to provide the required analysis, was previously developed for this watershed area, and is the regionally accepted model by Ecology for stream system analysis, it was selected for the DMP stream system hydrologic analysis.

The prior HSPF model of the watershed was initially reviewed for its structure, level of detail in watershed definition and associated analysis points, stream system and storage routing reaches, regional runoff and loss parameters, and other items pertinent to the DMP watershed analysis needs. The update needs for the HSPF model were then defined, and the resulting database was generated at the scale desired for the DMP planning effort, which is more detailed than the prior modeling assessment. This process required the development of a modeling schematic to show the hydrologic connectivity of the tributary subbasin areas along with the routing reaches considered for the updated, more detailed analysis. Figure 6-1 shows the resulting HSPF model subbasin area connectivity along with the stream system routing reaches (RCHRES). Various points of diversion, regional storage, and/or return flows (e.g., diversion to/from GRNRA, overflow to Springbrook Creek, etc.) were identified within the stream system, and the RCHRES routing reaches and storage and discharge ratings (FTABLES) were adjusted to reflect those conditions.

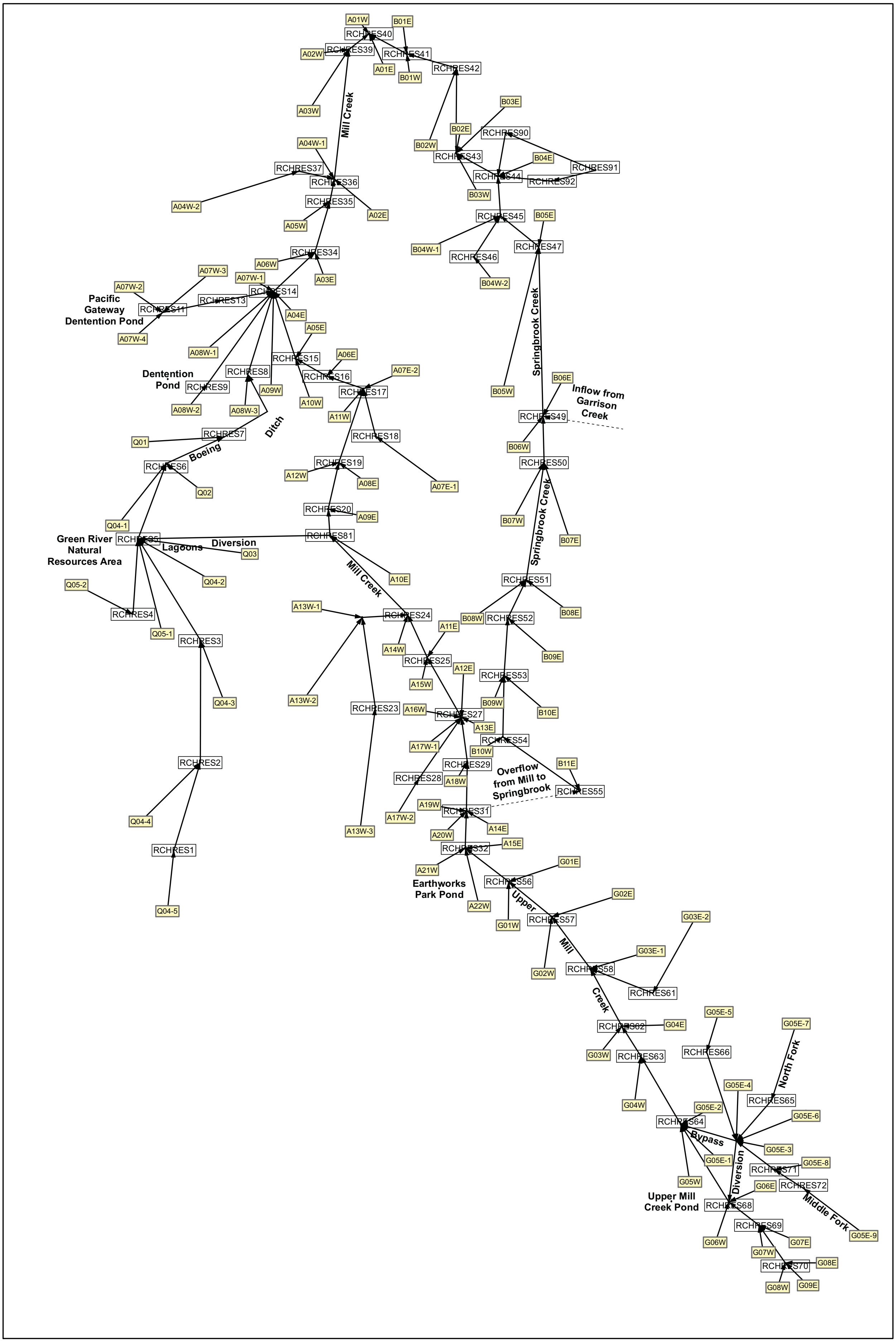


Figure 6-1
Receiving Water Hydrologic Model Schematic
HSPF Continuous Simulation Model

The HSPF model was then updated with current watershed characteristics and runoff parameters. The model was calibrated by comparing simulated and recorded streamflow at the Mill Creek Canyon detention facility for the period of January 1994 through September 2005. The gage is operated by the U.S. Geological Survey (Gage 12113347) in cooperation with the City. Local precipitation data supplemented with data from the SeaTac gage were used as input to the model for calibration purposes. More detailed discussion of the HSPF Mill/Springbrook Creek model calibration is included in Appendix E.

After satisfactory model calibration was achieved, the model was then used to simulate continuous runoff response to the Extended Time Series precipitation database (158-year record), with statistical analysis of the resulting runoff annual maxima for flood flow frequency and storage area stage-frequency analysis. The analysis considers the performance of four medium to large existing regional detention facilities: the Upper Mill Creek Detention Dam, the Lower Mill Creek Canyon Dam, the GRNRA lagoon, and the Pacific Gateway Park pond. Other smaller instream floodplain storage-routing effects were also included through evaluation of floodplain storage potential using results of existing hydraulic (HEC-RAS) models for the stream system or storage and discharge estimates derived from topographic sources and other simplified hydraulic calculations respectively. The model was also used to test the hydrologic effects and benefits of the various proposed stream and storage system improvement projects.

Key HSPF modeling considerations and assumptions for this analysis include:

- The HSPF model was configured using runoff parameters developed by the U.S. Geological Survey for the Puget Sound Lowlands
- The HSPF model was split into four parts to expedite its simulation time
- The Garrison Creek component to the HSPF model remains unchanged from the prior HSPF model
- Adjustments in the model contributing areas and routing reaches were made to reflect the effects of proposed improvements (Projects A-1, A-2, A-3, A-4, A-5, and A-7)

6.2.2 Results

The results of the HSPF hydrologic analysis conducted at the watershed scale for the Mill and Springbrook Creek stream systems to generate storm event peak flow estimates are reported in Tables 6-2 and 6-3. This analysis was conducted at the subbasin level of drainage area definition and was then rolled up to the selected points of modeling analysis. Stream diversions and their predicted peak flows contributions to or from the creek systems are also shown. Corresponding collective tributary drainage areas at the points of analysis are also reported.

The proposed projects described in Section 7 affect the improved condition analysis results presented for Mill Creek in Table 6-2. They would achieve reductions in peak flows along Lower Mill Creek for the assumed conditions. The peak flows along Springbrook Creek would not change for the improved analysis condition assuming that the Mill Creek larger event overflows to Springbrook Creek are maintained consistent with existing conditions. Therefore, only the existing condition peak flood flows are reported for Springbrook Creek in Table 6-3.

Table 6-2
Mill Creek Receiving Water Hydrologic Analysis Results – Existing and Improved Conditions

HSPF RCHRES	Description of Location	Drainage Area (acres)	Existing Conditions Computed Peak Flow Estimate (cfs)						Improved Conditions Computed Peak Flow Estimate (cfs)					
			Q2E	Q5E	Q10E	Q25E	Q50E	Q100E	Q2E	Q5E	Q10E	Q25E	Q50E	Q100E
32	Downstream of Earthworks Park	1,610	58	73	91	96	108	122	58	73	91	96	108	122
31	Downstream of overflow to Springbrook Creek	1,712	54	74	84	88	94	101	54	74	84	88	94	101
29	At Central Avenue	1,723	60	77	90	93	99	107	60	77	90	93	99	107
27	At SR 167	1,845	68	86	100	106	110	114	68	86	100	106	110	114
25	At BNRR crossing	1,898	75	93	110	120	122	135	75	93	110	120	122	135
24	At 76th Avenue South crossing	2,639	192	238	296	320	344	365	135	168	213	231	253	260
22	Storm drain inflow at 76th Avenue South	731	141	183	234	279	315	370	65	86	110	133	150	180
24	Before GRNRA diversion	2,639	192	238	296	320	344	370	135	168	213	231	253	270
81	Diversion to GRNRA	2,658	97	122	151	168	175	175	63	96	137	150	175	175
81	Bypass downstream of diversion to GRNRA		89	105	117	123	137	140	70	70	70	70	71	72
15	Upstream of confluence with Boeing Creek	3,389	154	186	222	230	254	274	141	168	196	208	232	241
5	Outflow from GRNRA	1,173	23	35	45	47	48	49	34	42	58	67	72	80
14	Downstream of confluence with Boeing Creek	5,249	192	236	284	298	328	361	187	231	273	284	314	337
36	At 192nd Street	5,777	242	305	373	388	435	478	232	300	358	373	427	455
39	Upstream of confluence with Springbrook Creek	5,884	252	319	392	411	461	503	242	319	378	393	450	479

Notes:

QnE = peak flow rate of the n-year storm event, existing land use/cover

RCHRES = reach or reservoir identification in HSPF hydrologic model

Results are based on use of the HSPF hydrologic model simulation using Extended Precipitation Time Series Input.

Drainage areas shown are for existing conditions.

Improved conditions include recommended improvements affecting Lower Mill Creek flows (Projects A-1, A-2, A-3, A-4, A-5, and A-7).

Table 6-3
Springbrook Creek Receiving Water Hydrologic Analysis Results – Existing Conditions

HSPF RCHRES	Description of Location	Drainage Area (acres)	Computed Peak Flow Estimate (cfs)					
			Q2E	Q5E	Q10E	Q25E	Q50E	Q100E
55	Upstream of Chandler Bay	86	18	21	26	27	29	30
54	At 88th Avenue South	107	19	24	29	31	33	35
53	At South 228th Street	199	25	34	42	45	53	55
51	At SR 167	366	36	50	62	69	80	88
49	At Garrison Creek	3,162	142	203	267	283	325	370
45	Upstream of Upper Springbrook Creek	3,808	205	278	343	366	405	450
44	Downstream of Upper Springbrook Creek	4,544	251	335	415	432	476	540
42	At 80th Avenue South	4,840	231	312	414	433	461	540
40	Downstream of Mill Creek (assuming existing Mill Creek conditions)	10,950	399	529	697	732	812	920
40	Downstream of Mill Creek (assuming improved Mill Creek conditions)		389	518	682	715	792	900

Notes:
QnE = peak flow rate of the n-year storm event, existing land use/cover
RCHRES = reach or reservoir identification in HSPF hydrologic model
Results are based on use of the HSPF hydrologic model simulation using Extended Precipitation Time Series Input.

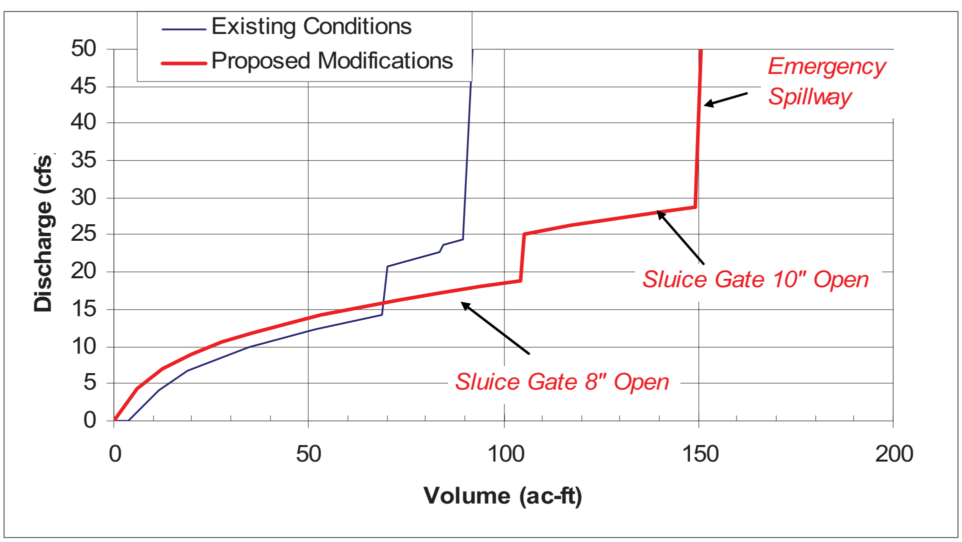
6.3 Upper Mill Creek Basin Hydrologic Analysis of Detention Storage Facilities

This subsection documents the key findings of the Upper Mill Creek hydrologic analysis of detention storage facilities as conducted by MGS in coordination with Anchor as part of the DMP update. Anchor staff provided selected input parameters for the hydrologic analysis and coordinated the approach and analysis goals with City staff. MGS defined the detailed analytical approach, developed the hydrologic model, validated its expected accuracy through calibration, and ran model simulations to evaluate existing conditions, proposed improvements, and expected benefits. Appendix E provides a memorandum developed by MGS to fully document the analysis approach, methods, assumptions, results, and recommendations.

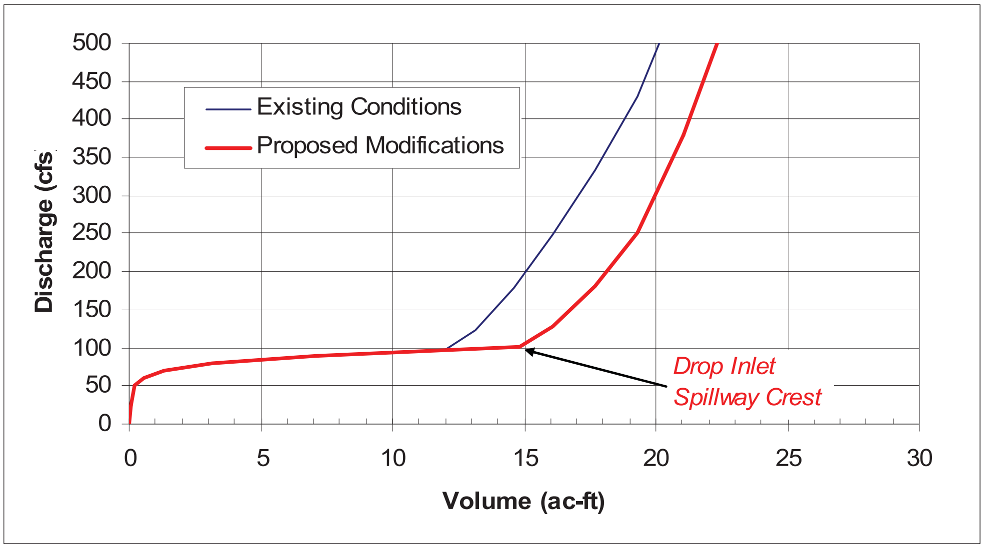
6.3.1 Approach, Methods, and Assumptions

The HSPF model was used to conduct hydrologic analysis of the Upper Mill Creek basin considering existing and future build-out land use and downstream flooding risk. This analysis included a functional assessment of flooding event level-of-protection achieved by two existing regional detention storage facilities: the Upper Mill Creek Detention Dam and the Lower Mill Creek Canyon Dam (at Earthworks Park). In addition, this analysis evaluated the effectiveness of a proposal to increase the flood storage at the Upper Mill Creek Pond through improvements to its upstream diversion structure and the upper detention pond dam. It also considers the benefits of improvements the City has currently designed for the Lower Mill Creek Canyon Dam (planned for construction in 2008).

Evaluation of the effectiveness of the dams' detention storage requires consideration of how the flow controls at the outlet works are operated. Graphs 6-1 and 6-2 document the current outlet works operations based on the City's documented operating procedures and also show the proposed operations with improvements targeted for both dams. The Upper Mill Creek detention dam and outlet works improvements are part of Project G-4, while the Lower Mill Creek Canyon detention dam and outlet works improvements are as currently designed and under bid advertisement for construction.



Graph 6-1
Upper Mill Creek Dam Outlet Works – Existing and Proposed Operations



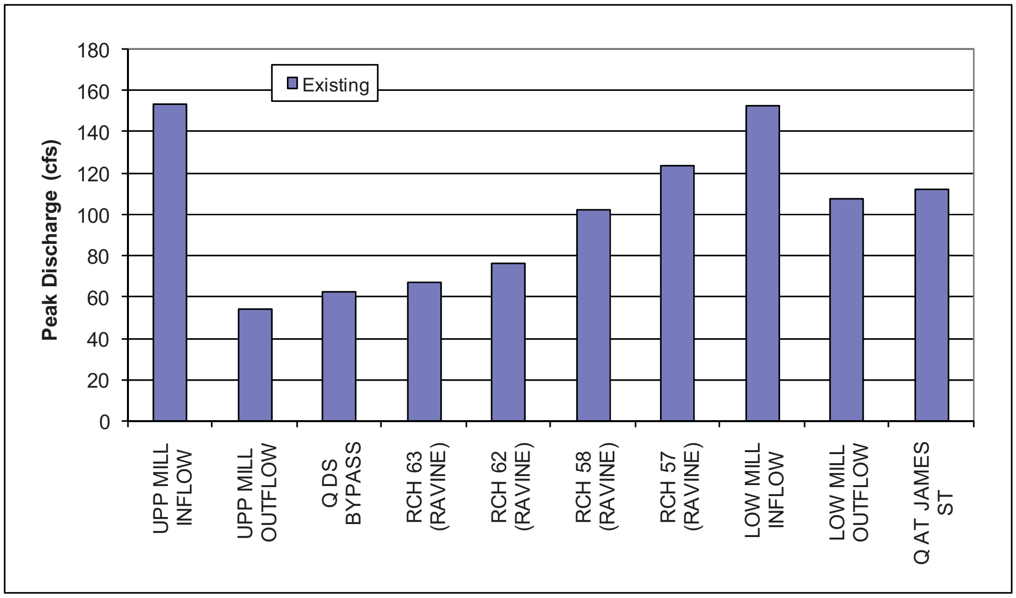
Graph 6-2
Lower Mill Creek Canyon Dam Outlet Works – Existing and Proposed Operations

The details of the analysis approach, methods of analysis, and key assumptions are documented in the MGS memorandum (Appendix E). The discussion in this subsection is limited to the key findings and recommendations of that analysis as reported below.

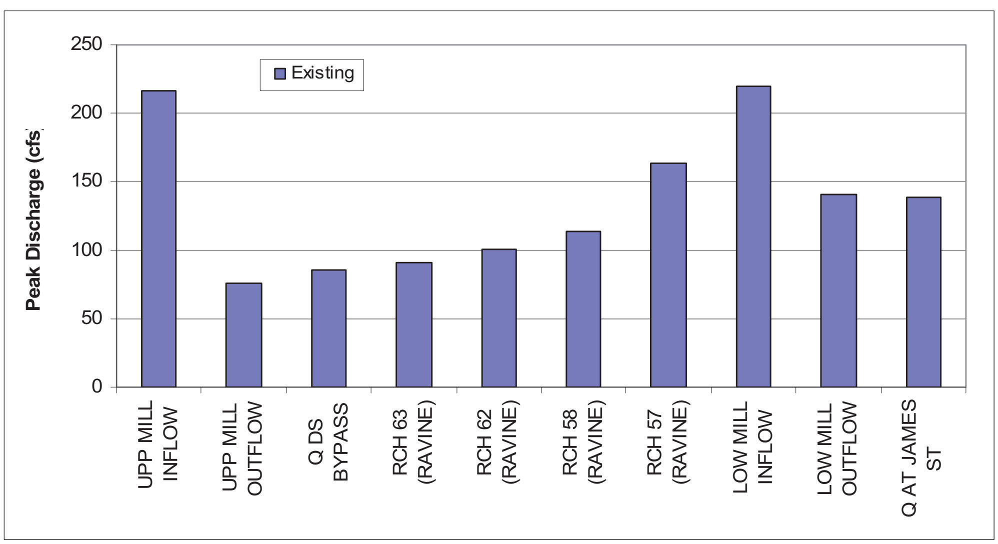
6.3.2 Results

In overview, the MGS analysis shows that expansion of the Upper Mill Creek detention pond reduces the 100-year peak discharge rates by about 67 percent relative to current conditions in the reaches immediately downstream of that storage facility. Downstream of this location, additional runoff enters from Basin G urbanized areas, principally from the north, increasing the peak discharge and runoff volume. Peak flow rates are again reduced at the Lower Mill Creek Canyon detention pond as a result of the increased storage from the proposed improvements to the dam and spillway as required by the Ecology Dam Safety (EDS) office. Downstream of the Lower Mill Creek Canyon detention pond, the 100-year peak discharge rate is reduced by about 10 percent as compared to existing conditions, and the predicted flooding duration of the 100-year event peak discharge is also significantly reduced.

Graphs 6-3 and 6-4 summarize the simulated 25- and 100-year flood event peak discharge rates along Upper Mill Creek for various points of analysis under existing land use conditions and detention storage facilities operation. The Upper Mill Creek detention pond inflow and outflow discharges are shown at the left, including bypass peak flows at the diversion structure (flow discharged to Upper Mill Creek Canyon without detention). The Lower Mill Creek Canyon detention pond predicted inflows and outflows and the simulated peak discharge at James Street are shown on the right.

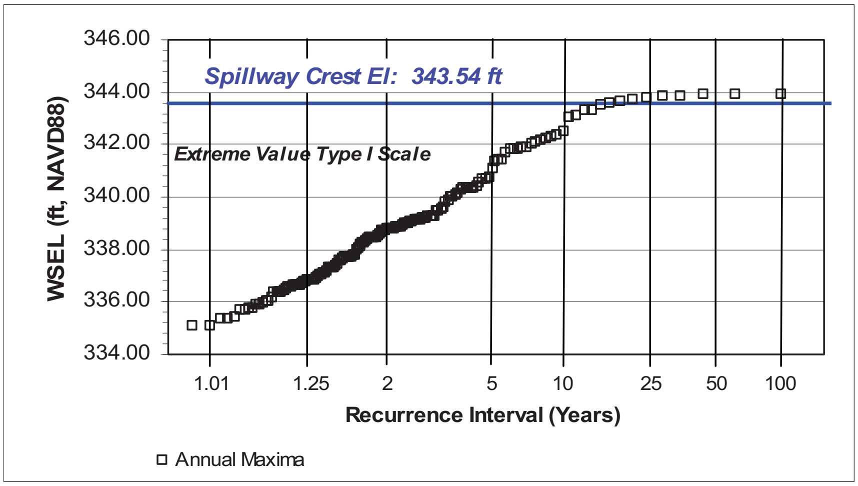


Graph 6-3
Upper Mill Creek Mainstem, 25-year Flood Recurrence Interval Summary – Existing Conditions

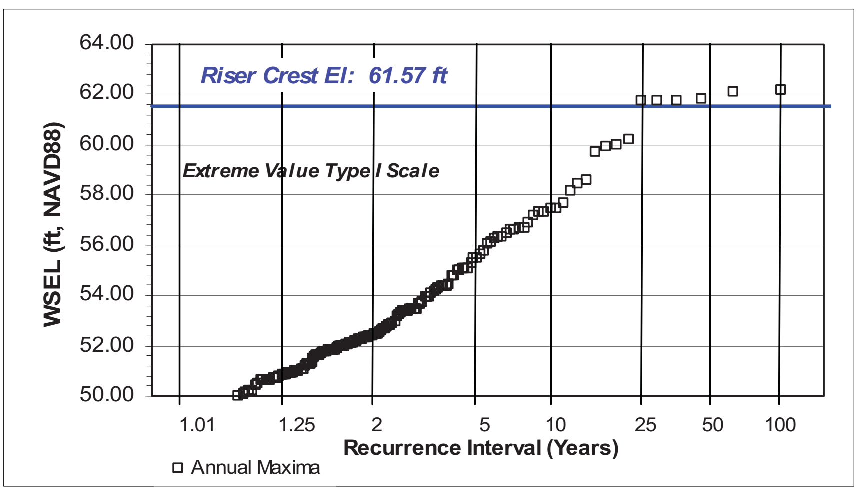


Graph 6-4
Upper Mill Creek Mainstem, 100-year Flood Recurrence Interval Summary – Existing Conditions

Graphs 6-5 and 6-6 report the simulated water surface elevation-flood frequency in both the Upper Mill Creek and Lower Mill Creek Canyon detention ponds under existing conditions. The spillway crest elevations are shown for comparison with predicted pond flood event water levels. The analysis shows that the Upper Mill Creek Canyon detention dam currently operates at approximately a 20-year level-of-protection (to spillway overflow). The Lower Mill Creek Canyon Dam provides a slightly higher level-of-protection, with spillway overflow expected at approximately a 25-year recurrence interval flood event.

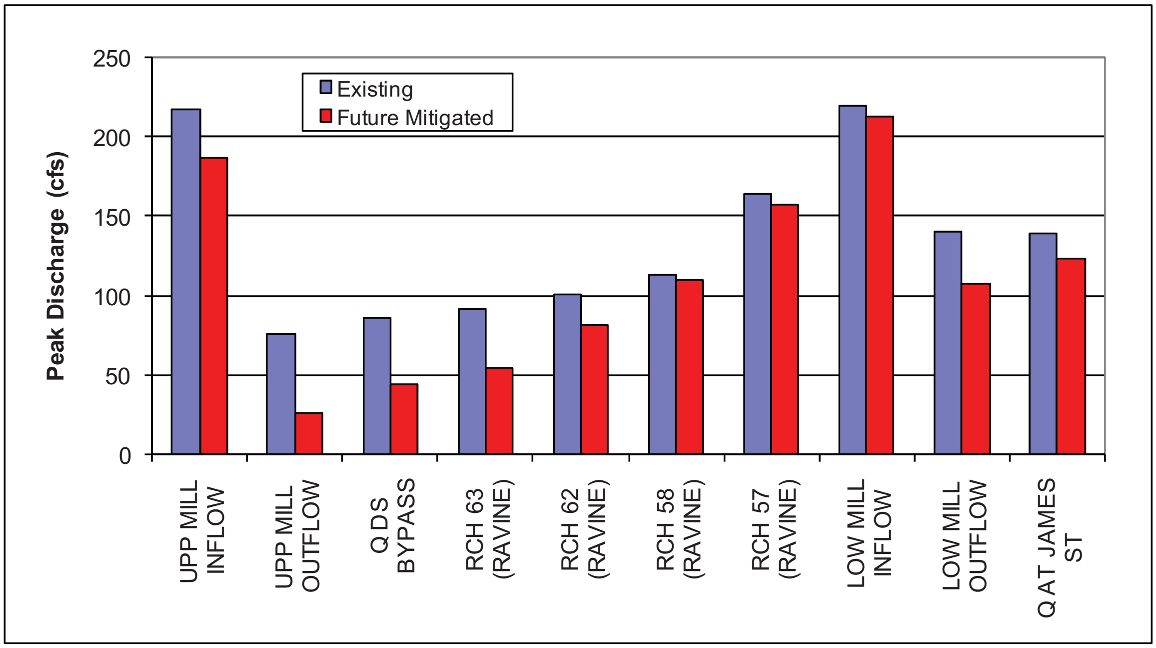


Graph 6-5
Upper Mill Creek Dam Water Surface Elevation-Frequency – Existing Conditions



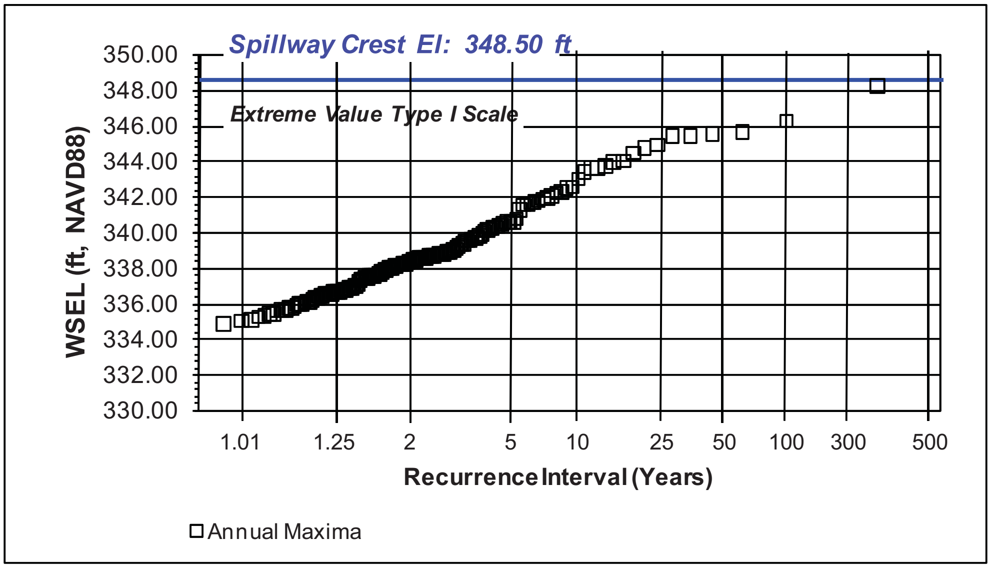
Graph 6-6
Lower Mill Creek Canyon Dam Water Surface Elevation-Frequency – Existing Conditions

Graph 6-7 shows a comparative analysis of existing land use peak flow analysis results along Upper Mill Creek Canyon as compared to simulated future land use, mitigated conditions throughout the basin. The results are based on detention storage retrofits to current standards, Upper Mill Creek diversion structure and detention dam improvements consistent with DMP recommendations, and Lower Mill Creek Canyon Dam safety improvements as currently designed. The analysis results show that for those assumed conditions, a net decrease in 100-year flood event discharges of approximately 20 cfs is expected at James Street under future land use, mitigated conditions, which translates to significant flood reduction benefits.

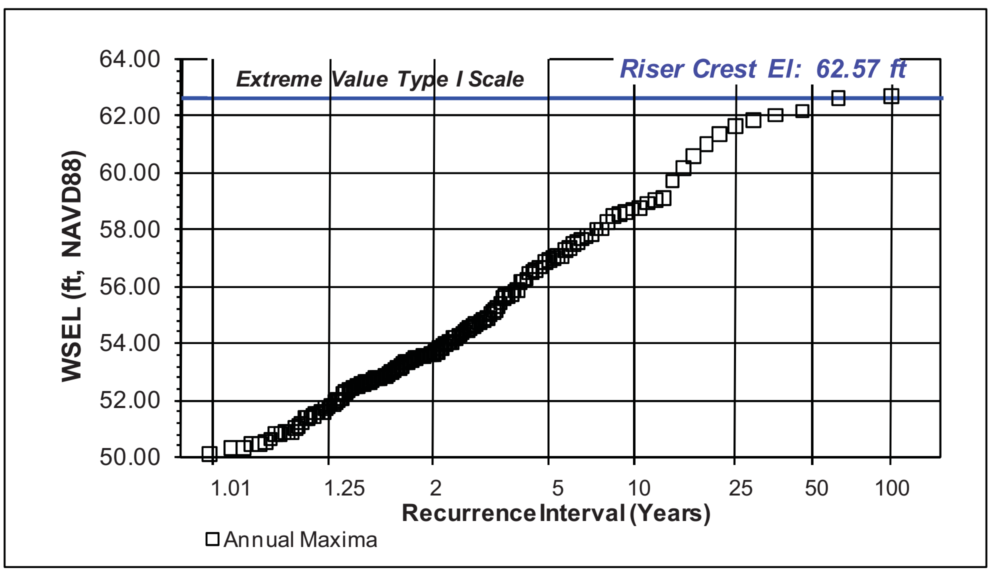


Graph 6-7
Upper Mill Creek Mainstem, 100-year Flood Recurrence Interval Summary
Comparison of Existing Conditions and Future Land Use with Mitigation

Graphs 6-8 and 6-9 illustrate the level of increased flood protection that can be achieved from proposed improvements at the Upper Mill Creek Detention Dam along with those currently designed for the Lower Mill Creek Canyon Dam. At the upper detention dam, the level-of-protection to spillway overflow increases from about a 20-year flood event for existing conditions to approximately a 500-year event. The 500-year event is comparable to EDS requirements associated with proposed modifications to the dam and spillway in this size of facility. For the lower detention dam, the level-of-protection to spillway overflow is raised from approximately a 25-year flood event to approximately a 100-year flood event.



Graph 6-8
Upper Mill Creek Dam Water Surface Elevation-Frequency
Future Mitigated Conditions



Graph 6-9
Lower Mill Creek Canyon Dam Water Surface Elevation-Frequency
Future Mitigated Conditions

In addition to the increase level of flood protection to Lower Mill Creek resulting from the collective Upper Mill Creek detention improvements, a reduction in flooding duration is predicted to result for future mitigated conditions with improvements compared to existing conditions. Those results are summarized in Table 6-4 for simulated 100-year event flooding conditions. The results show more than a two-fold reduction in the predicted duration of flooding for Lower Mill Creek at James Street for the conditions assumed for that analysis.

Table 6-4
Comparison of 100-year Peak Exceedance Duration – Existing and Future Mitigated Conditions

Location	Existing Condition 100-year Discharge (cfs)	Total Hours Current 100-year Flow is Exceeded during 158-year Simulation	
		Existing Conditions	Future Mitigated Conditions
Upper Mill Pond Inflow	215	0.7	0
Upper Mill Pond Outflow	75	4	0
Middle Ravine (Reach 62)	100	4	0
Mill Canyon Pond Inflow	220	0.4	0.2
Mill Canyon Pond Outflow	140	4	2
James Street Crossing	140	8	3

6.3.3 Recommendations

The following recommendations are made based on the hydrologic analysis and assumptions presented in the MGS analysis memorandum provided in Appendix E.

6.3.3.1 Raise Upper Mill Creek Detention Dam

The spillway at the Upper Mill Creek Detention Dam currently operates at around a 20-year recurrence interval. For larger floods, the reduction provided by the pond will be progressively less and will result in a dramatic increase in flooding along Lower Mill Creek. It is recommended that the Upper Mill Creek Detention Dam be raised by 5.5 feet to reduce the likelihood of overtopping to at least a 100-year recurrence interval.

Because of the high discharge rates that occur when the capacity of this structure is exceeded and the amount of infrastructure that would be impacted by flood waters along the lower reaches of Mill Creek, it would be prudent to increase the design level to a 1 in 500 Annual Exceedance Probability (AEP) or larger. This recommendation follows a risk-based design approach consistent with EDS standards whereby the design conservatism is a function of the consequences of potential downstream flood damages. Model simulations show that this recommended 5.5-foot raise meets the 1 in 500 AEP design goal.

6.3.3.2 Conduct Improved Flow Monitoring at Upper and Lower Mill Creek Detention Facilities

The performance of the Upper Mill Creek Detention Dam is key to mitigating the high peak discharge rates from the upper basin. Monitoring of flows immediately downstream of the dam and water surface elevation data in the pond and at the diversion structure should be performed using continuous recording devices.

The gage at the Lower Mill Creek Canyon Dam should be evaluated to ensure that accurate measurements are being made for high discharge rates. Turbulence in the control manhole may necessitate moving the gage to another location where high flows can be more accurately measured. The data recorded previously and the current gage configuration should be evaluated in coordination with the U.S. Geological Survey.

The monitoring data should be analyzed periodically to evaluate the performance of the detention facilities. The operation plan for each facility should be adjusted as necessary to maximize the flood control benefit. The monitoring data could also be used to refine the HSPF model developed for this study and aid in future assessments of the stormwater facility performance.

6.3.3.3 Install Debris Barriers/Trash Racks at Upper and Lower Mill Creek Detention Dam Outlet Works

The performance of the two regional detention facilities in the Mill Creek basin is dependent on the outlets being free of debris, which is often mobilized during large floods. Debris barriers and trash rack systems should be designed to minimize the head loss through the outlets of these ponds during floods.

6.3.3.4 Central Basin Flow Reduction through Enhanced On-site Controls

Downstream of the Upper Mill Creek Detention Dam, additional runoff enters from urbanized areas within Basin G, principally from the north, increasing the peak discharge and runoff volume in Mill Creek.

A combination of on-site detention and LID methods could be implemented to reduce the high flows entering the Upper Mill Creek ravine. LID methods could include downspout disconnection, rain gardens, open ditches that promote infiltration, and other similar approaches. The degree to which LID benefits could be achieved is highly dependent on having suitable soils for proper design of LID facilities and providing ongoing maintenance of those facilities.

6.4 Hydraulic Analysis of Trunk Drainage Systems

This section describes the results of hydraulic analysis conducted for existing TSD systems selected in coordination with City staff to define their flood flow capacities, adequacy, or deficiencies in comparison to flood flow estimates documented in Section 6.1. Figures 6-2a, 6-2b, and 6-2c show the extent of trunk drainage systems evaluated within the DMP planning area. Similar analyses were conducted for proposed TSD improvements to define their required sizes and the net flood reduction benefits achieved.

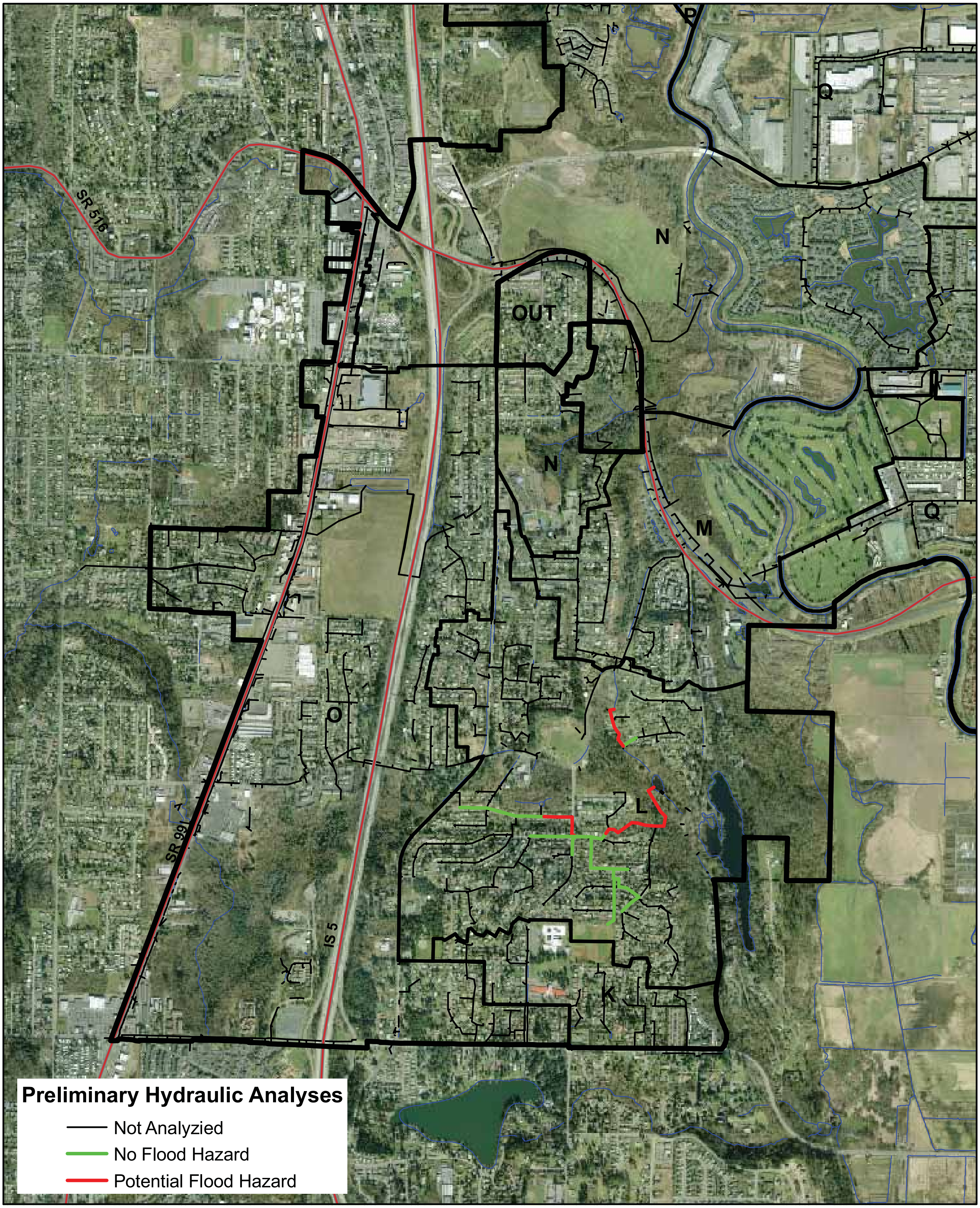


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Figure 6-2a
Hydraulic Screening Analysis
West Hill

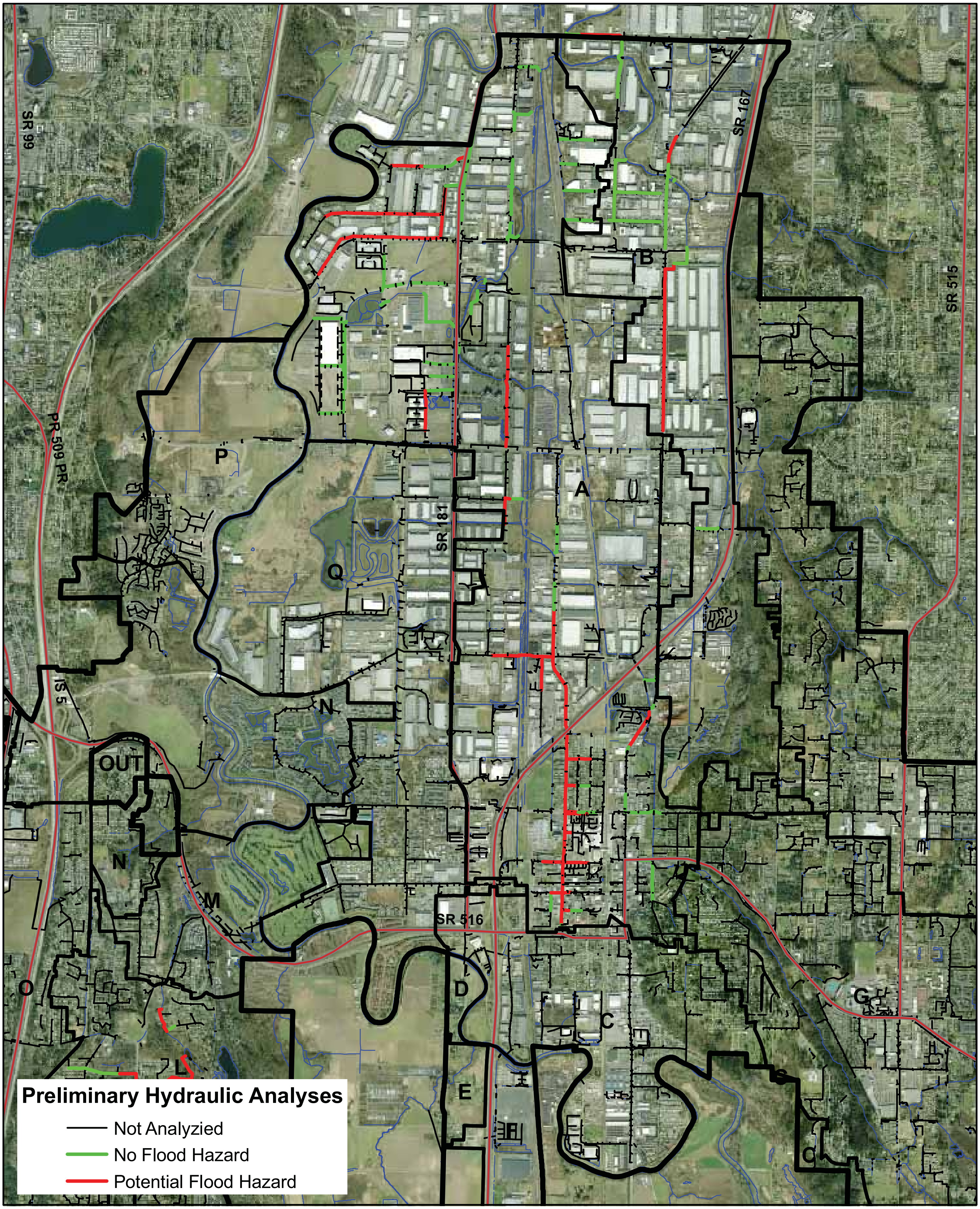

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Figure 6-2b
Hydraulic Screening Analysis
Green River Valley

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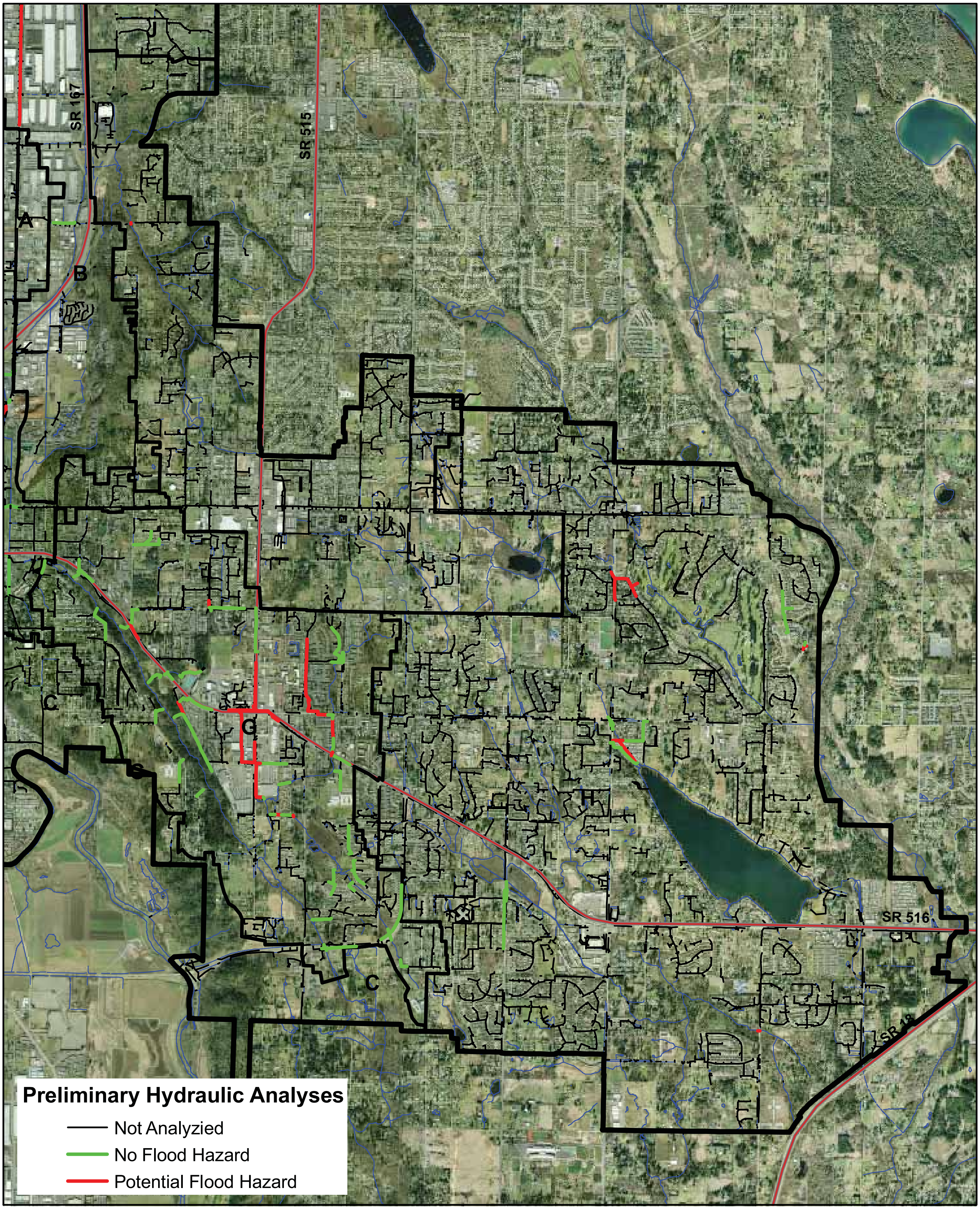

Figure 6-2c
Hydraulic Screening Analysis
East Hill

6.4.1 Approach, Methods, and Assumptions

The TSD system hydraulic analysis approach was based on use of an in-house (non-proprietary) spreadsheet hydraulic backwater modeling tool. It was set up as a planning-level screening analysis tool for each subbasin TSD system targeted for hydraulic capacity evaluation. Within those drainage systems, a series of representative pipe links (links) and nodes (catch basins) were defined based on the City's GIS drainage infrastructure database records and consideration of hydraulic controls within the drainage systems. Generally, points of analysis were selected at changes in TSD size, points of confluence with other significant interconnected lateral drainage systems, significant changes in TSD bottom slope, at flow routing location, and outfalls to receiving waters. Peak flow estimates were developed at those points of analysis for input of drainage system flow changes into the hydraulic backwater models. More detailed documentation of the hydraulic modeling tool and its use is included in Appendix F.

Key considerations and assumptions for the hydraulic modeling analysis are as follows:

- Analyses were completed to define existing TSD system conveyance capacity adequacy under 25-year, existing land use peak flood flow conditions
- Subcritical or critical flow conditions (with downstream control) were assumed for screening level hydraulic model analysis
- Starting water surface elevations for analysis at the outfalls of TSD systems were assumed at the top of existing or proposed storm drains; backwater-induced flooding of TSD systems under higher creek tailwater conditions does not typically provide justification for further increases in TSD system size
- Pipes with adverse grades were assumed to be flat for analysis purposes
- Invert elevations at pipe outfalls (and in other locations not covered in the City's GIS database) were assumed based on best available information and engineering judgment
- Only gravity flow conditions can be evaluated with this simplified hydraulic analysis tool; pump station hydraulic facilities were reviewed independently (where information was available for analysis)

6.4.2 Results

The results of the hydraulic modeling analysis of TSD systems selected for analysis are presented in Tables 6-5 through 6-22. Those tables show the computed 25-year flood event hydraulic grade elevations along the TSD systems under analysis conditions and assumptions for existing TSD drainage facilities as well as for expected conditions with recommended improvements as defined in Section 7. The difference in computed flood elevations defines the net flood elevation reduction benefit expected to be achieved. However, where elevations are below catch basin rims, the reduced flood elevations may be contained within TSD systems, and may not cause or reduce flood levels. Where computed flood (hydraulic grade) elevations exceeded catch basin rim elevations by more than 1 foot for the existing conditions analysis, flood levels at that point were assumed to be limited to approximately 1 foot higher than the lowest adjacent overflow elevation (shown in parentheses in the tables) to reflect surface overflows that would result. Items italicized in the tables indicate where assumed data entries were made to allow hydraulic analysis to be completed. Acronyms and abbreviations used in the tables are identified below:

- BCMPA = bottomless corrugated metal pipe arch
- BRCB = bottomless reinforced concrete box
- CB = catch basin
- CMP = corrugated metal pipe
- CMPA = corrugated metal pipe arch
- CPE = corrugated polyethylene pipe
- DIP = ductile iron pipe
- ft = feet
- HDPE = high density polyethylene pipe
- HGL = hydraulic grade line
- in = inch
- N/A = not applicable
- RCB = reinforced concrete box
- RCP = reinforced concrete pipe
- SD = storm drain (replacement pipe) - either reinforced concrete pipe, spiral rib pipe, or ductile iron pipe
- TSD = trunk storm drain

- WSEL = Water Surface Elevation

6.5 Hydraulic Analysis of Receiving Waters

This section describes the results of hydraulic analysis conducted for the Lower Mill Creek and Springbrook Creek receiving water drainage systems selected for analysis in coordination with City staff. This analysis was conducted to estimate flood profiles along those receiving waters and to generate maps showing the expected flood inundation limits for those flooding sources under existing conditions as well as with the collective stream system improvements recommended in Section 7. Comparison between those flood profiles and flood inundation limits mapping provides documentation of the net flood reduction benefits to be achieved for the recommended project improvements.

6.5.1 Approach, Methods, and Assumptions

The hydraulic analysis for the Lower Mill Creek and Springbrook Creek stream systems was conducted using the HEC-RAS hydraulic model, the accepted model used by FEMA for floodplain mapping analysis. Prior HEC-2 models of these stream systems have been completed by others (NHC 1996) as part of earlier updates to the FEMA Flood Insurance Study within the City (FEMA 1989).

Anchor initiated stream system hydraulic model development based on those earlier HEC-2 models and converted them to the current version of the HEC-RAS model. In addition, field reconnaissance was conducted for the entire Lower Mill Creek, Springbrook Creek, and the GRNRA lagoon loop to validate hydraulic structure geometries and estimate current sediment levels in the creeks at their culvert or bridge crossings of major roadways. New HEC-RAS models were also developed for the GRNRA diversion channel from Mill Creek, the lagoon, and the outlet channel back to Lower Mill Creek (the loop model). That HEC-RAS model was based on current conditions and improvements recently made in the outlet channel (Boeing Creek, also referred to as the Boeing Ditch) by the City. The Springbrook Creek hydraulic model was extended further upstream from its SR 167 crossing to the overflow confluence with Lower Mill Creek downstream of James Street based on field surveys conducted by the City inclusive of channel sections and bridge geometries.

For the December 3, 2007, flooding event (determined to be an approximate 2-year event on Mill Creek), field reconnaissance was conducted near the peak of the flood on the majority of the Lower Mill Creek system and a portion of the Springbrook Creek system to observe and document flooding conditions. Flood photographs were taken (Appendix C) and high water marks were staked along the Lower Mill Creek channel between Earthworks Park and the confluence of Lower Mill Creek and the Boeing Ditch channel at the West Valley Highway crossing. Typically these were placed at both sides of road crossings where accessible. The City survey crew subsequently completed a field survey to define the elevations of the marked flood elevations during that event, the results of which are included in Appendix F.

Anchor staff reviewed the gaged stream flow data for that event using the U.S. Geological Survey Earthworks Parks stream gage, and proceeded to calibrate the Lower Mill Creek updated HEC-RAS model to the December 3, 2007 event high water mark data. Anchor staff also made various measurements of water level along the Boeing Ditch channel during both low flows and the December 3, 2007 flood event, and used that data in combination with lagoon recorded water levels for calibration of the GRNRA lagoon loop model. Figure 6-3 shows the resulting flood profile calibration for Lower Mill Creek.

Key HEC-RAS hydraulic modeling assumptions include:

- Unobstructed flood flows conveyance were assumed at culvert and bridge crossings of the channel
- Excess sediment removal in hydraulic structures was assumed for improved channel conditions
- Manning's roughness values were estimated from field observation and adjusted with model calibration ranging from 0.036 to 0.10 in the channel and 0.05 to 0.20 in adjacent floodplain areas
- Channel expansion and contraction coefficients were assumed to range from 0.1 to 0.5 at all bridges and from 0.4 to 0.6 at all culvert crossings and major changes in channel alignment

After achieving a best-fit calibration to the available data sets, the HEC-RAS model was then run to simulate flood profiles along the Lower Mill Creek, Springbrook Creek, and GRNRA loop. Peak flood flow inputs from the HSPF hydrologic model were inputs at various locations throughout the stream systems. Numerous modeling iterations were completed using both the HSPF and HEC-RAS models including estimation of flow splits at the various diversion and overflow locations and flood routing effects of the GRNRA lagoon system. After various model refinements, flood profiles for all of the reaches under evaluation were generated for existing conditions. Those models were then modified for proposed improvements along Lower Mill Creek and the GRNRA loop. Figures 6-4 through 6-10 document the resultant flood profiles for those analyses.

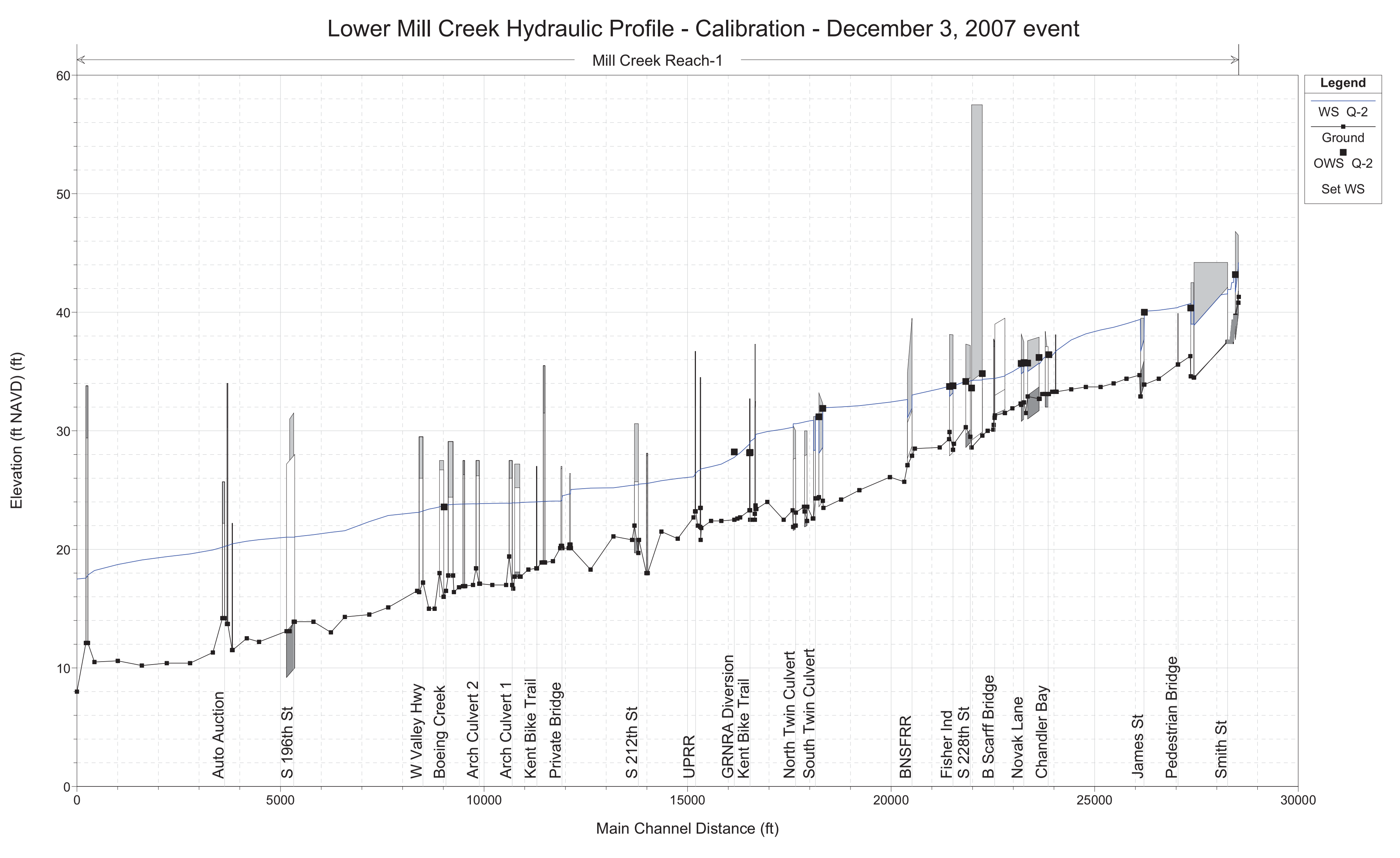

Figure 6-3
Hydraulic Profile
Lower Mill Creek - Calibration

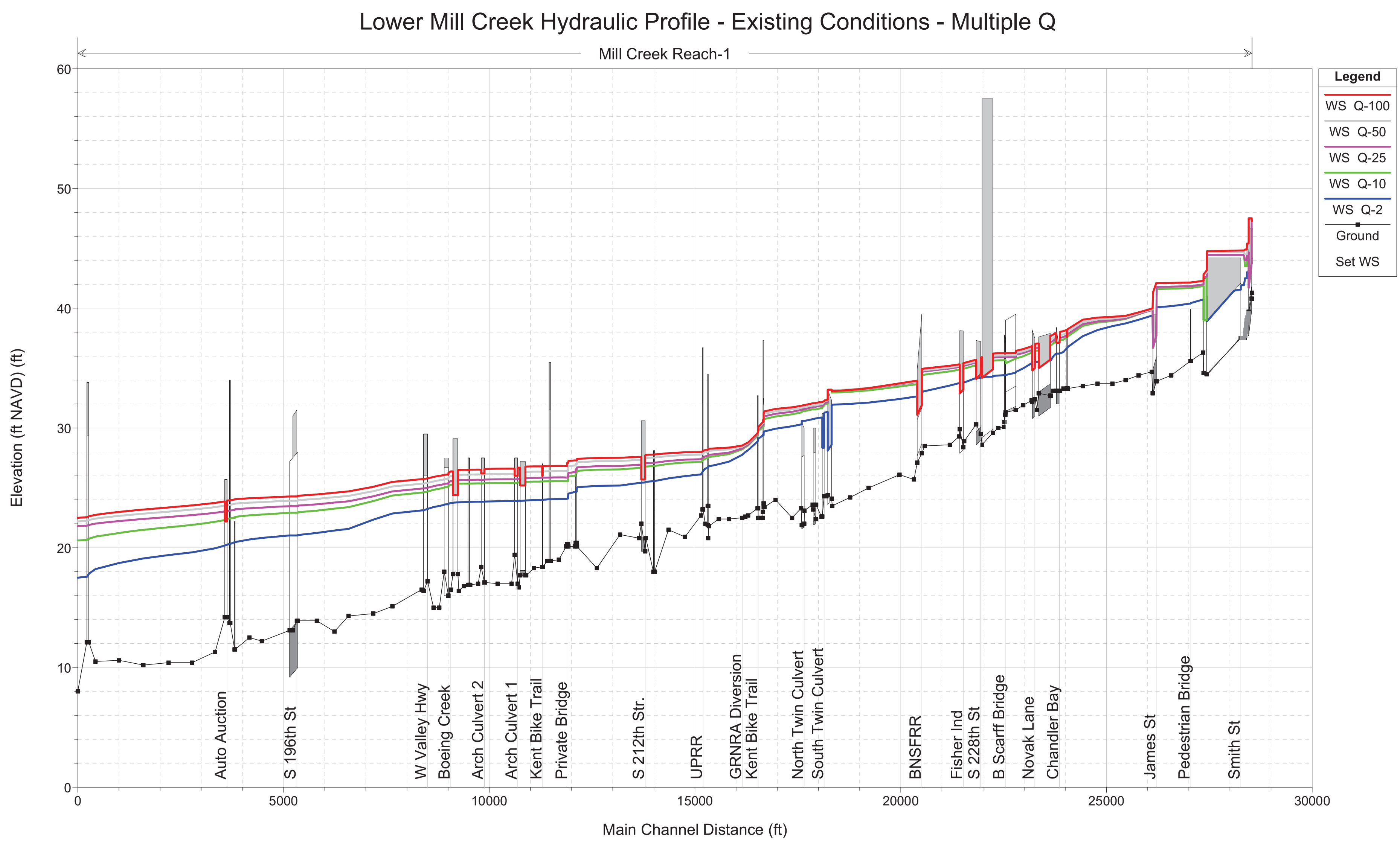

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Figure 6-4
Hydraulic Profile
Lower Mill Creek - Existing Conditions

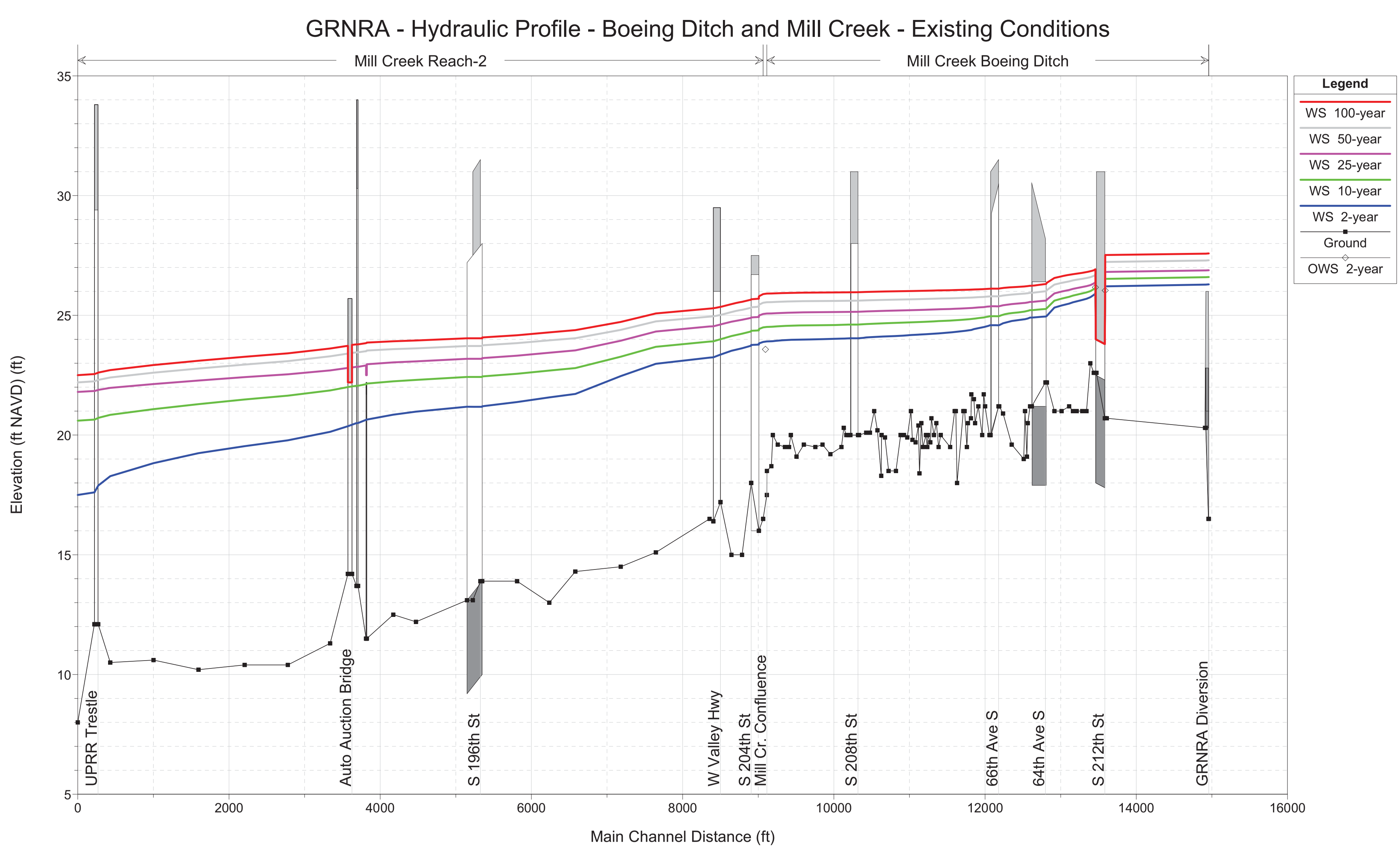


Figure 6-5
Hydraulic Profile
Boeing Ditch and Mill Creek - Existing Conditions

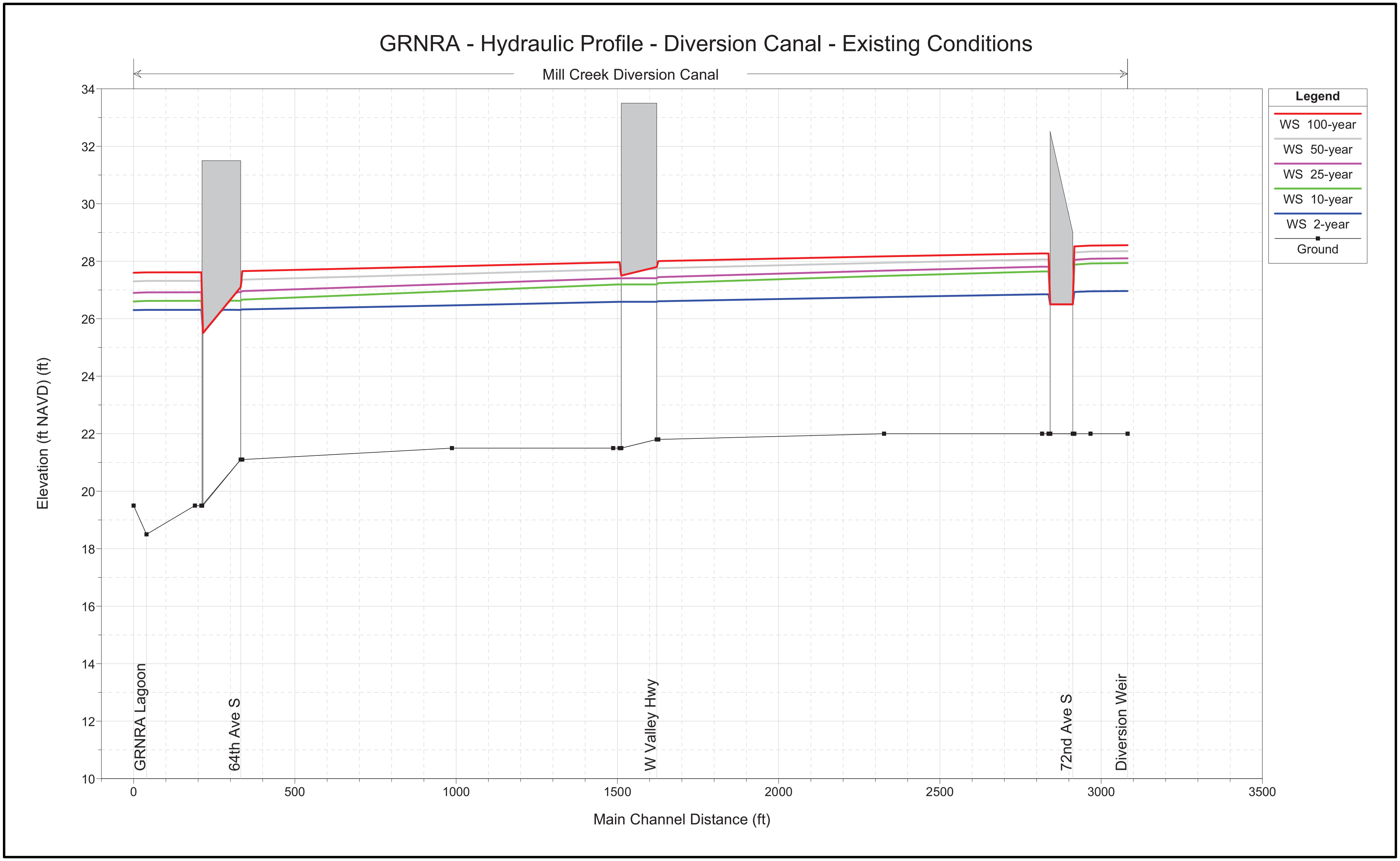


Figure 6-6
Hydraulic Profile
Mill Creek Diversion Canal - Existing Conditions

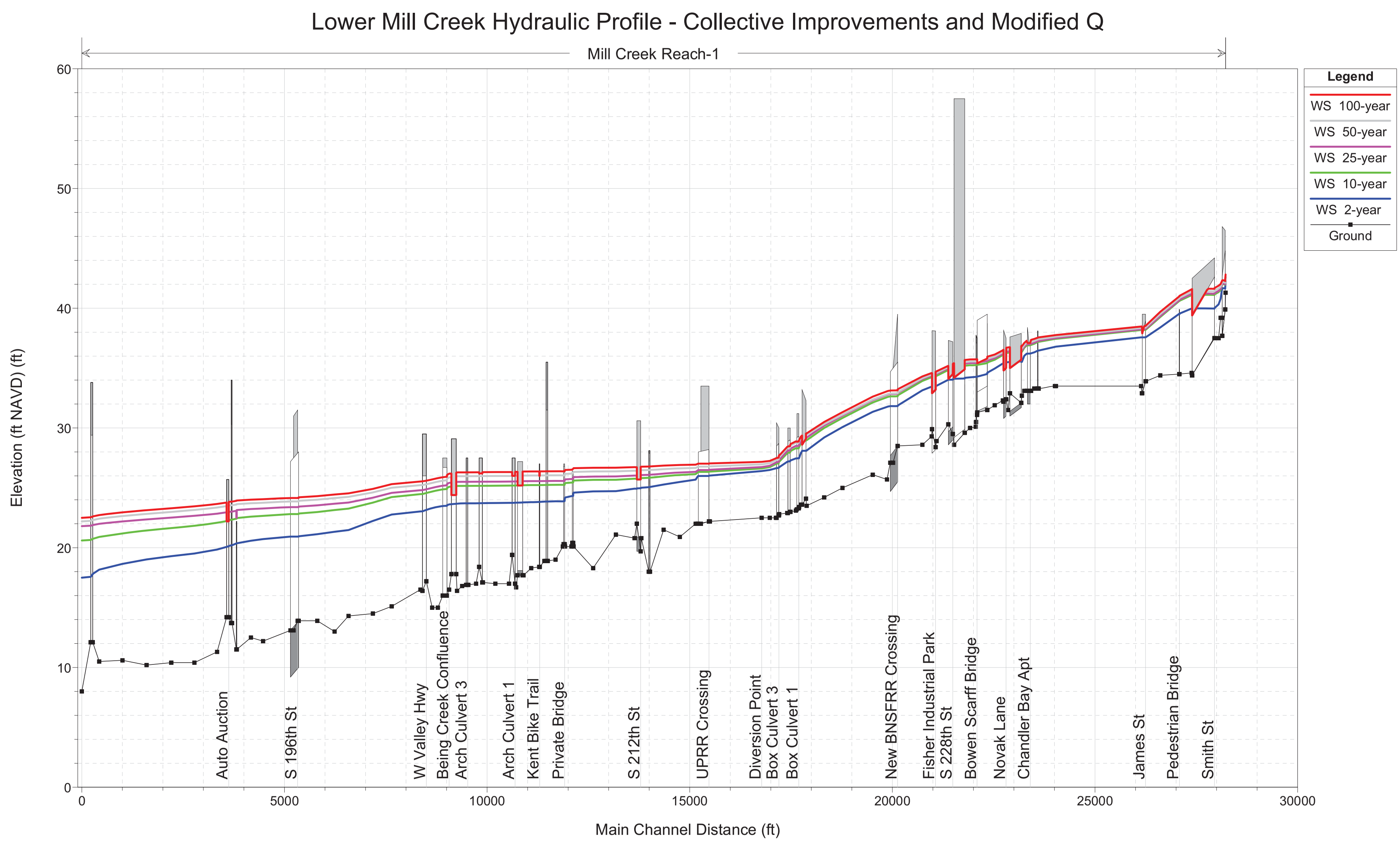


Figure 6-7
Hydraulic Profile
Lower Mill Creek - Improved Conditions

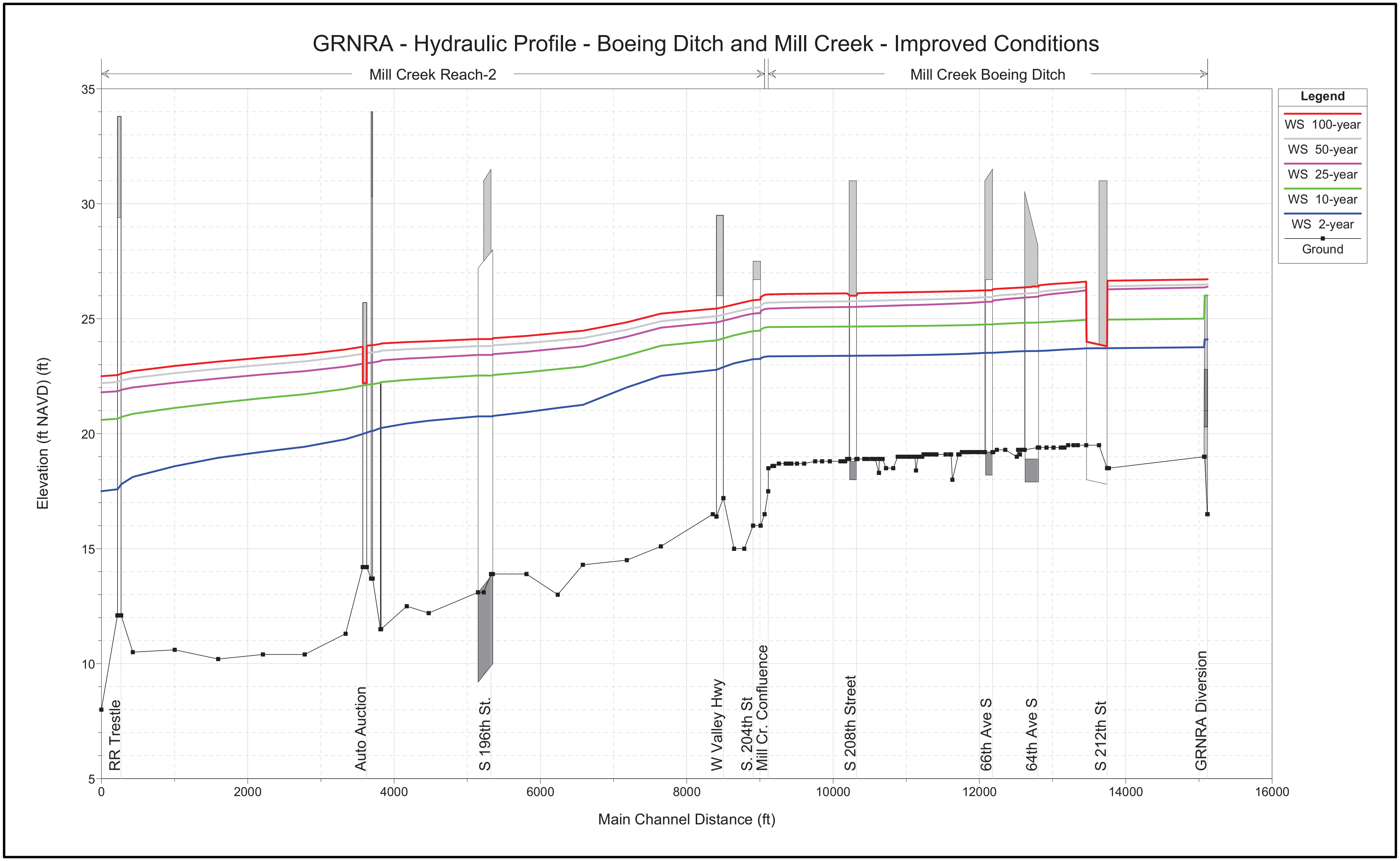


Figure 6-8
Hydraulic Profile
Boeing Ditch and Mill Creek - Improved Conditions

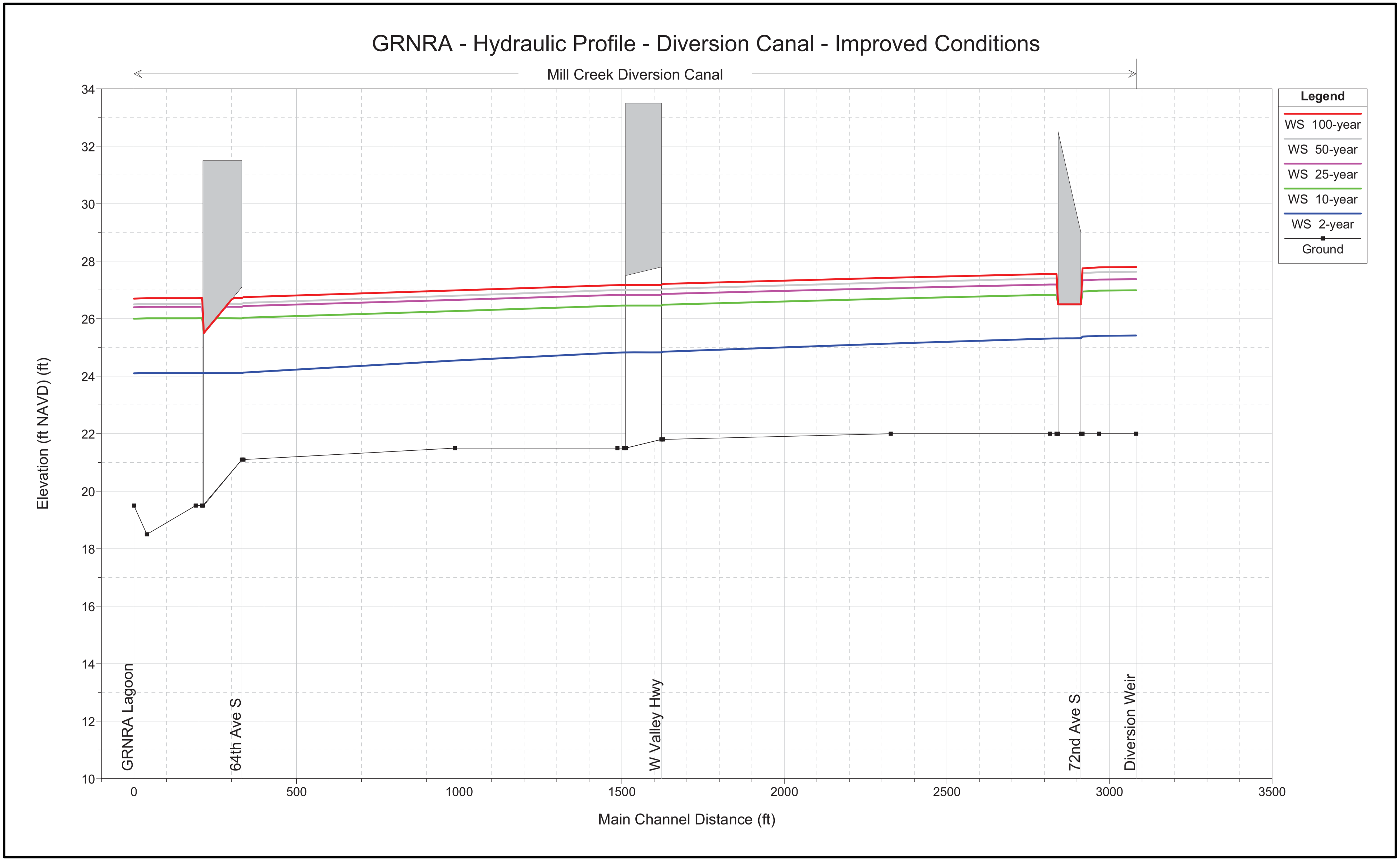


Figure 6-9
Hydraulic Profile
Mill Creek Diversion Canal - Improved Conditions

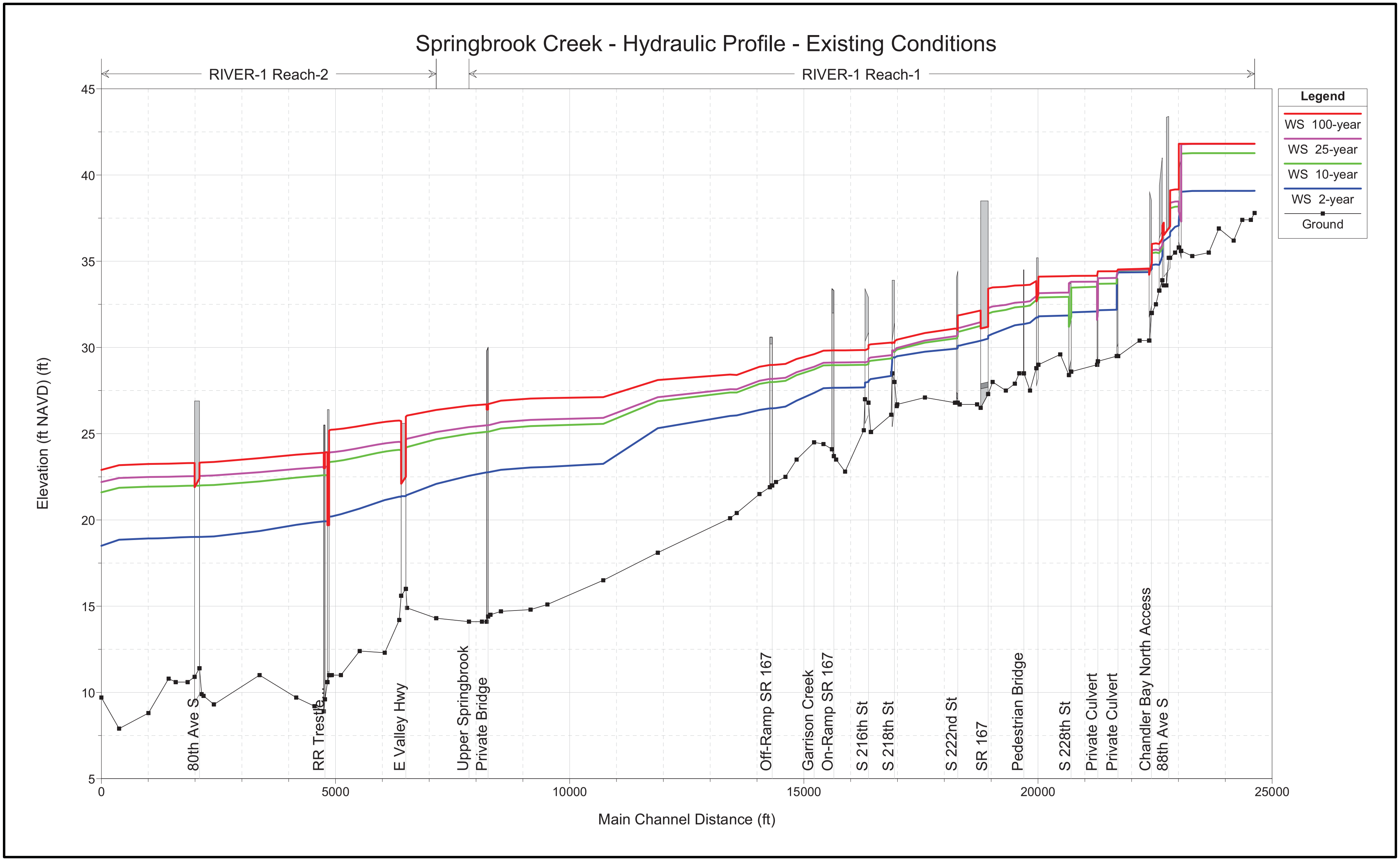
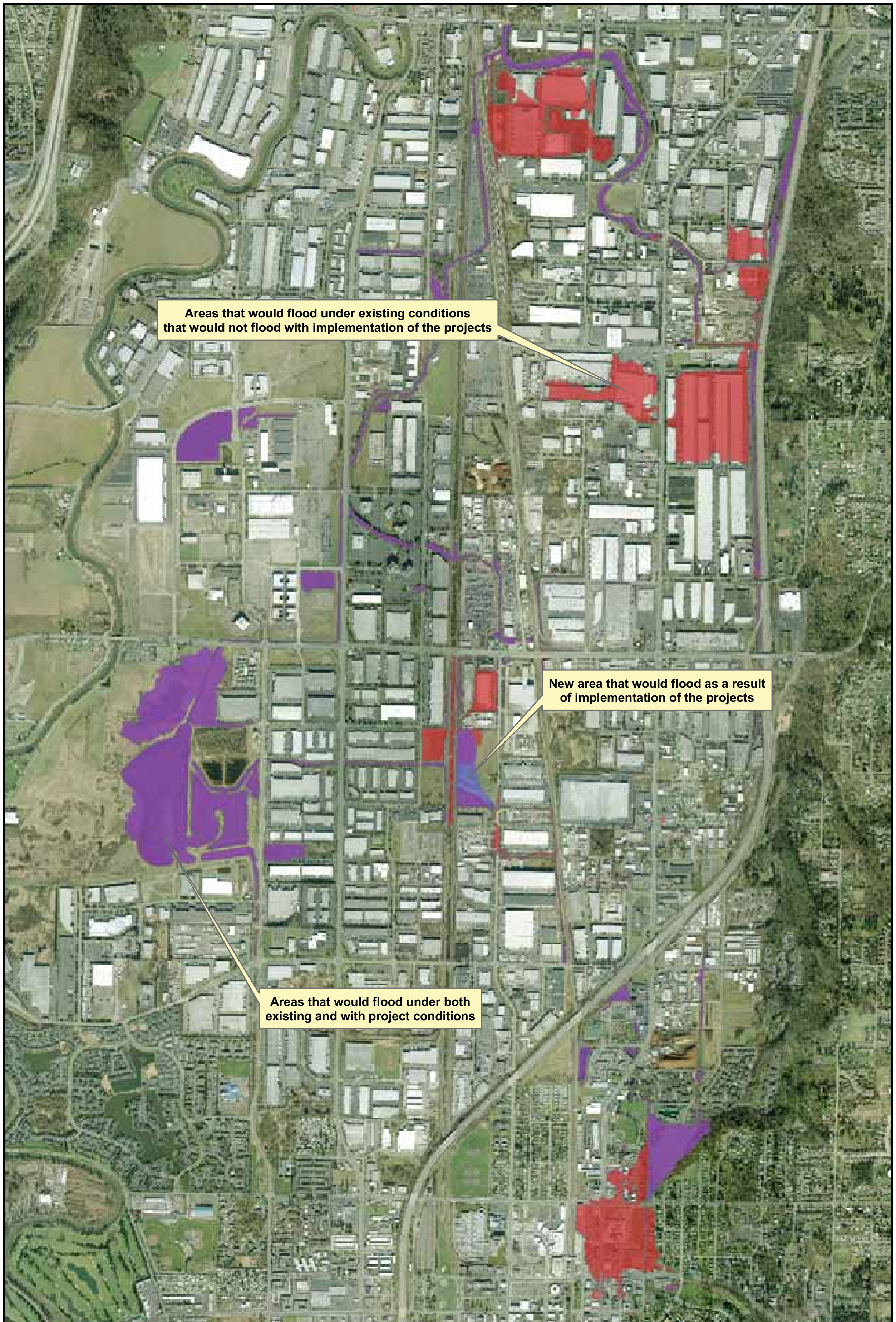


Figure 6-10
Hydraulic Profile
Springbrook Creek - Existing Conditions

6.5.2 Results

The results of the HEC-RAS hydraulic modeling analysis for Lower Mill Creek and Springbrook Creek are summarized in Tables 6-23 and 6-24, respectively. Those results include computed flood elevations for the 25-year flood event for both existing and improved conditions on Lower Mill Creek and for existing conditions on Springbrook Creek. The simulated net flood reduction benefits to be achieved through implementation of the collective Lower Mill Creek improvements summarized in Section 7 are also shown.

Based on these analysis results, Anchor prepared flood inundation mapping for both existing and improved conditions along the stream reaches evaluated. Those results are shown in Figure 6-11. The representations of flood prone areas are based on the computed flood elevation for creek flooding as overlain on the City's 2-foot contour interval topographic mapping. Comparison of those results illustrates the net flood inundation benefits expected to be achieved for the collective recommended stream system improvement projects along with Project A-5. That project results in a significant reduction in flood flows delivered to Lower Mill Creek at the 76th Avenue South TSD outfall. Please note that this assessment is not intended for mapping of floodplains to FEMA standards and does not reflect the effects of potentially higher local drainage system-induced flood levels beyond the flooding inundation limits associated with the receiving waters computed flood elevations.



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Implementation of the proposed CIP projects would reduce the extent of flooding caused by the receiving waters by approximately 190 acres. There is additional flooding, not shown, due to the TSD system.

Figure 6-11
25-Year Floodplain for Mill and Springbrook Creeks Under Existing and Proposed Project Conditions

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Table 6-5
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin A (Lower Mill Creek), Subbasin A13W (Reference Figure 7-6)

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement A-6 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement A-6	
										17.5	*34.4*	(24.0)	(24.0)	
	A13W-1	N/A	C212	49.7	89	5.05	66" *RCP*		STME316	22.0	34.4	24.4	24.4	0.0
	A13W-2	STMH.STMF220- STMH.STME316	C212	48.8	579	0.25	66" *RCP*		STMF220	23.4	34.4	26.0	26.0	0.0
	A13W-3	STMH.STMF219- STMH.STMF220	C212	24.8	618	0.24	66" *RCP*		STMF219	24.9	34.4	26.8	26.8	0.0
S 228th St /76th Ave S /4th Ave N intersection	A13W-4	STMH.STMF170- STMH.STMF219	C212	12.6	597	0.17	66" *RCP*		STMF170	25.9	34.6	27.4	27.4	0.0
Flow diversion at S 228th St /76th Ave S /4th Ave N intersection										25.9	34.6	(31.4)	(31.4)	
	A13W-5	STMH.STMF150- STMH.STMF170	D176	102.0	622	0.12	66" *RCP*		STMF150	26.7	35.4	32.1	32.1	0.0
	A13W-6	STMH.STMF148- STMH.STMF150	D176	102.0	166	0.14	66" *RCP*			26.9	35.4	32.4	32.4	0.0
	A13W-7	STMH.STMF148- STMH.STMF150	D176	96.9	442	0.15	54" *RCP*	60" TSD	STMF148	27.6	36.3	33.7	33.2	0.5
	A13W-8	STMH.STMF142- STMH.STMF148 STMH.STMF140- STMH.STMF142	D176	96.9	611	0.06	54" *RCP*	60" TSD	STMF142	28.0	37.0	35.5	34.2	1.3
	A13W-9	STMH.STMF140- STMH.STMF142	B32	93.7	140	0.47	48" *RCP*	60" TSD	STMF140	28.6	35.6	37.4 (36.6)	33.0	3.6
SR 167 and 4th Ave N overpass	A13W-10	STMH.STMF134- STMH.STMF140	B32	88.4	305	0.17	48" *RCP*	60" TSD	STMF134	29.1	37.0	38.1 (38.0)	33.6	4.4
	A13W-11	STMH.STMF134- STMH.STMF140 STMH.STMF132- STMH.STMF134	B32	88.4	394	0.10	48" *RCP*	60" TSD	STMF132	29.5	38.5	40.0 (39.5)	34.3	5.2

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement A-6 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement A-6	
4th Ave N /W Cloudy St intersection	A13W-12	STMH.STMF130-STMH.STMF132 STMH.STMF414-STMH.STMF130	B32	84.0	670	0.07	48" *RCP*	60" TSD	STMF414	30.0	37.4	42.2 (38.4)	35.0	3.4
4th Ave N /W James St intersection	A13W-13	STMH.STMF125-STMH.STMF414 STMH.STMF122-STMH.STMF125 STMH.STMF120-STMH.STMF122	B32	79.9	794	0.11	48" *RCP*	60" TSD	STMF120	30.9	38.1	41.2 (39.1)	35.8	3.3
	A13W-14	N/A	B32	61.7	69	0.23	42" *RCP*	48" TSD	N/A	31.0	38.0	39.8 (39.0)	36.2	2.8
4th Ave N /Ramsay Way intersection	A13W-15	STND.STMM098-STMH.STMM483 STMH.STMM482-STND.STMM098	B32	58.3	467	0.16	42" *RCP*	48" TSD	STMM109	31.8	38.9	40.9 (39.9)	37.1	2.8
4th Ave N /W Smith St intersection	A13W-16	STMH.STMM471-STND.STMM092 STND.STMM097-STMH.STMM1091 STND.STMM096-STND.STMM097 STND.STMM094-STND.STMM095 STND.STMM093-STND.STMM094 STMH.STMM476-STND.STMM093 STND.STMM092-STMH.STMM476	B32	53.6	748	0.16	36" *RCP*	48" TSD	STMM468	33.0	39.0	45.7 (40.0)	38.3	1.7
4th Ave S /W Gowe St intersection	A13W-17	STMH.STMM421-STND.STMM076 STND.STMM076-STND.STMM077 STND.STMM077-STMH.STMM425 STMH.STMM424-STMH.STMM425 STMH.STMM425-	B32 B37	36.1	781	0.10	36" *RCP*		STMM393	33.8	41.9	42.6	40.9	1.7

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement A-6 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement A-6	
		STMH.STMM449 STMH.STMM448-STMH.STMM468 STND.STMM068-STMH.STMM421 STND.STMM067-STND.STMM068 STMH.STMM393-STND.STMM067												
4th Ave S /W Titus St intersection	A13W-18	STND.STMM058-STMH.STMM393 STMH.STMM374-STND.STMM057 STMH.STMM369-STMH.STMM374 STMH.STMM366-STMH.STMM369	B37 C248	9.8	452	0.33	24” *RCP*		STMM366	35.3	42.2	43.5 (43.2)	41.8	1.4
4th Ave S W Saar St intersection	A13W-19	STND.STMM056-STMH.STMM366 STMH.STMM364-STND.STMM056 STND.STMM0140-STMH.STMM364 STND.STMM0139-STND.STMM0140 STMH.STMM360-STND.STMM0139	C248	4.1	426	0.30	24” *RCP*		STMM360	36.5	43.4	43.3	42.0	1.3
3rd Ave N /W Cole St intersection	A13W-28	STMH.STMF392-STMH.STMF132 STMH.STMF393-STMH.STMF392 STMH.STMF394-STMH.STMF393	C428	4.5	293	0.26	24” *RCP*		STMF394	31.4	35.6	39.6 (36.6)	34.4	2.2
2nd Ave N /W Cole St intersection	A13W-29	STMH.STMF397-STMH.STMF394 STMH.STMF654-STMH.STMF397 STMH.STMF442-STMH.STMF654	C428	3.0	280	0.35	21” *RCP*		STMF442	32.3	35.7	36.7	34.5	2.2

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement A-6 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement A-6	
3rd Ave N /W Cloudy St intersection	A13W-30	STMH.STMF732-STMH.STMF414 STMH.STMF413-STMH.STMF732 STMH.STMF412-STMH.STMF413	C428	4.1	295	0.76	24" *RCP*		STMF412	32.3	36.2	33.2	33.2	0.0
2nd Ave N /W Cloudy St intersection	A13W-31	STMH.STMF431-STMH.STMF412	C428	2.2	316	0.29	21" *RCP*		STMF431	33.2	37.8	34.0	34.0	0.0
3rd Ave N /W James St intersection	A13W-32	STMH.STMF118-STND.STMF0107	B28	2.7	341	0.99	18" *RCP*		STMF112	34.3	39.3	35.0	35.0	0.0
	A13W-33	STMH.STMF105-STMH.STMF107	B28	2.7	444	0.40	18" *RCP*		STMF105	36.0	40.5	37.0	37.0	0.0
	A13W-34	N/A	C889	3.4	227	0.21	24" PVC		N/A	31.5	40.3	39.1	36.2	2.9
	A13W-35	N/A	C889	3.4	323	0.23	24" PVC		N/A	32.2	41.0	39.2	36.3	2.9
	A13W-36	N/A	C838	4.7	57	0.00	24" RCP		N/A	31.3	38.4	40.0 (39.4)	37.2	2.2
3rd Pl N /Ramsay Way intersection	A13W-37	N/A	C838	4.7	140	1.36	24" RCP		N/A	33.2	38.8	34.4	34.4	0.0
	A13W-38	STMH.STMM467-STMH.STMM468 STND.STMM090-STMH.STMM467 STND.STMM089-STND.STMM090 STND.STMM088-STND.STMM089	C187	7.8	345	0.27	21" *RCP*		N/A	33.9	39.8	40.9 (40.8)	39.2	1.6
2nd Ave N /W Smith St intersection	A13W-39	STND.STMM087-STND.STMM088 STMH.STMM463-STND.STMM087 STND.STMM086-STMH.STMM463 STND.STMM085-	C187	7.8	323	0.20	21" *RCP*		N/A	34.6	40.9	41.8	40.2	1.6

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement A-6 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement A-6	
		STND.STMM086 STND.STMM084- STND.STMM085												
	A13W-40	STND.STMM091- STMH.STMM489 STMH.STMM489- STMH.STMM468 STMH.STMM900- STND.STMM091 STMH.STMM491- STMH.STMM900	B65	3.1	229	0.54	18” *RCP*		STMM491	34.2	39.2	35.1	35.1	0.0
	A13W-41	STMH.STMM494- STMH.STMM491	B65	3.1	269	0.38	18” *RCP*		STMM494	35.3	39.6	36.3	36.3	0.0
5th Ave S /W Gowe St intersection	A13W-42	STND.STMM058- STMH.STMM393 STMH.STMM389- STND.STMM060	B37	11.0	294	0.90	21” *RCP*		STMM389	36.4	42.0	38.5	38.5	0.0
	A13W-43	STMH.STMM859- STMH.STMM389	C48	2.6	50	2.64	18” *RCP*		STMM859	37.7	41.6	38.5	38.5	0.0
5th Ave S /W Titus St intersection	A13W-44	STMH.STMM860- STMH.STMM859 STMH.STMM861- STMH.STMM860 STMH.STMM863- STMH.STMM861	E242	2.6	391	0.31	21” *RCP*		STMM863	38.1	41.9	39.0	39.0	0.0
	A13W-45	STND.STMM058- STMH.STMM393 STMH.STMM526- STND.STMM064	B37 B79	6.2	225	0.36	24” *RCP*		STMM526	34.6	42.4	42.8	41.1	1.7
	A13W-46	STMH.STMM913- STMH.STMM356	C533	5.7	172	1.32	24” RCP		STMM913	37.5	41.9	38.7	38.7	0.0
	A13W-47	STMH.STMM916- STMH.STMM913	C533	5.7	317	0.18	24” RCP		STMM921	38.1	42.0	39.5	39.5	0.0

Notes:

All elevations shown are NAVD 88 datum (City current datum)

Computed elevations assume recommended CIP project A-5 improvements are existing conditions

(24.0) = Estimated starting WSEL at outfall or overflow elevation at catch basin

Italicized values = Assumed parameters based on engineering judgment where not included in the City’s GIS database

Table 6-6
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin A (Lower Mill Creek), Subbasin A04W (Reference Figure 7-8)

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement A-8 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement A-8	
Channel to Mill Creek NE of S196th St /72nd Ave S										*17.0*	*26.8*	(23.0)	(23.0)	
	A04W-1	N/A	C384	119.1	113	*0.00*	72" CMP		N/A	17.0	26.8	23.7	23.7	0.0
Open channel between 68th Ave S and 72nd Ave S										15.4	*28.5*	(21.6)	(21.6)	
	A04W-2	N/A	B85	112.3	88	0.33	Dual 60" *RCP*		STMB26 STMB25	15.7	28.5	21.7	21.7	0.0
	A04W-3	STMH.STMB194-STMH.STMB26 STMH.STMB193-STMH.STMB25	B85	102.0	27	0.26	Dual 60" *RCP*		STMB194 STMB193	15.8	29.5	21.8	21.8	0.0
S 191st Pl /66th Ave S intersection	A04W-4	STMH.STMLL65-STMH.STMB193 STND.STMB034-STMH.STMB194	C289	72.7	359	0.10	Dual 48" *RCP*		STMLL65	16.0	29.5	22.2	22.2	0.0
S 194th St /66th Ave S intersection	A04W-5	N/A	C289	69.2	735	0.06	Dual 48" *RCP*		STMB146	16.4	23.7	22.7	22.7	0.0
S 196th St /66th Ave S intersection	A04W-6	STMH.STMB79-STMH.STMB146 STMH.STMB74-STMH.STMB79	C289	33.0	603	0.36	42" *RCP*		STMB74	18.6	26.5	23.6	23.6	0.0
	A04W-7	STMH.STMB69-STMH.STMB74	B63	22.4	306	0.10	42" *RCP*		STMB69	18.9	26.5	23.8	23.8	0.0
S 196th St /62nd Ave S intersection	A04W-8	STND.STMB024-STMH.STMB69 STND.STMB023-STND.STMB024	B63	22.4	1089	0.19	36" *RCP*		STMB62	20.4	26.5	25.1	25.1	0.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement A-8 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement A-8	
		STMH.STMB68-STND.STMB023 STND.STMB022-STMH.STMB68 STMH.STMB66-STND.STMB022 STMH.STMB65-STMH.STMB66 STND.STMB021-STMH.STMB65 STND.STMB020-STND.STMB021 STMH.STMB62-STND.STMB020												
	A04W-9	STND.STMB019-STMH.STMB62 STMH.STMB57-STND.STMB019	B63	22.4	281	0.36	30” *RCP*	36” TSD	STMB57	21.4	26.5	26.2	25.5	0.7
	A04W-10	STND.STMB018-STMH.STMB57 STMH.STMB52-STND.STMB016 STMH.STMB48-STND.STMB041 STND.STMB041-STND.STMB042 STMH.STMB46-STMH.STMB48 STND.STMB040-STMH.STMB46 STMH.STMB41-STND.STMB040 STMH.STMB39-STMH.STMB41 STND.STMB017-STND.STMB018 STMH.STMB54-STND.STMB017 STND.STMB016-	B63	15.8	1521	0.24	27” *RCP*	36” TSD	STMB39	25.0	29.5	30.3	26.8	3.5

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement A-8 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement A-8	
		STMH.STMB54												
58th Pl S /Russell Rd S intersection	A04W-11	STMH.STMB34- STMH.STMB39	B63	8.1	255	0.18	24" *RCP*		STMB34	25.4	29.5	30.8 (30.5)	27.3	3.2
	A04W-12	STMH.STMMM94- STMH.STMMM95 STMH.STMMM106- STMH.STMMM94	C384 C195	23.8	303	0.66	36" *RCP*		STMMM106	19.0	28.6	21.2	21.2	0.0
S 190th St /72nd Ave S intersection	A04W-13	STMH.STMMM103- STMH.STMMM106	C195	19.0	374	0.24	36" *RCP*		STMMM103	19.9	26.8	22.1	22.1	0.0
	A04W-14	STMH.STMA97- STMH.STMA96	C384	15.8	205	0.40	27" *RCP*		STMA97	15.9	25.4	23.7	23.7	0.0
S 193rd St /72nd Ave S intersection	A04W-15	STMH.STMA99- STMH.STMA97	C384	15.8	117	0.68	27" *RCP*		STMA99	16.7	26.2	18.5	18.5	0.0
S 194th St /72nd Ave S intersection	A04W-16	STMH.STMA100- STMH.STMA99	C384	10.8	282	0.53	24" *RCP*			18.2	25.5	20.1	20.1	0.0
	A04W-17	N/A	B85	3.4	50	0.20	30" *RCP*		STMMM176	18.0	24.7	21.6	21.6	0.0
S 190th St /68th Ave S intersection	A04W-18	STMH.STMMM177- STMH.STMMM176 STMH.STMMM178- STMH.STMMM177 STMH.STMMM179- STMH.STMMM178 STMH.STMMM192- STMH.STMMM179	B85	3.4	553	0.26	24" *RCP*		STMMM192	19.5	26.2	21.7	21.7	0.0
	A04W-19	STMH.STMMM181- STMH.STMMM192 STMH.STMMM174- STMH.STMMM181 STMH.STMMM175- STMH.STMMM174	B85	3.4	469	0.18	24" *RCP*		STMMM175	20.3	25.5	21.9	21.9	0.0
	A04W-20	STMH.STMMM268-	C195	3.4	325	0.40	18" RCP		STMMM267	21.6	25.5	22.7	22.7	0.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics: Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement A-8 Size/Type	Upstream CB Characteristics: City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Computed 25-year HGL Elevation at Upstream CB: Existing Conditions	With Recommended Improvement A-8	25-year Flood Elevation Reduction Benefit (ft)
		STMH.STMMM175 STMH.STMMM267-STMH.STMMM268												
	A04W-21	N/A	B85	3.4	44	0.11	30" *RCP*		STMA156	19.1	25.0	21.6	21.6	0.0
S 193rd St /68th Ave S intersection	A04W-22	STND.STMA013-STMH.STMA156 STMH.STMA154-STND.STMA013	B85	3.4	220	0.11	30" *RCP*		STMA154	19.4	26.4	21.6	21.6	0.0
S 194th St /68th Ave S intersection	A04W-23	STMH.STMA152-STMH.STMA154	B85	3.4	283	0.00	30" *RCP*		STMA152	19.4	26.2	21.6	21.6	0.0
S 194th Pl /68th Ave S intersection	A04W-24	STMH.STMA150-STMH.STMA152 STMH.STMA149-STMH.STMA150	B85	3.4	334	0.32	24" *RCP*		STMA149	20.4	26.3	21.8	21.8	0.0
	A04W-25	STMH.STMLL62-STMH.STMB26	B85	3.1	214	0.37	36" *RCP*		STMLL62	16.5	26.0	21.7	21.7	0.0
	A04W-26	STMH.STMLL61-STMH.STMLL62	B85	3.1	205	0.49	36" *RCP*		STMLL61	17.5	26.0	18.2	18.2	0.0
S 190th St /68th Ave S intersection	A04W-27	STMH.STMLL81-STMH.STMLL61 STMH.STMLL79-STMH.STMLL81	B85	3.1	302	0.33	36" *RCP*		STMLL79	18.5	26.0	19.2	19.2	0.0
	A04W-28	STMH.STMLL80-STMH.STMLL79 STMH.STMLL83-STMH.STMLL80	B85	3.1	351	0.29	36" *RCP*		STMLL83	19.5	26.1	20.3	20.3	0.0
	A04W-29	STMH.STMB24-STMH.STMB25	B85	7.2	177	0.28	36" *RCP*		STMB24	16.2	27.5	21.7	21.7	0.0
	A04W-30	STMH.STMB23-STMH.STMB24 STMH.STMB22-STMH.STMB23	B85	7.2	302	0.33	30" *RCP*		STMB22	17.2	26.5	21.8	21.8	0.0
	A04W-31	STMH.STMB21-STMH.STMB22 STMH.STMB20-STMH.STMB21	B85	7.2	301	0.33	30" *RCP*		STMB20	18.2	26.6	21.9	21.9	0.0
	A04W-32	STMH.STMB19-STMH.STMB20	B85	7.2	297	0.44	30" *RCP*		STMB18	19.5	26.5	20.6	20.6	0.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement A-8 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement A-8	
		STMH.STMB18-STMH.STMB19												
S 196th St /68th Ave S intersection	A04W-33	STMH.STMB17-STMH.STMB18 STMH.STMB11-STMH.STMB17	B85	7.2	332	0.39	30” *RCP*		STMB11	20.8	26.7	22.2	22.2	0.0
S 190th St /68th Ave S intersection	A04W-34	STMH.STMLL59-STMH.STMB194	B85	29.4	719	0.07	60” *RCP*		STMLL59	16.1	25.4	21.9	21.9	0.0
	A04W-35	STMH.STMLL58-STMH.STMLL59	C289	29.4	195	1.04	30” *RCP*	36” TSD	STMLL58	18.2	23.4	20.8	20.7	0.1
S190th St /66th Ave S intersection	A04W-36	STMH.STMLL55-STMH.STMLL58 STMH.STMLL54-STMH.STMLL55	C289	29.4	337	0.18	30” *RCP*	36” TSD	STMLL54	18.8	23.2	22.8	21.5	1.3
	A04W-37	STMH.STMLL50-STMH.STMLL54	C289	26.2	176	0.51	30” *RCP*	36” TSD	STMLL50	19.7	26.0	23.7	22.0	1.7
	A04W-38	STMH.STMLL47-STMH.STMLL50	C289	26.2	400	0.20	30” *RCP*	36” TSD	STMLL47	20.5	26.1	25.6	22.9	2.7
S190th St /64th Ave S intersection	A04W-39	STMH.STMLL44-STMH.STMLL47	C289	26.2	156	0.20	30” *RCP*	36” TSD	STMLL44	20.8	25.6	26.4	23.3	3.1
	A04W-40	STMH.STMLL40-STMH.STMLL44	C289	21.9	197	0.24	27” *RCP*		STMLL40	21.3	27.3	27.6	24.5	3.1
	A04W-41	N/A	C289	21.9	348	0.10	27” *RCP*		STMLL37	21.6	28.4	29.9 (29.4)	26.8	2.6
S 190th St /62nd Ave S intersection	A04W-42	STMH.STMLL34-STMH.STMLL37	C289	8.3	162	0.18	27” *RCP*		STMLL34	21.9	27.5	29.6 (28.5)	27.0	1.5
	A04W-43	STND.STMB015-STMH.STMB146 STMH.STMB142-STND.STMB014	C289	36.3	326	0.34	48” *RCP*		STMB142	17.5	27.2	22.9	22.9	0.0
S 194th St /64th Ave S intersection	A04W-44	STMH.STMB139-STMH.STMB142	C289	36.3	383	0.26	42” *RCP*		STMB139	18.5	24.4	23.5	23.5	0.0
S 194th St /62nd Ave	A04W-45	STMH.STMB123-STMH.STMB139	C289	36.3	710	0.18	42” *RCP*		STMB119	19.7	26.8	24.6	24.6	0.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement A-8 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement A-8	
S intersection		STMH.STMB119-STMH.STMB123												
	A04W-46	STMH.STMB108-STMH.STMB119 STMH.STMB107-STMH.STMB108 STMH.STMB104-STMH.STMB107	C289	36.3	828	0.20	36" *RCP*		STMB104	21.4	28.4	27.2	27.2	0.0
	A04W-47	STMH.STMB101-STMH.STMB104 STMH.STMB98-STMH.STMB101 STMH.STMB95-STMH.STMB98	C289	36.3	757	0.17	36" *RCP*		STMB95	22.6	28.8	30.0	30.0	0.0

Notes:

All elevations shown are NAVD 88 datum (City current datum)

(23.0) = Estimated starting WSEL at outfall or overflow elevation at catch basin

Italicized values = Assumed parameters based on engineering judgment where not included in the City's GIS database

Table 6-7
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin B (Lower Springbrook Creek), Subbasin B04W (Reference Figure 7-10)

					TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		
Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement B-2 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement B-2	25-year Flood Elevation Reduction Benefit (ft)
S 196th St TSD												(23.2)	(23.2)	
Springbrook Ck to 196th St TSD	B04Wa-1		B99.4	54	100	0.08	42” RCP	54” TSD	STMU354	19.81	28.27	23.5	23.3	0.2
	B04Wa-2	STMH.STMU355-STMH.STMU354	B99.4	53	228	0.00	42” RCP	54” TSD	STMU355	19.80	30.05	24.9	23.8	1.1
	B04Wa-3	STMH.STMU356-STMH.STMU355	B99.4	53	235	0.00	42” RCP	54” TSD	STMU356	19.80	28.77	25.8	24.1	1.7
84th Ave S	B04Wa-4	STMH.STMA283-STMH.STMU356	B99.4	53	54	0.04	42” RCP	54” TSD	STMA283	19.82	28.22	26.2	24.2	2.0
	B04Wa-5		B99.4	38	80	0.20	42” RCP	54” TSD	STMA282	19.98	28.10	26.6	24.5	2.1
	B04Wa-6	STMH.STMA281-STMH.STMA282	B99.4	38	27	0.07	42” RCP	54” TSD	STMA281	20.00	27.51	26.7	24.7	2.0
	B04Wa-7		B99.4	38	42	0.17	42” RCP	54” TSD	STMA270	20.07	27.10	26.9	24.8	2.1
	B04Wa-8	STMH.STMA268-STMH.STMA270	B99.4	38	172	0.01	42” RCP	54” TSD	STMA268	20.09	26.24	27.3 (27.2)	25.0	2.2
	B04Wa-9	STMH.STMA266-STMH.STMA268	B99.4	38	166	0.03	42” RCP	54” TSD	STMA266	20.14	25.44	27.6 (26.4)	25.2	1.2
	B04Wa-10		B99.4	38	305	0.03	42” RCP	54” TSD	STMA263	20.24	25.64	28.2 (26.6)	25.5	1.1
81st Ave S	B04Wa-11	STMH.STMA262-STMH.STMA263	B99.4	15	34	Adverse	36” RCP	54” TSD	STMA262	20.22	25.67	28.5 (26.7)	25.6	1.1
	B04Wa-12	STMH.STMA258-STMH.STMA262	B99.4	15	97	0.15	36” RCP	54” TSD	STMA258	20.37	25.97	28.6 (27.0)	25.6	1.4
	B04Wa-13	STMH.STMA257-STMH.STMA258	B99.4	15	118	0.04	36” RCP	54” TSD	STMA257	20.42	26.42	28.7 (27.4)	25.6	1.8
84th Ave TSD												(20.5)	(20.5)	
Springbrook Ck to 84th Ave TSD	B04Wb-1		E183	131	103	0	54” RCP	72” TSD	STMU79	16.03	23.51	21.0	20.7	0.3
	B04Wb-2	STMH.STMU78-STMH.STMU79	E183	127	309	0.18	54” RCP	72” TSD	STMU78	16.63	27.51	23.9	21.2	2.7
	B04Wb-3	STMH.STMU77-STMH.STMU78	B52	127	113	0.23	54” RCP	72” TSD	STMU77	16.89	28.51	25.8	22.0	3.8

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement B-2 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement B-2	
	B04Wb-4	STMH.STMU76-STMH.STMU77	B52	127	222	0.18	54” RCP	72” TSD	STMU76	17.29	29.01	28.2	22.4	5.8
	B04Wb-5	STMH.STMU75-STMH.STMU76	B52	127	143	0.19	54” RCP	72” TSD	STMU75	17.56	26.51	30.3 (27.5)	23.1	4.4
	B04Wb-6	STMH.STMU74-STMH.STMU75	B52	127	221	0.20	54” RCP	72” TSD	STMU74	18.01	27.76	32.7 (28.8)	23.8	5.0
84th Ave S TSD	B04Wb-7	STMH.STMU69-STMH.STMU74	B52	127	222	0.16	48” RCP	72” TSD	STMU69	18.36	26.78	35.9 (27.8)	24.4	3.4
	B04W- 8	STMH.STMU62-STMH.STMU69	B52	120	316	0.17	42” RCP	72” TSD	STMU62	18.90	26.76	41.2 (27.8)	24.8	3.0
	B04Wb-9	STMH.STMU55-STMH.STMU62	B52	110	224	0.41	42” RCP	60” TSD	STMU55	19.81	27.06	47.5 (28.1)	25.4	2.7
	B04Wb-10	STMH.STMU50-STMH.STMU55	B52	100	306	0.22	42” RCP	54” TSD	STMU50	20.49	26.59	51.9 (27.6)	24.7	2.9
	B04Wb-11	STMH.STMU45-STMH.STMU50	B52	95	305	0.26	42” RCP	54” TSD	STMU45	21.28	27.22	55.6 (28.2)	25.8	2.4
	B04Wb-12	STMH.STMU40-STMH.STMU45	B52	90	336	0.35	42” RCP	54” TSD	STMU40	22.46	27.21	59.2 (28.2)	26.7	1.5
	B04Wb-13	STMH.STMU35-STMH.STMU40	B52	84	333	0.26	36” RCP	54” TSD	STMU35	23.31	27.96	61.8 (29.0)	27.5	1.5
	B04Wb-14	STMH.STMU30-STMH.STMU35	B52	77	338	0.24	30” RCP	48” TSD	STMU30	24.12	28.98	68.4 (30.0)	28.7	1.3
	B04Wb-15	STMH.STMU24-STMH.STMU30	B52	45	328	0.32	30” RCP	48” TSD	STMU24	25.17	30.17	60.4 (31.2)	29.3	1.9
	B04Wb-16	STMH.STMU23-STMH.STMU24	B52	39	155	0.76	30” RCP	36” TSD	STMU23	26.34	30.05	57.9 (31.0)	30.0	1.0
	B04Wb-17	STMH.STMU19-STMH.STMU23	B52	35	169	Adverse	30” RCP	36” TSD	STMU19	26.07	31.17	57.7 (32.2)	29.8	2.4
	B04Wb-18	STMH.STMU13-STMH.STMU19	B52	23	325	0.51	24” RCP	36” TSD	STMU13	26.56	32.40	59.7 (33.4)	30.5	2.9
	B04Wb-19	STMH.STME69-STMH.STMU13	B52	6.5	403	0.24	18” RCP	30” TSD	STME69	27.53	32.37	58.0 (33.4)	30.7	2.7
S 210th St	B04Wb-20	STMH.STME64-STMH.STME69	B52	4	389	0.22	18” RCP	24” TSD	STME64	28.39	32.55	57.1 (33.5)	30.8	2.7

Notes:

All elevations shown are NAVD 88 datum (City current datum)

(23.2) = Estimated starting WSEL at outfall or overflow elevation at catch basin

Italicized values = Assumed parameters based on engineering judgment where not included in the City’s GIS database

Table 6-8
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin B (Springbrook Creek), Subbasin B03E(north) (Reference Figure 7-11)

					TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		
Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement B-3 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement B-3	25-year Flood Elevation Reduction Benefit (ft)
S 180th St										10.0	26.4	(13.0)	(13.0)	
	B03E(north)-1	N/A	C332	71.8	29	0.00	36" *RCP*	54" TSD	N/A	10.0	26.4	15.7	13.9	1.8
	B03E(north)-2	STMH.STMMM94-STMH.STMMM228	C332	71.8	329	0.00	36" *RCP*	54" TSD	STMMM94	10.0	26.2	21.9	14.5	7.4
	B03E(north)-3	STMH.STMMM93-STMH.STMMM94	C332	71.8	521	0.60	36" *RCP*	54" TSD	STMMM93	11.7	24.9	30.3 (25.9)	15.4	10.5
	B03E(north)-4	STMH.STMMM227-STMH.STMMM93	N/A	71.8	52	0.02	36" *RCP*	54" TSD	STMMM227	11.7	24.9	28.9 (25.9)	15.7	10.2
80th Ave S /S 180th St intersection	B03E(north)-5	STMH.STMMM88-STMH.STMMM227 STMH.STMMM85-STMH.STMMM88	C332	71.8	556	*0.00*	36" *RCP*	54" TSD	STMMM85	*11.7*	24.1	33.0 (25.1)	16.4	8.7
	B03E(north)-6	STMH.STMMM79-STMH.STMMM85	C332	71.8	608	0.10	54" *RCP*		STMMM79	12.1	21.7	26.4 (22.7)	17.4	5.3
	B03E(north)-7	STMH.STMNN70-STMH.STMMM79	C332	71.8	515	0.26	54" *RCP*		STMNN70	13.4	22.0	23.9 (23.0)	18.2	4.8
	B03E(north)-8	STMH.STMNN26-STMH.STMNN70	C332	66.3	478	0.00	48" *RCP*		STMNN26	13.4	21.1	24.7 (22.1)	19.5	2.6
88th Ave S /S 180th St intersection	B03E(north)-9	STMH.STMNN25-STMH.STMNN26	C332	36.4	507	0.53	48" *CMP*		STMNN23	13.7	22.3	22.4	19.7	2.7
	B03E(north)-10	STMH.STMNN20-STMH.STMNN23	C332	33.1	399	0.11	36" *RCP*		STMNN20	14.1	22.7	23.9 (23.7)	21.1	2.6
	B03E(north)-11	STMH.STMNN834-STMH.STMNN20	C332 C685	3.5	78	1.82	18" *CMP*		STMNN834	15.5	21.8	24.4 (22.8)	21.7	1.1
	B03E(north)-12	STMH.STMNN19-STMH.STMNN20	C332 C685	3.5	151	0.33	18" *RCP*		STMNN832	16.0	22.2	23.1	21.9	1.2
	B03E(north)-13	STMH.STMNN19-STMH.STMNN832	C332 C685	3.5	66	0.00	18" *RCP*		STMNN19	16.0	22.3	23.3	22.0	1.3
	B03E(north)-14	STMH.STMNN833-STMH.STMNN19	C332 C685	3.5	63	0.00	18" *RCP*		STMNN833	15.7	23.2	23.4	22.1	1.3

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement B-3 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement B-3	
S 180th St /E Valley Hwy intersection	B03E(north)-15	N/A	C332 C685	3.5	80	0.00	18” *RCP*		STMNN16	15.5	24.1	23.6	22.3	1.3

Notes:

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(13.0) = Estimated starting WSEL at outfall or overflow elevation at catch basin

Italicized values = Assumed parameters based on engineering judgment where not included in the City’s GIS database

Table 6-9
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin C (Horseshoe Acres/Green River), Subbasin C02 (Reference Figure 7-12)

					TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		
Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement C-1 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement C-1	25-year Flood Elevation Reduction Benefit (ft)
Green R. SW of Kent-Des Moines Rd /SR 167				30.5						35.11	*40.80*	(38.6)	(38.6)	
	C02-1	STMH.STMM139-STMH.STMM140		30.5	324	0.31	42" *RCP*		STMM138	36.1	40.8	39.2	39.2	0.0
	C02-2	N/A		20.1	408	0	*24"RCP*		N/A	*36.1*	*43.1*	42.3	42.3	0.0
Open channel at SR 167 /Kent-Des Moines Rd										N/A	N/A	(39.1)	(40.1)	
	C02-3	STMH.STMM149-STMH.STMM148	C70	12.3	151	*0*	18" *RCP*	30" TSD	STMM148	37.6	42.6	42.3	40.4	1.9
6th Ave S between W Willis St and W Crow St	C02-4	STMH.STMM630-STMH.STMM149 STMH.STMM147-STMH.STMM630 STMH.STMM713-STMH.STMM147 STND.STMM0129-STMH.STMM713 STMH.STMM714-STND.STMM0129	REF.E242 CA19	7.5	461	0.27	18" *RCP*	24" TSD	STMM714	38.9	42.4	45.0 (43.4)	41.0	2.4
	C02-5	STMH.STMM181-STMH.STMM714	CA19 C134	7.5	195	0.29	18" *RCP*	24" TSD	STMM181	39.4	43.9	44.6	41.3	3.3
	C02-6	STMH.STMM180-STMH.STMM181	CA19 C134	6.1	232	0.16	18" *RCP*		STMM180	39.8	44.0	45.5 (45.0)	42.1	2.9
W Willis St /4th Ave S intersection	C02-7	STMH.STMM671-STMH.STMM180 STMH.STMM179-STND.STMM0136	CA19 C134	6.1	229	0.14	18" *RCP*		STMM179	40.1	43.1	46.1 (44.1)	43.2	0.9
West of 5th Ave S and W Crow St	C02-8	STMH.STMM954-STMH.STMM149 STMH.STMM150-	C70	4.8	300	0.26	15" *RCP*		STMM150	38.4	44.1	44.3	41.6	2.7

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement C-1 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement C-1	
intersection		STMH.STMM149												

Notes:

All elevations shown are NAVD 88 datum (City current datum)

(38.6) = Estimated starting WSEL at outfall or overflow elevation at catch basin

Italicized values = Assumed parameters based on engineering judgment where not included in the City's GIS database

Table 6-10
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin C (Horseshoe Acres – Green River), Subbasin C05 (Reference Figure 7-13)

					TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		
Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement C-2 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement C-2	25-year Flood Elevation Reduction Benefit (ft)
Detention Pond north of S 259th St				29.5						34.0	*52.5*	(38.0)	(38.0)	
West inlet of pond	C05-1	N/A	N/A	25.1	141	0.09	48” RCP		STMN147	34.1	52.5	38.1	38.1	0.0
	C05-2	STMH.STMN144-STMH.STMN146	B98	25.1	375	0.09	48” RCP		STMN144	34.4	42.3	38.3	38.3	0.0
Runs west off 3rd Ave S	C05-3	STMH.STMN145-STMH.STMN144 STMH.STMN148-STMH.STMN145	B98	10.4	348	0.60	36” RCP		STMN148	36.5	42.0	37.9	37.9	0.0
	C05-4	STMH.STMN150-STMH.STMN149 STMH.STMN149-STMH.STMN148	B98	10.4	494	0.16	30” RCP		STMN150	37.3	43.5	39.0	39.0	0.0
Runs north along 5th Ave S	C05-5	STMH.STMN151-STMH.STMN150 STMH.STMN152-STMH.STMN151	B98	9.1	417	0.25	24” RCP		STMN152	38.3	43.5	39.9	39.9	0.0
	C05-6	STMH.STMM1060-STMH.STMN152 STMH.STMM1061-STMH.STMM1060	B98	3.8	453	0.24	18” RCP		STMM106	39.4	44.3	40.7	40.7	0.0
Runs east off 5th Ave S	C05-7	STMH.STMM1062-STMH.STMM1061	B98	3.8	169	0.21	18” RCP		STMM106	39.8	44.5	41.1	41.1	0.0
Runs south along 5th Ave S	C05-8	STMH.STMN153-STMH.STMN150	B98	3.4	362	0.41	18” RCP		STMN153	38.8	46.1	39.9	39.9	0.0
Runs north along 3rd Ave S	C05-9	STMH.STMN143-STMH.STMN144	B98	19.8	549	0.10	36” RCP		STMM105	35.0	43.7	38.8	38.8	0.0
	C05-10	N/A	B98	15.1	336	0.44	30” RCP		STMM105	39.4	47.4	41.2	41.2	0.0
Proposed				6.2	*582*	*0.05*		18” TSD		*39.7*	*47.4*	*48.4*	*43.5*	*4.9*

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement C-2 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement C-2	
3rd Ave S extension														
East inlet of pond	C05-11	N/A	B98	12.2	111	0.37	24" RCP		N/A	34.4	46.3	38.5	38.5	0.0
	C05-12	STMH.STMN158-STMH.STMN157	B98	7.5	662	0.09	24" RCP		STMN158	35.0	45.7	39.4	39.4	0.0
	C05-13	STMH.STMM1063-STMH.STMN158 STMH.STMM1064-STMH.STMM1063	B98	7.5	584	0.24	18" RCP		STMM106	36.4	46.3	42.6	42.6	0.0
Proposed 1st Ave S extension				2.4	*582*	*0.05*		12" TSD		*36.7*	*46.3*	*47.3*	*45.6*	*1.7*

Notes:

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(38.0) = Estimated starting WSEL at outfall or overflow elevation at catch basin

Italicized values = Assumed parameters based on engineering judgment where not included in the City's GIS database

Table 6-11
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin C (Horseshoe Acres – Green River), Subbasin C07 (Reference Figure 7-14)

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement C-3 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement C-3	
Northern detention pond west of 79th Ave S/S 266th St junction										*35.8*	*45.1*	(37.8)	(37.8)	
	C07-1	N/A	C756.1	21.3	121	0.01	24" *RCP*		N/A	35.8	46.9	38.9	38.9	0.0
	C07-2	N/A	C756.1	21.3	227	0.33	24" *RCP*		N/A	36.6	46.5	40.9	40.9	0.0
	C07-3	N/A	C756.1	17.3	208	0.34	24" *RCP*		N/A	37.3	48.1	42.0	42.0	0.0
	C07-4	N/A	C756.1	15.0	456	0.50	24" *RCP*		N/A	39.6	49.4	41.9	41.9	0.0
Eastern detention pond south of S 266th St										40.0	*45.9*	(41.5)	(42.0)	
	C07-5	N/A	C756.1	15.0	71	2.07	18" *RCP*	24" TSD	N/A	41.5	45.9	44.0	43.2	0.8
	C07-6	N/A	C756.1	12.0	278	0.48	18" *RCP*	24" TSD	N/A	42.8	47.4	47.6	44.8	2.8
	C07-7	N/A	C756.1	12.0	197	0.54	18" *RCP*	24" TSD	N/A	43.9	47.5	50.5 (48.5)	45.9	2.6
Pump east of 79th Ave S/S 266th St junction										*37.4*	*45.2*	(38.4)	(38.4)	
	C07-8	STMH.STMN127-STMH.STMN126	C756	3.6	150	1.87	12" *RCP*		STMN127	40.2	46.9	41.3	41.3	0.0
79th Ave S /S 266th St junction	C07-9	STMH.STMN129-STMH.STMN127	C756	3.6	124	0.61	12" *RCP*		STMN129	40.9	47.6	43.0	43.0	0.0
	C07-10	STMH.STMN130-STMH.STMN129 STMH.STMN131-STMH.STMN130 STMH.STMN133-STMH.STMN131 STMH.STMN134-	C756	2.4	424	0.40	12" *RCP*		STMN134	42.6	45.7	45.0	45.0	0.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement C-3 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement C-3	
		STMH.STMN133												
North of 79th Ave S /S 266th St junction	C07-11	STMH.STMN136-STMH.STMN134	C756	2.4	150	0.49	12” *RCP*		STMN136	43.6	46.5	45.9	45.9	0.0
				3.9						41.2	47.6	(42.7)	(42.7)	
North of northern detention pond	C07-12		C756.1	3.9	99	0.53	18” *RCP*		N/A	41.7	47.7	42.9	42.9	0.0

Notes:

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(37.8) = Estimated starting WSEL at outfall or overflow elevation at catch basin

Italicized values = Assumed parameters based on engineering judgment where not included in the City’s GIS database

Table 6-12
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin C (Horseshoe Acres – Green River), Subbasin C08 (Reference Figure 7-15)

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement C-4 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement C-4	
Green River SE of Central Ave S/S 259th St intersection										*33.2*	*47.7*	(37.2)	(37.2)	
	C08-1	N/A	D178/B45	105.4	315	*0.00*	48" *RCP*	72" TSD	STMN41	33.2	47.7	39.1	37.7	1.4
	C08-2	STMH.STMN38-STMH.STMN41	D178/B45	105.4	295	0.22	48" *RCP*	72" TSD	STMN38	33.9	48.5	41.8	38.5	3.3
	C08-3	STND.STMN012-STMH.STMN38 STND.STMN011-STND.STMN012 STMH.STMN35-STND.STMN011	B45	61.5	178	0.29	36" *RCP*	48" TSD	STMN35	34.4	48.8	43.9	39.1	4.8
	C08-4	STND.STMN010-STMH.STMN35 STND.STMN009-STND.STMN010 STMH.STMN31-STND.STMN009	B45	61.5	313	0.28	36" *RCP*		STMN31	35.2	48.4	47.4	42.5	4.9
S 259th St /Central Ave S intersection	C08-5	STND.STMN008-STMH.STMN31 STMH.STMN27-STND.STMN007 STMH.STMN26-STMH.STMN27	B45	54.9	226	0.19	36" *RCP*		STMN27	35.7	47.8	49.7 (48.8)	44.9	3.9
	C08-6	STND.STMN004-STMH.STMN26 STND.STMP003-STND.STMP004 STMH.STMN19-STND.STMN003	B45	43.1	299	0.24	36" *RCP*		STMN19	36.4	48.5	50.3 (49.5)	46.4	3.1

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement C-4 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement C-4	
	C08-7	STND.STMN002-STMH.STMN19 STMH.STMN13-STND.STMN001	B45	43.1	400	0.10	36" *RCP*		STMN13	36.8	48.7	51.5 (49.7)	48.4	1.3
	C08-8	STMH.STMN11-STMH.STMN13	B45	33.8	80	0.80	30" *RCP*	36" TSD	STMN11	37.4	48.6	40.2	39.8	0.4
	C08-9	STND.STMM0149-STMH.STMN11 STND.STMM0148-STND.STMM0149 STMH.STMM187-STND.STMM0148	B45	33.8	268	0.18	30" *RCP*		STMM187	37.9	47.5	42.4	41.9	0.5
	C08-10	STND.STMM0147-STMH.STMM187 STND.STMM0146-STND.STMM0147	B45	33.8	394	0.37	30" *RCP*		STMM194	39.4	47.4	45.4	45.0	0.4
E Morton St/Central Ave S intersection	C08-11	STMH.STMM202-STMH.STMM194	B45	26.9	328	0.81	24" *RCP*	30" TSD	STMM202	40.6	47.3	51.1 (48.3)	43.0	5.3
	C08-12	STND.STMM0145-STMH.STMM608 STND.STMM0144-STND.STMM0145 STMH.STMM207-STND.STMM0144	B45	10.8	313	0.39	18" *RCP*		STMM207	41.8	46.4	52.5 (47.4)	47.1	0.3
	C08-13	STMH.STMM996-STND.STMM0162	C415 FLD	6.9	294	*0.00*	18" *RCP*		STMM996	*37.9*	*47.4*	49.9 (48.4)	44.6	3.8
	C08-14	STMH.STMM609-STMH.STMM608 STMH.STMM610-STMH.STMM609	C368	12.2	354	1.47	18" *RCP*		STMM610	43.1	53.2	44.8	44.8	0.0
	C08-15	STMH.STMM612-STMH.STMM610	C368	12.2	189	14.98	18" *RCP*		STMM612	71.4	84.1	73.1	73.1	0.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement C-4 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement C-4	
	C08-16	STMH.STMN43-STMH.STMN38 STND.STMN016-STMH.STMN43 STND.STMN015-STND.STMN016 STMH.STMN77-STND.STMN015	B45	43.9	307	2.02	36” *RCP*		STMN77	40.1	47.1	43.4	43.4	0.0
	C08-17	STMH.STMN48-STMH.STMN77	B45	33.3	158	0.04	36” *RCP*		STMN48	40.1	47.3	44.0	44.0	0.0
	C08-18	STND.STMN014-STMH.STMN48 STND.STMN013-STND.STMN014 STMH.STMN55-STND.STMN013	B45	26.9	260	0.40	30” *RCP*	36” TSD	STMN55	41.2	48.0	45.3	44.5	0.8
	C08-19	STMH.STMN59-STMH.STMN55	B45	26.9	305	0.28	27” *RCP*	36” TSD	STMN59	42.0	47.6	48.0	45.1	2.9
	C08-20	STND.STMN021-STMH.STMN59 STND.STMN020-STND.STMN021 STMH.STMN62-STND.STMN019	B45	20.6	302	0.28	24” *RCP*	30” TSD	STMN62	42.9	47.2	51.1 (48.2)	46.0	2.2
S 266th St /Central Ave S intersection	C08-21	STND.STMN019-STMH.STMN62 STND.STMN018-STND.STMN019 STMH.STMN67-STND.STMN018 STMH.STMN70-STMH.STMN67	B45	9.1	499	0.51	21” *RCP*	30” TSD	STMN70	45.4	48.3	50.2 (49.3)	47.0	2.3
S Alder Ln /Central Ave S intersection	C08-22	STMH.STMN77-STMH.STMN78 STMH.STMN81-STMH.STMN78	C451	21.1	343	0.49	24” *RCP*		N/A	41.7	48.6	46.7	47.1	0.0
	C08-23	N/A	C753	8.4	311	0.53	12” PVC	18” TSD	STMGG11	43.4	50.2	64.6 (51.2)	49.2	2.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement C-4 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement C-4	
	C08-24	STMH.STMGG116-STMH.STMGG117	C753	8.4	39	1.39	12” PVC	18” TSD	STMGG11	43.9	50.3	54.2 (51.3)	45.5	5.8
	C08-25	STMH.STMGG115-STMH.STMGG116	C753	8.4	92	0.38	12” *PVC*	18” TSD	STMGG11	44.3	49.5	57.2 (50.5)	46.3	4.2
	C08-26	STMH.STMGG114-STMH.STMGG115	C753	8.4	180	0.32	12” *PVC*	18” TSD	STMGG11	44.8	47.6	63.0 (48.6)	47.9	0.7
	C08-27	STMH.STMN101-STMH.STMN100 STMH.STMGG57-STMH.STMN101	C386 C789	11.9	779	1.19	21” *RCP*		STMGG57	44.9	50.5	46.7	46.7	0.0
	C08-28	STMH.STMGG61-STMH.STMGG57 STMH.STMGG62-STMH.STMGG61	C395	3.4	445	0.84	18” *RCP*		STMGG62	48.6	53.0	49.8	49.8	0.0

Notes:

All elevations shown are NAVD 88 datum (City current datum)

(37.2) = Estimated starting WSEL at outfall or overflow elevation at catch basin

Italicized values = Assumed parameters based on engineering judgment where not included in the City’s GIS database

Table 6-13
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin G (Upper Mill Creek), Subbasin G07E7 (Reference Figure 7-17)

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement G-1 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement G-1	
North Fork Upper Mill Creek under Kent Kangley Rd												418.9	418.9	0.0
	G05E7-1	UNK	UNK	24.50	91	4.48	60" *RCP*		Ditch	417.9	418.0(EXT) 419.0(PRP)	419.5	419.5	0.0
Open channel north of Kent Kangley Rd										410	N/A	(413)	(413)	0.0
	G05E7-2	UNK	C251	24.10	42	0.26	27" *RCP*	36" TSD	STMFF129	410.1	417.0	414.1	413.3	0.8
	G05E7-3	STMH.STMFF128-STMH.STMFF129	C251	23.30	55	0.55	27" *RCP*	36" TSD	STMFF128	410.4	416.4	414.8	413.6	1.2
	G05E7-4	STND.STMFF033-STMH.STMFF128-STMH.STMFF123-STND.STMFF033	C251	21.80	243	0.40	27" *RCP*	36" TSD	STMFF123	411.4	417.3	416.2	414.2	2.0
	G05E7-5	STMH.STMFF121-STMH.STMFF123	C251	20.30	214	1.62	24" *RCP*	36" TSD	STMFF121	414.9	419.4	420.3	416.6	3.7
	G05E7-6	STMH.STMFF120-STMH.STMFF121	C251	18.80	120	0.60	24" *RCP*	36" TSD	STMFF120	415.6	420.6	421.4	417.2	4.2
110 Pl SE between 256 St and Kent Kangley Rd	G05E7-7	STMH.STMFF117-STMH.STMFF120	C251	18.00	174	0.50	24" *RCP*	36" TSD	STMFF117	416.5	422.4	422.8	418.1	4.7
	G05E7-8	STMH.STMFF115-STMH.STMFF117	C251	17.44	95	0.55	24" *RCP*	36" TSD	STMFF115	417.0	426.3	424.1	419.1	5.0
	G05E7-9	STMH.STMFF113-STMH.STMFF115	C251	17.29	134	0.25	24" *RCP*	36" TSD	STMFF113	417.3	425.2	425.1	419.3	5.8
	G05E7-10	STMH.STMFF111-STMH.STMFF113	C251	17.29	252	0.25	24" *RCP*	36" TSD	STMFF111	417.9	423.1	427.3 (424.1)	420.1	4.0
	G05E7-	STMH.STMFF331-	FLD	17.29	20	1.90	18" *RCP*	36" TSD	STMFF331	418.3	424.5	428.6	420.3	5.2

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement G-1 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement G-1	
	11	STMH.STMFF111										(425.5)		
109th Pl SE and SE 256th St intersection	G05E7-12	STMH.STMBB203-STMH.STMFF331	FLD	16.93	59	2.24	18" *RCP*	36" TSD	STMBB203	419.6	423.2	432.3 (424.2)	421.7	2.5
109th Ave SE and 256th St intersection	G05E7-13	STMH.STMBB156-STMH.STMBB203	C345	16.56	261	0.46	18" *RCP*	36" TSD	STMBB156	420.8	429.3	440.8 (430.3)	422.9	7.4
	G05E7-14	STMH.STMBB157-STMH.STMBB156	C345	16.56	12	2.00	18" *RCP*	36" TSD	STMBB157	421.1	429.6	442.7 (430.6)	423.1	7.5
	G05E7-15	STMH.STMBB158-STMH.STMBB157	C345	16.56	18	0.50	24" *RCP*	36" TSD	STMBB158	421.2	423.9	443.4 (424.9)	423.2	1.7
	G05E7-16	STMH.STMBB159-STMH.STMBB158	C345	16.20	94	0.17	24" *RCP*	36" TSD	STMBB159	421.3	426.4	445.7 (427.4)	423.5	3.9
	G05E7-17	STMH.STMBB163-STMH.STMBB159	C345	15.84	146	0.43	35" x 24" arch RCP	36" TSD	STMBB163	422.0	425.1	446.6 (426.1)	424.2	1.6
	G05E7-18	STMH.STMBB164-STMH.STMBB163	C345	15.84	35	0.51	35" x 24" arch RCP		STMBB164	422.1	424.9	446.9 (425.9)	424.5	1.4
	G05E7-19	STMH.STMBB165-STMH.STMBB164	C345	15.48	144	0.14	35" x 24" arch RCP		STMBB165	422.3	426.0	447.8 (427.0)	425.6	1.4
SE 254th Pl and 109th Ave SE intersection	G05E7-20	STMH.STMBB696-STMH.STMBB165	C345	13.68	105	0.39	35" x 24" arch RCP		STMBB696	422.7	426.5	448.3 (427.5)	426.1	1.4
	G05E7-21	STMH.STMBB168-STMH.STMBB696	C345	13.40	33	0.15	35" x 24" arch RCP		STMBB168	422.8	427.0	448.6 (428.0)	426.5	1.5
	G05E7-22	STMH.STMBB170-STMH.STMBB168	C345	13.10	102	0.29	24" *RCP*		STMBB170	423.1	427.8	449.3 (428.8)	427.2	1.6
	G05E7-23	STMH.STMBB173-STMH.STMBB170	C345	12.60	120	0.19	24" *RCP*		STMBB173	423.3	428.6	450.1 (429.6)	428.0	1.6
108th Pl SE and 109th Ave SE	G05E7-24	STMH.STMBB175 -STMH.STMBB173	C345	11.50	143	0.17	21" *RCP*	24" TSD	STMBB175	423.6	429.5	451.4 (430.5)	428.6	1.9
	G05E7-25	STMH.STMBB177-STMH.STMBB175	C345	10.00	148	0.13	21" *RCP*	24" TSD	STMBB177	423.8	430.5	452.4 (431.5)	429.2	2.3

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement G-1 Size/Type	Upstream CB Characteristics City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Computed 25-year HGL Elevation at Upstream CB Existing Conditions	With Recommended Improvement G-1	25-year Flood Elevation Reduction Benefit (ft)
	G05E7-26	STMH.STMBB179-STMH.STMBB177	C345	8.30	153	0.11	21” *RCP*	24” TSD	STMBB179	423.9	431.5	453.1 (432.5)	429.5	3.0
	G05E7-27	STMH.STMBB181-STMH.STMBB179	C345	8.26	85	-0.08 (0.00)	21” *RCP*	24” TSD	STMBB181	423.9	432.3	453.6 (433.3)	429.8	3.5
	G05E7-28	STMH.STMBB182-STMH.STMBB181	C345	8.26	31	15.94	18” *RCP*	24” TSD	STMBB182	428.8	432.2	458.1 (433.2)	430.4	2.8
	G05E7-29	STMH.STMBB185-STMH.STMBB182	UNK	7.50	150	0.80	*15” RCP*	18” TSD	STMBB185	430.0	433.5	461.0 (434.5)	431.8	2.7
	G05E7-30	STMH.STMBB187-STMH.STMBB185	C345	6.20	141	0.71	15” *RCP*	18” TSD	STMBB187	431.0	434.7	462.9 (435.7)	432.6	3.1
	G05E7-31	STMH.STMBB189-STMH.STMBB187	C345	5.00	147	0.81	15” *RCP*	18” TSD	STMBB189	432.2	435.8	466.3 (436.8)	433.6	3.2
SE 250th St and 109th Ave SE	G05E7-32	STMH.STMBB191-STMH.STMBB189	C345	4.13	92	1.33	12” *RCP*	18” TSD	STMBB191	433.4	436.5	471.1 (437.5)	434.6	2.9

Notes:

All elevations shown are NAVD 88 datum (City current datum)

Link 1 is a culvert so the rim elevation changes as the top of pipe changes

Italicized values = Assumed parameters based on engineering judgment where not included in the City’s GIS database

Table 6-14
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin G (Upper Mill Creek), Subbasin G05E (Reference Figure 7-18)

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics: Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement G-2 Size/Type	Upstream CB Characteristics: City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Computed 25-year HGL Elevation at Upstream CB: Existing Conditions	With Recommended Improvement G-2	25-year Flood Elevation Reduction Benefit (ft)
North Fork Upper Mill Creek Southern end of shopping center												363.6	363.6	0.0
	G05E4-1		C730	86.50	50	-0.22 (0.00)	48" RCP	60" TSD	STMFF710	EX 359.5 PR 358.8	369.7	364.9	364.1	0.8
	G05E4-2	STMH.STMFF710-STMH.STMFF708	C730	86.50	181	0.32	48" CMP	60" TSD	STMFF708	EX 360.1 PR 359.3	366.2	368.2 (367.2)	364.8	2.4
	G05E4-3	UNK	C730	86.50	211	0.48	57" x 38" Arch CP (48" RCP)	60" TSD	STMFF256	EX 361.1 PR 360.0	366.3	369.4 (367.3)	365.1	2.2
	G05E4-4	STMH.STMFF256-STMH.STMFF291	C364	80.80	393	0.17	*57" x 38" Arch CP (48" RCP)*	2 to 42" TSD	STMFF291	EX 361.8 PR 361.1	366.0	371.0 (367.0)	365.6	1.4
SE 260th St and 104th Ave SE intersection	G05E4-5	STMH.STMFF291-STMH.STMFF246	C364	79.38	264	0.53	*57" x 38" Arch CP (48" RCP)*	2 to 42" TSD	STMFF246	361.9	367.7	372.8 (368.7)	366.4	2.3
SE 260th St and 104th Ave SE intersection	G05E4-6	STMH.STMFF246-STMH.STMFF58	C364	68.61	28	-0.11 (0.00)	36" CMP	60" TSD	STMFF58	361.9	368.2	373.5 (369.2)	366.7	6.0
North of SE 260th St and 104th Ave SE intersection	G05E4-7	STMH.STMFF58-STND.STMFF023-STND.STMFF022-STMH.STMFF49	B48	6.42	368	2.08	21" *RCP*	36" TSD	STMFF049	369.5	374.9	376.0 (375.9)	370.5	5.4
	G05E4-8	STMH.STMFF49-STMH.STMFF021	B48	6.42	155	3.52	18" *RCP*	36" TSD	UNK	*EX 375.0 PR 373.1*	*377.5*	376.2	374.0	2.2

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement G-2 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement G-2	
East of SE 260th St and 104th Ave SE intersection	G05E4-9	STMH.STMFF246-STMH.STMFF247	C364	10.77	21	6.43	27" RCP	36" TSD	STMFF247	363.3	368.2	373.3 (369.2)	366.6	2.6
	G05E4-10	STMH.STMFF247-STND.STMFF031-STMH.STMFF248	C364	10.77	95	1.05	27" RCP		STMFF248	364.3	370.0	373.6 (371.0)	367.0	4.0
	G05E4-11	STMH.STMFF248-STMH.STMFF249	C364	8.58	216	1.32	24" RCP		STMFF249	367.1	378.4	374.6	368.4	6.2
	G05E4-12	STMH.STMFF249-STND.STMFF030-UNK-UNK-UNK-MH.STMFF250	C364	7.19	297	1.51	24" RCP		STMFF250	371.6	385.6	375.6	372.8	2.8
	G05E4-13	STMH.STMFF250-STND.STMFF027-STMH.STMFF251	B67	4.19	158	8.33	18" RCP		STMFF251	384.8	393.0	386.0	386.0	0.0
SE 260th St and 104th Ave SE intersection	G05E4-14	STMH.STMFF58-STMH.STMFF290	B48	62.19	20	0.55	36" CMP	48" TSD	STMFF290	*EX 362.0* PR 362.1	*369.0*	377.5 (370.0)	367.1	2.9
	G05E4-15	STMH.STMFF290-STMH.STMFF56	B48	62.19	17	5.88	36" *RCP*	48" TSD	STMFF56	*EX 363.0* PR 362.3	*368.0*	366.6	367.3	
	G05E4-16	STMH.STMFF56-STND.STMFF015-STND.STMFF014-STND.STMFF013-UNK-UNK-UNK	B66	62.19	293	0.86	36" *RCP*	48" TSD	STMFF201	365.5	372.0	370.9	369.4	1.5
	G05E4-17	STMH.STMFF201-STMH.STMFF204	B66	59.75	266	2.00	36" *RCP*	48" TSD	STMFF204	370.8	379.2	377.0	374.3	2.7
	G05E4-18	STMH.STMFF204-STMH.STMFF18	B66	58.94	143	-0.21 (0.00)	36" *RCP*	48" TSD	STMFF18	369.7	379.0	379.7	375.0	4.7
	G02E4-19	STMH.STMFF18-STMH.STMFF23	UNK	54.88	229	0.77	*36" RCP*	48" TSD	STMFF23	371.4	381.2	382.0	375.8	6.2

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement G-2 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement G-2	
	G05E4-20	STMH.STMFF23-STMH.STMFF29	C122	54.07	227	0.85	36" *RCP*	48" TSD	STMFF29	373.4	382.8	384.5 (383.8)	376.0	7.8
	G05E4-21	STMH.STMFF29-STND.STMFF012-STND.STMBB011-STMH.STMBB106	C122	48.65	269	0.64	36" *RCP*	48" TSD	STMBB106	375.1	384.1	386.5 (385.1)	377.6	7.5
	G05E4-22	STMH.STMBB106-STMH.STMBB105	CA21	48.05	127	0.66	36" *RCP*	48" TSD	STMBB105	375.9	*387.0*	388.3 (388.0)	379.2	8.8
	G05E4-23	STMH.STMBB105-STMH.STMBB104	CA21	48.05	27	0.56	36" *RCP*	48" TSD	STMBB104	376.1	*387.0*	389.5 (388.0)	379.8	8.2
SE 256th St between 102nd Pl SE and 104th Ave SE	G05E4-24	STMH.STMBB104-STMH.STMBB442	CA21	48.05	60	0.68	36" *RCP*	48" TSD	STMBB442	376.5	*387.0*	402.3 (388.0)	379.8	8.2
102nd Pl SE and SE 256th St intersection	G05E4-25	STMH.STMBB442-STMH.STMBB102	CA21	11.58	179	1.48	24" *RCP*		STMBB102	379.1	386.6	403.7 (387.6)	382.1	5.5
	G05E4-26	STMH.STMBB102-STMH.STMBB101	CA21	11.58	115	0.14	18" *RCP*		STMBB101	*379.3*	*387.0*	391.0 (388.0)	383.8	4.2
	G05E4-27	STMH.STMBB142-STMH.STMBB111	CA21	33.59	323	1.62	30" *RCP*		STMBB111	381.7	393.0	397.2 (394.0)	386.0	8.0
SE 256th St and 104th Ave SE intersection	G05E4-28	STMH.STMBB111-STMH.STMBB439	CA21	33.59	48	0.42	30" *RCP*		STMBB439	381.9	394.1	409.9 (395.1)	387.5	7.6
	G05E4-29	STMH.STMBB439-STMH.STMBB438	B48	18.48	89	3.81	21" *RCP*		STMBB438	385.3	396.0	414.7 (397.0)	392.3	4.7
	G05E4-30	STMH.STMBB438-STMH.STMBB91	B48	18.48	56	1.23	21" *RCP*		STMBB91	386.0	396.5	416.8 (397.5)	394.4	3.1
	G05E4-31	STMH.STMBB91-STND.STMBB009-UNK-UNK	B48	16.72	276	3.26	21" *RCP*		STMBB87	395.0	401.9	427.5 (402.9)	397.9	5

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement G-2 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement G-2	
SE 253rd Pl and 104th Ave SE intersection	G02E4-32	STMH.STMBB87-STND.STMBB007-STND.STMBB006-STND.STMBB005-STMH.STMBB79	B48	9.71	397	2.02	21" *RCP*		STMBB79	403.0	410.0	433.0 (411.0)	404.9	6.1
	G05E4-33	STMH.STMBB79-STND.STMBB004-STND.STMBB003-STMH.STMBB74	B48	1.94	413	1.94	18" *RCP*		STMBB74	411.0	417.9	433.5 (419.0)	411.8	7.2
SE 256th St and 104th Ave SE intersection	G05E4-34	STMH.STMBB439-STMH.STMBB115	C116	6.34	46	2.59	30" *RCP*		STMBB115	383.1	394.4	398.7 (395.4)	387.6	7.8
	G05E4-35	STMH.STMBB115-STMH.STMBB118	C116	6.34	73	12.67	18" *RCP*		STMBB118	392.4	396.4	404.6 (397.4)	395.1	2.3
	G05E4-36	STMH.STMBB118-STMH.STMBB120	C116	6.34	108	2.44	18" *RCP*		STMBB120	*395.0*	*400.0*	406.5 (401.0)	397.0	4
SE 256th St and SE Kent Kangley Rd intersection	G05E4-37	STMH.STMBB120-STMH.STMBB121	C116	6.34	134	1.70	18" *RCP*		STMBB121	397.3	403.3	408.2 (404.3)	399.0	5.3
SE 256th St and SE Kent Kangley Rd intersection	G05E4-38	STMH.STMBB121-STMH.STMBB124	C116	6.34	40	1.90	18" *RCP*		STMBB124	398.0	403.3	408.9 (404.3)	399.7	9.2
	G05E4-39	UNK	C116	6.34	131	3.12	12" *RCP*	18" TSD	STMBB129	402.1	*407.0*	414.6 (408.0)	403.7	4.3
	G05E4-40	STMH.STMBB129-STMH.STMFF70	CA29	6.34	37	3.57	*12" RCP*	18" TSD	STMFF70	403.5	406.3	417.4 (407.3)	405.1	2.2
	G05E4-41	STMH.STMFF70-STMH.STMFF74	CA29	6.34	193	1.99	15" RCP		STMFF74	407.3	411.2	422.0 (412.2)	410.0	2.2

Notes

All elevations shown are NAVD 88 datum (City current datum)

Arch pipe was modeled with equivalent area round pipe; modeled sizes are in parenthesis

Where negative slopes were present, outlet invert elevations were changed to make the slope 0; altered elevations and slopes are shown in the table in parenthesis

Italicized values = Assumed parameters based on engineering judgment where not included in the City's GIS database

Table 6-15
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin G (Upper Mill Creek), Subbasin G04E (Reference Figure 7-21)

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement G-5 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement G-5	
Upper Mill Creek embankment												233.1	233.1	0.0
	G04E1-1	UNK	C154	20.8	32	0	30" RCP		STMGG97	230.5	343.5	233.3	233.3	0.0
	G04E1-2	STMH.STMGG96-STMH.STMGG97	C154	20.8	75	54.27	15" RCP	30" TSD	STMGG96	271.2	278.5	274.7	273.1	1.6
	G04E1-3	STMH.STMGG50-STMH.STMGG96	C154	20.8	90	38.61	15" RCP	30" TSD	STMGG50	306.0	308.7	313.9 (309.7)	308.5	1.2
	G04E1-4	STMH.STMGG49-STMH.STMGG50	B66	20.8	57	15.67	15" RCP	30" TSD	STMGG49	314.9	322.1	322.8	317.4	5.4
	G04E1-5	STMH.STMGG48-STMH.STMGG49	B66	7.7	16	18.06	15" RCP	24" TSD	STMGG48	317.8	319.1	327.1 (320.1)	319.4	.7
98th Ave S and 97th Pl	G04E1-6	STND.STMGG001-STMH.STMGG48 STND.STMAA036-STND.STMGG001 STMH.STMAA314-STND.STMAA036	B66	7.7	18	0.63	18" RCP	24" TSD	STMAA314	319.9	323.1	329.3 (324.1)	321.5	2.6
	G04E1-7	STMH.STMAA315-STMH.STMAA314	B66	7.7	8	3.25	12" RCP		STMAA315	3202	324.7	330.4 (325.7)	322.7	3
	G04E1-8	STMH.STMAA316-STMH.STMAA315	B66	4.6	35	5.77	12" RCP		STMAA316	322.2	*332.0*	332.8	325.1	7.7
	G04E1-9	STMH.STMAA235-STMH.STMAA316	FLD	4.6	130	5.86	18" RCP		STMAA235	329.8	336.0	331.1	331.1	0.0
	G04E1-10	STMH.STMAA234-STMH.STMAA235	C257	4.6	122	9.69	18" RCP		STMAA234	341.6	356.9	343.0	343.0	0.0
	G04E1-11	STMH.STMAA233-STMH.STMAA334	C257	4.6	65	16.29	18" RCP		STMAA233	352.2	*357.0*	353.5	353.5	0.0
	G04E1-12	STMH.STMAA232-STMH.STMAA333	UNK	3.1	37	3.22	12" RCP		STMAA232	353.4	*358.0*	354.3	354.3	0.0
	G04E1-13	STMH.STMAA231-STMH.STMAA332	CA21	1.5	163	5.37	12" RCP		STMAA231	362.2	*367.0*	362.8	362.8	0.0
	G04E1-14	STMH.STMAA230-STMH.STMAA231	CA21	1.2	203	5.10	12" RCP		STMAA230	372.5	*376.0*	373.1	373.1	0.0
	G04E1-	STMH.STMAA698-	CA21	0.6	141	3.72	12" RCP		STMBB93	378.1	*381.0*	378.1	378.1	0.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement G-5 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement G-5	
	15	STMH.STMAA726												
E Canyon Dr SE and 100th Pl SE	G04E1-16	STMH.STMAA699-STMH.STMAA698	CA21	0.4	131	2.10	12" RCP		STMBB94	380.5	*384.0*	380.8	380.8	0.0
	G04E1-17	STND.STMGG004-STMH.STMGG49-STMH.STMGG43-STND.STMGG004 STND.STMGG003-STMH.STMGG43	B66	12.0	314	2.72	27" RCP		STMGG43	323.4	327.2	324.9	324.9	0.0
	G04E1-18	STND.STMGG003-STMH.STMGG43-STMH.STMGG40-STND.STMGG003	B66	10.2	353	1.60	24" RCP		STMGG40	329.1	333.4	330.4	330.4	0.0
	G04E1-19	STND.STMGG002-STMH.STMGG40 STMH.STMFF237-STND.STMGG002	B66	8.8	354	1.91	24" RCP		STMFF237	335.8	340.2	337.1	337.1	0.0
	G04E1-20	STND.STMFF010-STMH.STMFF237 STMH.STMFF235-STND.STMFF010	B66	9.1	347	1.27	24" RCP		STMFF235	340.2	346.6	341.5	341.5	0.0
	G04E1-21	STMH.STMFF233-STMH.STMFF235	B66	1.8	269	1.47	18" RCP		STMFF235	344.2	349.5	344.7	344.7	0.0

Notes:

All elevations shown are NAVD 88 datum (City current datum)

Italicized values = Assumed parameters based on engineering judgment where not included in the City's GIS database

Table 6-16
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin G (Upper Mill Creek), Subbasin G03E (Reference Figure 7-22)

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement G-6 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement G-6	
100th Ave SE and S 248th St												368.8	368.8	0.0
	G03E2-1	UNK	C493	8.66	73	0.56	21” RCP		STMBB282	367.4	384.2	369.3	369.3	0.0
	G03E2-2	STMH.STMBB284-STMH.STMBB282	C493	0.92	61	23.93	18” RCP		STMBB284	382.0	386.0	382.4	382.4	0.0
	G03E2-3	STMH.STMBB283-STMH.STMBB284	C493	0.61	188	3.90	12” CMP		STMBB283	389.4	369.7	389.7	389.7	0.0
	G03E2-4	STMH.STMBB65-STMH.STMBB2830	C709	0.55	319	3.35	12” CMP		STMBB650	409.6	412.9	410.0	410.0	0.0
	G03E2-5	STMH.STMBB639-STMH.STMBB650	C754	0.43	88	6.08	12” RPVC		STMBB639	415.0	418.2	415.3	415.3	0.0
	G03E2-6	STMH.STMBB640-STMH.STMBB369	C754	0.30	108	5.54	12” RPVC		STMBB640	420.9	424.1	421.2	421.2	0.0
SE 248th St and 103rd Ave SE	G03E2-7	STMH.STMBB651-STMH.STMBB640	C754	0.25	82	5.54	12” RPVC		STMBB648	425.5	428.6	425.7	425.7	0.0
100th Ave SE and SE 248th St	G03E2-8	STMH.STMBB260-STMH.STMBB282	UNK	7.44	65	0.92	12” RCP	18” TSD	STMBB260	368.0	383.4	374.2	369.8	4.4
100th Ave SE and SE 247th Pl	G03E2-9	STMH.STMBB261-STMH.STMBB260	C493	7.44	168	0.23	12” RCP	18” TSD	STMBB261	368.4	380.9	382.2	375.2	7

Notes:

All elevations shown are NAVD 88 datum (City current datum)

Italicized values = Assumed parameters based on engineering judgment where not included in the City’s GIS database

Table 6-17
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin G (Upper Mill Creek), Subbasin G02E (Reference Figure 7-23)

				Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		
Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference		Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement G-7 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement G-7	25-year Flood Elevation Reduction Benefit (ft)
Upper Mill Creek embankment												131.3	131.3	
	G02E1-1	UNK	UNK	26.6	16	0.05	27” *RCP*	30” TSD	STMAA290	129.9	141.5	132.1	132.0	0.1
	G02E1-2	STMH.STMAA289-STMH.STMAA290	C154	26.6	123	0.57	18” *RCP*	30” TSD	STMAA289	199.5	208.5	231.3 (209.5)	202.4	7.1
	G02E1-3	STMH.STMAA288-STMH.STMAA289	UNK	26.6	75	0.16	18” *RCP*	30” TSD	STMAA288	241.9	249.3	247.9	244.1	3.8
Canyon Dr SE of 94th Ave S	G02E1-4	STMH.STMAA287-STMH.STMAA288	C154	26.6	65	0.03	30” *RCP*		STMAA287	244.1	249.8	250.2	247.1	3.1
	G02E1-5	STMH.STMAA281-STMH.STMAA287	C154	14.1	161	0.06	18” *RCP*		STMAA281	253.5	257.5	260.5	257.4	3.1
	G02E1-6	STMH.STMAA267-STMH.STMAA281	C154	14.1	109	0.04	18” *RCP*		STMAA267	372.2	375.5	275.9	259.6	16.3
94th Ave S north of Canyon Dr SE	G02E1-7	STMH.STMAA266-STMH.STMAA267	C154	9.74	112	0.01	18” *RCP*		STMAA266	373.0	376.1	277.1	267.4	9.7
	G02E1-8	STMH.STMAA285-STMH.STMAA287	C154	12.35	34	0.01	30” *RCP*		STMAA285	244.4	250.5	247.2	245.8	1.4
	G02E1-9	STMH.STMAA284-STMH.STMAA285	C154	12.35	47	0.07	24” *RCP*		STMAA284	247.7	252.8	249.2	249.2	0
	G02E1-10	STMH.STMAA736-STMH.STMAA284	C832	10.53	92	0.04	24” RCP		STMAA736	251.8	256.5	253.2	253.2	0
	G02E1-11	UNK	C832	9.98	131	0.05	24” RCP		STMAA737	257.8	263.0	259.2	259.2	0
94th Ave S and S 248th St intersection	G02E1-12	UNK	C832	9.44	108	0.06	24” RCP		STMAA738	263.9	272.0	265.6	265.6	0
	G02E1-13	UNK	C832	9.44	154	0.08	24” RCP		STMAA739	276.7	283.7	278.5	278.5	0

Notes:
All elevations shown are NAVD 88 datum (City current datum)
Italicized values = Assumed parameters based on engineering judgment where not included in the City’s GIS database

Table 6-18
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin H (Soos Creek/Meridian Valley), Subbasin H11 (Reference Figure 7-25)

					TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		
Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement H-2 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement H-2	25-year Flood Elevation Reduction Benefit (ft)
												374.8	374.8	0.0
	H11-1	UNK	MVCC	37.4	139	0.14	21" *RCP*	30" TSD	UNK	373.2	379.8	384.4 (380.8)	376.6	4.2
	H11-2	UNK	MVCC	36.9	35	3.43	21" *RCP*	30" TSD	UNK	374.4	379.8	391.8 (380.8)	378.2	2.6
	H11-3	UNK	MVCC	26.0	110	3.66	18" *RCP*	30" TSD	UNK	378.4	382.5	403.6 (383.5)	381.4	2.1
	H11-4	UNK	MVCC	25.3	113	6.14	18" *RCP*	30" TSD	UNK	385.4	390.7	415.7 (391.7)	388.2	3.5
	H11-5	UNK	C783	23.9	134	1.97	24" *RCP*	30" TSD	UNK	388.0	391.1	421.2 (392.1)	390.0	2.1
	H11-6	UNK	UNK	23.9	164	9.73	18" *RCP*	24" TSD	UNK	404.0	408.2	451.2 (409.2)	406.2	3
	H11-7	UNK	C788	23.9	33	7.24	18" *RCP*	24" TSD	STMOO299	406.4	411.2	461.3 (412.2)	409.7	2.5
132nd Ave SE and SE 245th St intersection	H11-8	STMH.STMOO298-STMH.STMOO299	FLD	7.1	132	2.46	18" *RCP*		STMOO298	409.6	412.5	463.6 (413.5)	412.0	1.5
	H11-9	STMH.STMOO297-STMH.STMOO298	FLD	7.0	165	6.53	18" *RCP*		STMOO297	420.4	424.2	471.1 (425.2)	421.7	3.5
	H11-10	STMH.STMOO295-STMH.STMOO297	FLD	6.9	204	6.49	18" RCP		STMOO295	433.6	436.1	480.0 (437.1)	434.9	2.2
132nd Ave SE south of SE 246th Ct	H11-11	UNK	FLD	6.5	60	17.30	18" RCP		UNK	444.0	448.0	486.4 (449.0)	445.2	3.8
	H11-12	UNK	MVCC	10.9	75	3.60	15" RCP	18" TSD	STMPP64	377.1	381.9	396.5 (382.9)	379.5	3.4
	H11-13	UNK	MVCC	10.0	54	3.48	15" RCP	18" TSD	UNK	379.0	383.4	400.0 (384.4)	381.2	3.2

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement H-2 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement H-2	
133rd Ave SE between SE 245th St and SE 247th St	H11-14	UNK	MVCC	9.6	148	9.12	12” *RCP*	18” TSD	UNK	392.5	396.5	417.6 (397.5)	394.6	2.9
	H11-15	UNK	C788	16.61	67	0.85	12” *RCP*	24” TSD	UNK	406.9	410.5	514.1 (411.5)	411.1	0.4
	H11-16	UNK	C788	16.61	129	1.00	12” *RCP*	24” TSD	UNK	408.2	415.5	612.6 (416.5)	412.2	4.3

Notes:

All elevations shown are NAVD 88 datum (City current datum)

Italicized values = Assumed parameters based on engineering judgment where not included in the City’s GIS database

Table 6-19
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin H (Soos Creek/Meridian Valley), Subbasin H131 (Reference Figure 7-26)

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics: Length (ft)	TSD Link Characteristics: Slope (%)	TSD Link Characteristics: Existing Size/Type	TSD Link Characteristics: Recommended Improvement H-3 Size/Type	Upstream CB Characteristics: City GIS Reference (UNIT ID)	Upstream CB Characteristics: Invert Elevation	Upstream CB Characteristics: Rim Elevation	Computed 25-year HGL Elevation at Upstream CB: Existing Conditions	Computed 25-year HGL Elevation at Upstream CB: With Recommended Improvement H-3	25-year Flood Elevation Reduction Benefit (ft)
												N/A	357.8	N/A
	H131-1	UNK	FLD	9.77	51	0.59	15" RCP	18" TSD	STMOO303	356.1	360.1	N/A	360.0	N/A
	H131-2	STMH.STMOO302-STMH.STMOO303	FLD	9.29	115	0.77	15" RCP	18" TSD	STMOO302	357.0	360.5	N/A	360.5	N/A
146th Ave SE and 145th Pl SE intersection	H131-3	N/A	N/A	9.29	30	1.73	N/A	30" TSD	N/A	357.5	361.0	N/A	360.0	N/A
	H131-4	N/A	N/A	6.85	360	14.03	N/A	18" TSD	N/A	408.0	412.0	N/A	409.7	N/A
	H131-5	N/A	N/A	6.48	300	1.67	N/A	18" TSD	STMOO230	*413.0*	*416.0*	N/A	414.6	N/A
	H131-6	STMH.STMOO229-STMH.STMOO230	C641	4.63	158	2.81	12" RCP		STMOO229	417.5	420.3	418.7	418.7	0.0
145th Pl SE and 148th Ln SE north intersection	H131-7	STMH.STMOO288-STMH.STMOO229	C641	4.44	59	4.23	12" RCP		STMOO228	420.0	420.2	421.4	421.2	0.2
	H131-8	STMH.STMOO222-STMH.STMOO228	C641	4.04	100	0.69	12" RCP		STMOO222	420.7	427.0	423.2	423.1	0.1
	H131-9	STMH.STMOO218-STMH.STMOO219	C641	3.66	64	9.45	12" RCP		STMOO218	426.8	431.1	427.8	427.8	0.0
	H131-10	STMH.STMOO217-STMH.STMOO218	C641	3.58	72	6.07	12" RCP		STMOO217	431.1	435.4	432.6	432.6	0.0
	H131-11	STMH.STMOO216-STMH.STMOO217	C641	3.52	42	4.68	12" RCP		STMOO216	433.1	436.7	434.5	434.5	0.0
145th Pl SE and SE 247th St intersection	H131-12	STMH.STMOO211-STMH.STMOO216	C641	.3.45	144	7.57	12" RCP		STMOO211	*444.0*	*448.0*	445.4	445.0	0.4
	H131-13	STMH.STMOO209-STMH.STMOO211	C641	2.04	297	7.74	12" RCP		STMOO209	*467.0*	*470.0*	468.0	468.0	0.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement H-3 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement H-3	
	H131-14	STMH.STMOO207-STMH.STMOO209	C641	1.69	149	7.36	12” RCP		STMOO207	*478.0*	*481.0*	478.9	478.9	0.0
	H131-15	STMH.STMOO304-STMH.STMOO303	FLD	0.47	87	6.78	12” RCP		STMOO304	*362.0*	*365.0*	N/A	362.4	N/A
	H131-16	STMH.STMOO230-STMH.STMOO231	C641	1.66	42	2.37	12” RCP		STMOO231	*414.0*	*417.0*	414.9	415.1	-0.2
	H131-17	STMH.STMOO212-STMH.STMOO211	C641	0.86	79	0	12” RCP		STMOO212	*444.0*	*447.0*	445.5	445.1	0.0
	H131-18	STMH.STMOO215-STMH.STMOO212	C641	0.52	158	3.79	12” RCP		STMOO215	*450.0*	*453.0*	450.5	450.5	0.0

Notes:

All elevations shown are NAVD 88 datum (City current datum)

Because of insufficient GIS data, existing HGL elevations were taken assuming that Link 6 was the outfall.

Italicized values = Assumed parameters based on engineering judgment where not included in the City’s GIS database

Table 6-20
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin H (Meridian Valley Creek, Lake Meridian Tributary, Big Soos Creek, Soosette Creek, Little Soosette Creek), Subbasin H30 (Reference Figure 7-27)

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement H-4 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement H-4	
259th St East of 132nd Pl SE														
258th St East of 132nd Pl SE	H30-1	STMH.STMDD160-STMH.STMDD161	Survey	EX 36.2 PR 0.0	247	2.37	24" CMP	Abandoned	STMDD160	382.4	387.1	401.2 (388.1)		
SE 257th Ct	H30-2	STMH.STMDD159-STMH.STMDD160	Survey	EX 34.3 PR 0.0	448	3.15	24" CMP	Abandoned	STMDD159	396.5	401.8	438.9 (402.8)		
	H30-3	STMH.STMDD158-STMH.STMDD159	Survey	EX 7.5 PR 26.8	136	4.20	18" PVC	30" TSD	EX STMDD158 PR STMDD159	402.2	407.3	404.0	402.0	2.0
	H30-4	STMH.STMDD157-STMH.STMDD158	Survey	EX 7.4 PR 26.8	EX 71 PR 62	0.91	18" PVC	30" TSD	EX STMDD157 PR STMDD158	402.9	409.8	404.7	401.0	3.7
East of 132nd Ave SE between SE 257th Ct and SE 256th St	H30-5	STMH.STMEE604-STMH.STMDD157	Survey	EX 7.4 PR 7.2	59	19.9	18" RCP		STMEE604	414.6	418.9	416.3	416.3	0.0
	H30-6	STMH.STMDD162-STMH.STMDD159	Survey	EX 18.3 PR 18.3	111	3.47	18" RCP	30" TSD	STMDD162	400.4	402.4	458.7 (403.4)	402.1	1.3
	H30-7	STMH.STMDD163-STMH.STMDD162	Survey	EX 17.5 PR 17.5	152	1.07	18" RCP	30" TSD	STMDD163	402.0	403.8	467.7 (404.8)	403.7	1.1
	H30-8	STMH.STMDD164-STMH.STMDD163	Survey	EX 16.8 PR 16.8	207	1.77	18" RCP	30" TSD	STMDD164	405.7	407.7	484.9 (408.7)	407.3	1.4
135th Ave SE and SE	H30-9	STMH.STMDD165-STMH.STMDD164	Survey	EX 16.4 PR 16.4	164	3.40	18" RCP	30" TSD	STMDD165	411.2	414.4	414.7	413.4	1.3

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement H-4 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement H-4	
257th Ct Intersection														
	H30-10	STMH.STMDD184-STMH.STMDD165	Survey	EX 15.9 PR 15.9	100	2.84	18" CMP	30" TSD	STMDD184	414.1	419.3	423.2 (420.3)	415.7	4.6
	H30-11	STMH.STMDD183-STMH.STMDD184	Survey	EX 15.7 PR 15.7	104	3.77	18" CMP	30" TSD	STMDD183	418.0	423.2	431.8 (424.2)	419.6	4.6
	H30-12	STMH.STMDD182-STMH.STMDD183	Survey	EX 15.6 PR 15.6	103	3.17	18" CMP	30" TSD	STMDD182	421.2	426.9	440.0 (427.9)	422.8	5.1
SE 256th St and 135th Ave SE intersect	H30-13	STMH.STMDD181-STMH.STMDD182	Survey	EX 15.1 PR 15.1	200	1.78	18" CMP	30" TSD	STMDD181	424.8	431.4	455.8 (432.4)	426.9	5.5
	H30-14	STMH.STMDD180-STMH.STMDD181	Survey	EX 14.9 PR 14.9	102	0.08	24" CMP		STMDD180	424.9	432.1	457.9 (433.1)	428.9	4.2
	H30-15	UNK	C710	EX 16.5 PR 57.6	55	0.22	30" RCP	42" TSD	STMDD370	374.9	378.9	377.4	378.7	-1.3
132nd Pl SE and SE 259th St intersection	H30-16	STMH.STMDD169-STMH.STMDD170	C710	EX 16.4 PR 57.4	104	0.22	30" RCP	42" TSD	STMDD369	375.1	380.0	377.7	379.3	-1.6
	H30-17	STMH.STMDD168-STMH.STMDD169	C710	EX 16.1 PR 57.2	143	0.23	30" PVC	42" TSD	STMDD368	375.4	384.9	377.9	380.1	-2.2
132nd Pl SE and SE 258th Ct intersection	H30-18	STMH.STMDD167-STMH.STMDD168	C710	EX 15.8 PR 56.8	EX 255 PR 125	3.58	30" PVC	42" TSD	STMDD367	*384.6*	*393.4*	386.2	383.8	2.4
	H30-19	STMH.STMDD166-STMH.STMDD307	C710	EX 15.7 PR 55.5	64	2.57	30" PVC	42" TSD	STMDD366	386.2	394.9	388.4	390.1	-1.7
132nd Pl SE and SE 258th St intersection	H30-20	STMH.STMDD365-STMH.STMDD360	C710	EX 15.7 PR 54.8	163	5.74	30" PVC	42" TSD	STMDD365	395.6	403.7	397.7	399.4	-1.7
	H30-21	STMH.STMDD396-STMH.STMDD365	C710	EX 15.4 PR 54.4	46	0.91	30" PVC	42" TSD	STMDD364	396.0	405.4	398.1	399.8	-1.7
	H30-22	STMH.STMDD395-STMH.STMDD396	C710	EX 15.3 PR 54.5	90	1.10	30" PVC	42" TSD	STMDD363	397.0	404.9	399.1	400.8	-1.7

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement H-4 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement H-4	
	H30-23	STMH.STMDD157-STMH.STMDD395	C710	EX 15.3 PR 7.4	23	25.24	24" PVC		STMDD157	402.9	409.8	404.6	404.0	0.6
	H30-24	STMH.STMDD394-STMH.STMDD395	C710	EX 20.3 PR 20.3	39	21.60	15" PVC		STMDD362	405.3	418.0	408.7	411.9	-3.2
East of 132nd Ave SE between SE 257th Ct and SE 256th St	H30-25	STMH.STMEE771-STMH.STMDD394	C710	EX 20.3 PR 20.3	45	16.51	15" PVC		STMEE771	412.7	418.1	420.3	420.3	0.0
	H30-26	N/A	N/A	PR 1.2	PR 175	N/A	N/A	12" TSD	N/A	N/A	N/A		384.6	
	H30-27	N/A	N/A	PR 35.3	PR 131	N/A	N/A	42" TSD	N/A	N/A	N/A		388.2	
	H30-28	N/A	N/A	PR 0.6	PR 163	N/A	N/A	12" TSD	N/A	N/A	N/A		390.3	

Notes:

All elevations shown are NAVD 88 datum (City current datum)

For links that were realigned vertically so the flow changed directions (links 3 and 4), proposed HGL elevations are for downstream CBs.

Proposed design split existing link 18 into two pieces (link 18 and link 27)

Italicized values = Assumed parameters based on engineering judgment where not included in the City's GIS database

Table 6-21
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin L (Lake Fenwick), Subbasin L01 (Reference Figure 7-36)

				Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		
Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference		Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement L-1 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement L-1	25-year Flood Elevation Reduction Benefit (ft)
Lake Fenwick treatment wetland										128.0	133.0	(131.0)	(131.0)	
	L01-1	N/A	L.FNWK	128.7	50	0.02	36” *RCP*	60” TSD	STMP292	128.0	135.0	140.6 (136.0)	133.3	2.7
	L01-2	STMH.STMP290-STMH.STMP291 STMH.STMP291-STMH.STMP292	L.FNWK	128.7	483	0.52	36” *RCP*	60” TSD	STMP290	130.5	142.0	161.6 (143.0)	135.9	7.1
	L01-3	STMH.STMP289-STMH.STMP290	L.FNWK	128.7	146	8.22	24” *RCP*	36” TSD	STMP289	142.5	180.0	229.2 (181.0)	153.2	27.8
	L01-4	STMH.STMP277-STMH.STMP278 STMH.STMP278-STMH.STMP279 STMH.STMP279-STMH.STMP288 STMH.STMP288-STMH.STMP289	L.FNWK	125.4	500	10.6	21” *RCP*	36” TSD	STMP277	195.7	220.0	555.6 (221.0)	206.0	15.0
	L01-5	STMH.STMP276-STMH.STMP277	L.FNWK	125.4	260	10.8	21” *RCP*	36” TSD	STMP276	*223.8*	256.0	446.2 (257.0)	234.1	22.9
	L01-6	STMH.STMP274-STMH.STMP275 STMH.STMP275-STMH.STMP276	L.FNWK	125.4	158	7.91	24” *RCP*	36” TSD	STMP274	236.3	252.0	342.4 (253.0)	246.6	6.4
	L01-7	STMH.STMP273-STMH.STMP274	L.FNWK	122.5	86	7.36	27” *RCP*	36” TSD	STMP273	242.6	262.0	273.8 (263.0)	247.9	15.1
	L01-8	STMH.STMP272-STMH.STMP273	C112	122.5	103	22.2	36” *RCP*		STMP272	265.5	277.5	275.5	275.5	0.0
S 262nd St /43rd Ave S intersection	L01-9	STMH.STMP271-STMH.STMP272	C112	122.5	162	5.06	36” *RCP*		STMP271	273.7	288.7	283.7	283.7	0.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement L-1 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement L-1	
S 262nd St /42nd Ave S intersection	L01-10	STMH.STMP203-STMH.STMP271	C112	97.7	245	3.12	36” *RCP*		STMP203	281.3	298.9	288.8	288.8	0.0
S 261st St /42nd Ave S intersection	L01-11	STMH.STMP131-STMH.STMP134 STMH.STMP134-STMH.STMP203	C112 C199	82.7	328	0.08	36” *RCP*	42” TSD	STMP131	281.6	300.5	297.0	292.7	4.3
	L01-12	STMH.STMP127-STMH.STMP131	C199	82.7	409	0.91	36” *RCP*	48” TSD	STMP127	285.3	295.2	305.2 (296.2)	288.7	7.5
	L01-13	STMH.STMP90-STMH.STMP127	C199	34.9	435	0.86	30” *RCP*		STMP90	289.1	297.2	291.6	291.6	0.0
S 261st St /36th Ave S intersection	L01-14	STMH.STMP81-STMH.STMP89 STMH.STMP89-STMH.STMP90	C199	13.0	446	2.37	24” *RCP*		STMP81	299.6	309.4	301.2	301.2	0.0
	L01-15	STMH.STMP79-STMH.STMP80 STMH.STMP80-STMH.STMP81	C111	9.2	390	10.7	24” *RCP*		STMP79	341.2	346.7	343.0	343.0	0.0
S 263rd St /43rd Ave S intersection	L01-16	STMH.STMP269-STND.STMP052 STND.STMP052-STMH.STMP271 STMH.STMP267-STND.STMP051 STND.STMP051-STMH.STMP269	C112	23.4	422	7.06	21” *RCP*		STMP267	303.5	311.0	307.5	307.5	0.0
	L01-17	STMH.STMP266-STND.STMP049 STND.STMP049-STND.STMP050 STND.STMP050-STMH.STMP267	C112	21.1	339	1.48	21” *RCP*		STMP266	308.5	316.9	315.3	315.3	0.0
	L01-18	STMH.STMP264-STMH.STMP266	C112	19.9	136	11.5	21” *RCP*		STMP264	324.1	333.1	327.4	327.4	0.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement L-1 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement L-1	
	L01-19	STMH.STMP238-STMH.STMP262	C218	13.0	71	9.63	24" *RCP*		STMP238	330.9	337.1	333.1	333.1	0.0
	L01-20	STMH.STMP237-STMH.STMP238	C218	13.0	123	0.53	24" *RCP*		STMP237	331.6	343.4	333.9	333.9	0.0
Somerset Ln S /Carnaby Way S intersection	L01-21	STMH.STMP232-STND.STMP072 STND.STMP072-STMH.STMP237 STMH.STMP231-STMH.STMP232	C218	13.0	324	14.3	18" *RCP*		STMP231	378.1	382.2	380.8	380.8	0.0
Hampton Way /Carnaby Way intersection	L01-22	STMH.STMP226-STMH.STMP227 STND.STMP071-STMH.STMP231 STND.STMP070-STND.STMP071 STMH.STMP227-STND.STMP070	C218 C464	3.7	283	1.56	18" *RCP*		STMP226	382.5	390.3	383.6	383.6	0.0
	L01-23	STMH.STMP265-STMH.STMP266	C112	1.3	220	5.46	21" *RCP*		STMP265	320.5	325.8	321.1	321.1	0.0
	L01-24	STMH.STMP261-STMH.STMP262	C89	6.9	123	8.47	21" *RCP*		STMP261	334.5	342.1	335.7	335.7	0.0
	L01-25	STMH.STMP251-STMH.STMP261 STMH.STMP250-STMH.STMP251 STMH.STMP240-STMH.STMP250	C89	2.3	518	10.6	21" *RCP*		STMP240	389.5	394.7	390.4	390.4	0.0
Totem Middle School track/field	L01-26	STMH.STMP239-STMH.STMP240	C89	2.3	55	9.33	21" *RCP*		STMP239	394.6	398.7	395.5	395.5	0.0

					TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		
Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement L-1 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement L-1	25-year Flood Elevation Reduction Benefit (ft)
S 262nd Pl /42nd Ave S intersection	L01-27	STND.STMP045-STMH.STMP202 STMH.STMP684-STND.STMP078 STMH.STMP202-STND.STMP078 STND.STMP078-STMH.STMP203	C112	5.2	215	14.0	18” *RCP*		STMP199	311.4	321.0	312.8	312.8	0.0
S 262nd St /39th Pl S intersection	L01-28	STND.STMP039-STMH.STMP181 STMH.STMP181-STND.STMP040 STND.STMP040-STMH.STMP203	C84	9.8	657	6.48	18” *RCP*		STMP177	323.9	332.5	326.1	326.1	0.0

Notes:

All elevations shown are NAVD 88 datum (City current datum)

(13.0) = Estimated starting WSEL at outfall or overflow elevation at catch basin

Italicized values = Assumed parameters based on engineering judgment where not included in the City’s GIS database

Table 6-22
Trunk Storm Drain Hydraulic Analysis Results Summary – Basin Q (GRNRA), Subbasin Q05 (Reference Figure 7-39)

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement Q-1 Size/Type	Upstream CB Characteristics City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Computed 25-year HGL Elevation at Upstream CB Existing Conditions	With Recommended Improvement Q-1	25-year Flood Elevation Reduction Benefit (ft)
Southern lagoon										*21.9*	*28.5*	(26.4)	(26.4)	
	Q05-1	N/A	C328	83.2	372	*0.00*	54" *RCP*		STMG62	21.9	28.5	27.2	27.2	0.0
	Q05-2	STND.STMG028-STMH.STMG62 STMH.STMG60-STND.STMG028	C328	83.2	296	0.08	54" *RCP*		STMG60	22.1	29.6	28.4	28.4	0.0
	Q05-3	STMH.STMG56-STMH.STMG60	C328	57.1	280	0.26	54" *RCP*		STMG56	22.8	31.4	28.7	28.7	0.0
S 226th St /58th Pl S intersection	Q05-4	STMH.STMG38-STMH.STMG56	C328	57.1	252	0.10	54" *RCP*		STMG38	23.1	29.8	29.0	29.0	0.0
	Q05-5	STMH.STMG34-STMH.STMG38	C328	45.0	347	0.15	48" *RCP*	54" TSD	STMG34	23.6	30.5	29.5	29.3	0.2
	Q05-6	STMH.STMG28-STMH.STMG34	C328	45.0	311	0.21	42" *RCP*	54" TSD	STMG28	24.3	31.5	30.3	29.5	0.8
	Q05-7	STMH.STMG21-STMH.STMG28	C328	45.0	370	0.18	42" *RCP*	48" TSD	STMG21	25.0	30.7	31.5	30.2	1.3
S 226th St /54th Ave S intersection	Q05-8	STMH.STMG20-STMH.STMG21	C328	45.0	43	0.00	42" *RCP*	48" TSD	STMG20	25.0	31.4	31.8	30.3	1.5
	Q05-9	STMH.STMG102-STMH.STMG20	C328	45.0	309	0.00	24" *RCP*	48" TSD	STMG102	25.0	31.8	45.6 (32.8)	30.7	2.1
	Q05-10	STMH.STMG99-STMH.STMG102	C328	45.0	330	0.12	24" *RCP*	48" TSD	STMG99	25.3	31.4	50.0 (32.4)	31.1	1.3
	Q05-11	STMH.STMG96-STMH.STMG99	C328	45.0	313	0.18	36" *RCP*	48" TSD	STMG96	25.9	32.0	34.1 (33.0)	31.5	1.5
	Q05-12	STMH.STMG93-STMH.STMG96	C328	45.0	345	0.11	36" *RCP*	48" TSD	STMG93	26.3	32.0	35.5 (33.0)	32.2	0.8
	Q05-13	N/A	C329	35.1	323	0.20	48" *RCP*		STMG63	22.5	28.0	26.8	26.8	0.0
	Q05-14	STMH.STMG61-STMH.STMG63	C329	35.1	277	0.27	48" *RCP*		STMG61	23.3	30.8	27.1	27.1	0.0
	Q05-15	STMH.STMG57-STMH.STMG61 STMH.STMG269-	C329	35.1	185	0.01	48" *RCP*		STMG269	23.3	31.3	27.3	27.3	0.0

Location	TSD Link Identifier	City GIS Reference (UNIT ID)	City GIS As-built Plan Reference	Computed 25-year Flood Event Peak Discharge (cfs)	TSD Link Characteristics				Upstream CB Characteristics			Computed 25-year HGL Elevation at Upstream CB		25-year Flood Elevation Reduction Benefit (ft)
					Length (ft)	Slope (%)	Existing Size/Type	Recommended Improvement Q-1 Size/Type	City GIS Reference (UNIT ID)	Invert Elevation	Rim Elevation	Existing Conditions	With Recommended Improvement Q-1	
		STMH.STMG57												
S 226th St /58th Pl S intersection	Q05-16	STMH.STMG35-STMH.STMG269	C329	35.1	354	0.01	48" *RCP*		STMG35	23.3	29.2	27.5	27.5	0.0
	Q05-17	STMH.STMG31-STMH.STMG35	C329	35.1	243	0.24	48" *RCP*		STMG31	23.9	30.1	27.8	27.8	0.0
	Q05-18	STMH.STMG27-STMH.STMG31	C329	35.1	332	0.05	48" *RCP*		STMG27	24.1	31.4	28.0	28.0	0.0
	Q05-19	STMH.STMG23-STMH.STMG27 STND.STMG014-STMH.STMG23	C329	35.1	291	0.11	48" *RCP*		STMG23	24.4	30.0	28.2	28.2	0.0
S 226th St /54th Ave S intersection	Q05-20	STND.STMG014-STMH.STMG23	C329	35.1	91	*0.00*	48" *RCP*		N/A	*24.4*	*30.0*	28.4	28.4	0.0
	Q05-21	STMH.STMG68-STMH.STMG60 STMH.STMG73-STMH.STMG68	C329	26.1	763	0.26	36" *RCP*		STMG73	24.1	29.7	29.7	29.7	0.0
	Q05-22	STMH.STMG74-STMH.STMG73	C329	26.1	322	0.26	27" *RCP*	36" TSD	STMG74	24.9	30.3	32.9 (31.3)	30.5	0.8
	Q05-23	N/A	C871	26.1	118	0.11	24" CPEP	36" TSD	N/A	24.2	29.6	32.8 (30.6)	30.2	0.4
	Q05-24	STMH.STMG40-STMH.STMG38	C329	12.1	65	2.11	36" *RCP*		STMG40	24.5	29.5	26.0	26.0	0.0
	Q05-25	STMH.STMG43-STMH.STMG40	C329	12.1	235	0.12	36" *RCP*		STMG43	24.8	30.8	26.4	26.4	0.0
	Q05-26	STMH.STMG44-STMH.STMG43	C329	12.1	177	0.19	36" *RCP*		STMG44	25.1	30.3	26.7	26.7	0.0
	Q05-27	STMH.STMG48-STMH.STMG44	C329	12.1	264	0.14	36" *RCP*		STMG48	25.5	30.4	27.1	27.1	0.0
	Q05-28	STMH.STMG50-STMH.STMG48	C329	12.1	151	0.21	36" *RCP*		STMG50	25.8	32.5	27.4	27.4	0.0

Notes:

All elevations shown are NAVD 88 datum (City current datum)

(26.4) = Estimated starting WSEL at outfall or overflow elevation at catch basin

Italicized values = Assumed parameters based on engineering judgment where not included in the City's GIS database

Table 6-23
Lower Mill Creek Hydraulic Analysis Results Summary – Existing and Improved Conditions

HEC-RAS River Station	Location	Computed Water Surface Elevation 25-year Flood Event (ft)		
		Existing Conditions	Improved Conditions	Flood Reduction Benefit
84	Downstream of Earthworks Park	47.4	42.7	4.7
83	Upstream of Titus Street	47.4	42.1	5.3
79	Upstream of Smith Street	44.4	41.3	3.1
76	Upstream of James Street	41.8	38.3	3.5
70	Upstream of Central Avenue	37.2	36.5	0.7
68	Upstream of Novak Lane	36.7	36.4	0.3
61	Upstream of SR 167	35.9	35.4	0.5
59	Upstream of South 228th Street	35.6	35.1	0.5
57.7	Upstream of BNRR	34.7	32.9	1.8
53	Upstream of 76th Avenue South	33.1	29.2	3.9
47	Upstream of diversion point	31.5	27.1	4.4
40.1	Downstream of Union Pacific Railroad	27.5	26.4	1.1
37.2	Upstream of South 212th Street	27.0	26.1	0.9
31.1	Upstream of Kent Bike Trail	25.8	25.6	0.2
29.2	Upstream of 72nd Avenue South	25.8	25.6	0.2
19.2	Upstream of West Valley Highway	25.6	25.5	0.1
18	Downstream of Boeing Creek confluence	25.6	25.4	0.2
17.1	Upstream of South 204th Street	25.5	25.3	0.2
16.1	Upstream of West Valley Highway	25.0	24.9	0.1
11	Upstream of 196th Street	23.5	23.5	0.0
9.4	Upstream of Kent Bike Trail	23.2	23.2	0.0
8.7	Upstream of Auto Auction Bridge	23.1	23.0	0.1
2	Upstream of Springbrook Creek confluence	21.8	21.8	0.0

Notes:
Water surface elevation datum: NAVD.
Results are based on use of the updated HEC-RAS hydraulic model.
Improved conditions include recommended improvements affecting Lower Mill Creek (Projects A-1, A-2, A-3, A-4, A-5, A-7, and A-9).

Table 6-24
Springbrook Creek Hydraulic Analysis Results Summary – Existing Conditions

HEC-RAS River Station	Location	Computed Water Surface Elevation 25-year Flood Event (ft)
68	Upstream of Chandler Bay	41.8
58	Upstream of 88th Avenue South	38.4
51	Upstream of South 228th Street	33.8
41	Upstream of SR 167	32.3
29.5	Upstream of Garrison Creek confluence	29.1
29	Downstream of Garrison Creek confluence	28.9
16.5	Upstream of Upper Springbrook Creek	25.5
15	Downstream of Upper Springbrook Creek	25.1
5.9	Upstream of 80th Avenue South	22.6
3	Upstream of Mill Creek	22.5
2	Downstream of Mill Creek	22.4

Notes:
Water surface elevation datum: NAVD.
Results are based on use of the updated HEC-RAS hydraulic model.

7 PROJECT IMPROVEMENT NEEDS, ASSESSMENT, AND RECOMMENDATIONS

This section provides documentation of the alternative and recommended solutions evaluated to planning area priority drainage problems documented in Section 5 as well as other drainage system deficiencies identified through hydrologic and hydraulic analyses as reported in Section 6. A table is presented for each identified project to summarize the project, the drainage problems that they address, the solution opportunities that were evaluated, alternative project improvements that were considered, the recommended alternative for implementation, other project dependencies, expected key benefits from project implementation, whether property and/or easement acquisition is required, and the estimated implementation costs and priorities. Photographs of the project improvements area are also included. The projects were grouped into two sections. Section 7.1 describes project opportunities that provide improvement to the receiving waters drainage systems. Section 7.2 provides similar information for proposed TSD improvement projects that discharge to the receiving water drainage systems.

7.1 Stream Improvement Opportunities and Recommended Projects

This section describes the identified project improvement needs along the receiving waters (streams, creeks, lakes, and associated hydraulic crossings) evaluated in the DMP. These improvements are proposed for integration into the City's updated Stormwater CIP as guidance for projects implementation after DMP approval by the City Council. All projects are targeted to provide flood reduction benefits to a minimum 25-year level-of-protection standard unless otherwise identified as a higher standard. The basis for recommended projects estimated implementation cost opinions at this planning level of analysis included in the project tables is discussed in Section 7.3.

The City is also participating with the Corps, Seattle District and a multitude of other local agencies in the Green-Duwamish Ecosystem Restoration Program (ERP). That program seeks comprehensive river and stream corridor restoration actions within the entire Green-Duwamish Watershed to benefit anadromous fisheries stocks as well as wildlife species that are either listed or proposed to be listed as endangered under the ESA. The Green-Duwamish ERP focuses on the restoration of critical habitats for those species using a multi-disciplinary approach and full coordination of project design and permitting for implementation with interested federal, state, and local agencies (including the City of Kent), and tribal interests. This program was authorized in the Water Resources

Development Act of 2000. Total program implementation costs have been estimated by the Corps to be $195 million, a federal cost-share of 65 percent and a 35 percent local match. The Green-Duwamish ERP Feasibility Report (October 2000) was approved by the Federal Office of Management and Budget (OMB) in November 2005.

Proposed Green-Duwamish ERP actions include restoring tidal estuary habitats, removal or setback river levees, re-connection of historic ox-bow channels and floodplains, and restoration of river and tributary watershed streams fish passage/habitat, spawning, and wildlife habitat areas (e.g., placement of large woody debris, culvert removals/replacements, and extensive riparian plantings). The first project to be constructed under the Green-Duwamish ERP in 2005 was the City's Meridian Valley Creek Restoration upstream from its confluence with Big Soos Creek. The City is also currently participating in phased construction of the Lake Meridian Outlet/Cow Creek relocation and restoration improvements (Phase 1 was constructed in 2007, with Phase 2 and 3 construction planned for 2008/2009 subject to funding availability). Additional upcoming City of Kent Green-Duwamish ERP projects include the Green River Riverview Park and Garrison Creek (4 sites) restoration projects. The City's near-term (5-year) budget for Green-Duwamish ERP restoration projects has been estimated at $500,000.

Project A-1, Basin A, Subbasin A15E ***Mill Creek TSD, Restoration at Senior Center – Titus Street to Smith Street***	
Figure reference	7-1
Drainage problems addressed	LMC-4, PM-14
Problem type, description, conditions	Frequent flooding potential along Mill Creek at Senior Center, Titus Street, and East Smith Street due to undersized TSD downstream of Earthworks Park detention facility and upstream of Lower Mill Creek channel
Solution needs, opportunities	Improve flood protection level and emergency access; remove accumulated sediments in Mill Creek at TSD outlet; daylight TSD to open channel segment; improve fish passage
Solution alternatives	Alternative 1 – Replace Titus Street Mill Creek crossing with three-sided 14-foot by 5-foot box culvert; install 430 feet of parallel 54-inch TSD adjacent to Senior Center downstream to Smith Street/Kennebeck Avenue intersection; install junction structure with existing TSD and 170 feet of thee-sided 14-foot by 5-foot three-sided box culvert with outfall to Mill Creek downstream of Smith Street; and remove sediment at outfall Alternative 2 – Same as Alternative 1, except replace existing 54-inch TSD with restored Mill Creek stream channel and revegetated buffer adjacent to Senior Center (with pedestrian and parking lot crossings for access) downstream to Smith Street/Kennebeck Avenue intersection
Recommended improvement	Alternative 1
Other project dependencies	A-2, A-3 (implement first or jointly)
Key benefits	Reduces flooding potential and associated emergency response at Senior Center, daylights a section of Mill Creek by restoring open channel segment, and improves fish passage/habitat
Property, easement acquisition needs	Yes
Estimated implementation cost	$895,000
Implementation priority	High
Photographs	 

Project A-2, Basin A, Subbasin A15E ***Mill Creek Restoration – Smith Street to James Street***	
Figure reference	7-2
Drainage problems addressed	LMC-3, LMC-4, LMC-5, PM-13
Problem type, description, conditions	Frequent and extensive flooding potential along Mill Creek including adjacent residential structures along Kennebeck Avenue to the east and Mill Creek Middle School to the west; linear restrictive channel with sediment accumulation; low habitat value
Solution needs, opportunities	Improve flood protection level, expand channel capacity and complexity; remove accumulated sediments; improve water quality and potential fish use
Solution alternatives	Alternative 1 – In combination with lowered flood elevations associated with Project A-1, provide floodwater containment improvements in this reach along with stream bank revegetation and habitat features; raise 825 feet of Kennebeck Avenue (east side); construct 765 feet of landscaped containment berms (east and west side); construct 600-foot length flood wall along school athletic field; improve lateral drainage systems and outfalls and add flap gates
Recommended improvement	Alternative 1
Other project dependencies	A-1, A-3 (implement jointly or first)
Key benefits	Flood reduction frequency and magnitude in flood prone area adjacent to Kennebeck Lane and Mill Creek Middle School by lowered flood levels with Project A-3; added containment berm and flood wall limits overbank flooding potential for larger events; flap gates to control backwater flooding potential in tributary local drainages; revegetation of berms and instream (channel fringe) LWD placement limits access to stream; improves water quality; improves fish habitat
Property, easement acquisition needs	Yes
Estimated implementation cost	$1,181,000
Implementation priority	High
Photographs	 

Project A-3, Basin A, Subbasin A14E Mill Creek Relocation/Restoration – James Street to Chandler Bay Drive	
Figure reference	7-3
Drainage problems addressed	LMC-3, LMC-4, LMC-5, PM-10, PM-13
Problem type, description, conditions	Frequent and extensive flooding potential along Mill Creek including adjacent residential structures and East James Street arterial roadway; overflows to Upper Springbrook Creek; linear restrictive channel with sediment accumulation; low habitat value
Solution needs, opportunities	Improve flood protection level; expand channel capacity and complexity; remove accumulated sediments; improve water quality and potential fish use; integrate with adjacent wetland habitat; provide passive public access
Solution alternatives	Alternative 1 – Relocate and restore approximately 2,100 feet of Mill Creek to east through wetland, away from existing development; connect nature trail to Memorial Park; controlled overflow bypass to Springbrook Creek; improve James Street culvert; restore and revegetate wetland/riparian corridor; enhance instream fish use/habitat; enlarge existing channel upstream of Chandler Bay Drive Alternative 2 – Same major components as Alternative 1, except keep Mill Creek in existing alignment and widen to east to limit property acquisition needs; potential need to relocate trunk sanitary sewer along this alignment
Recommended improvement	Alternative 1
Other project dependencies	None
Key benefits	Flood reduction frequency and magnitude; limits overflows to Springbrook Creek; restores meandering channel alignment; improves water quality, fish habitat, and wetland value/complexity; public involvement/education and core downtown water resource feature
Property, easement acquisition needs	Yes
Estimated implementation cost	$4,672,000
Implementation priority	High
Photographs	 

Project A-4, Basin A, Subbasin A14W **Mill Creek Culvert Replacement – Burlington Northern Santa Fe Railroad**	
Figure reference	7-4
Drainage problems addressed	None Identified
Problem type, description, conditions	Increased Mill Creek flood levels upstream of Burlington Northern Santa Fe Railroad (BNSF RR) crossing due to existing restrictive culvert; culvert alignment is perpendicular to upstream and downstream channel inducing energy loss and promoting localized sedimentation in channel; fish passage limitation
Solution needs, opportunities	Realign and replace BNSF RR culvert; remove excess channel sediment upstream and downstream of crossing; improve fish passage; potential for coordination of construction with assumed rail closures for the South 228th Street TIP railroad under crossing improvements
Solution alternatives	Alternative 1 – Replace existing culvert with 100 feet of 10-foot by 7-foot three-sided box culvert along existing alignment under BNSF RR (assumes open cut permitted); restore rail line; remove excess streambed sediment from sediment from upstream and downstream channel; restore with streambed gravel substrate Alternative 2 – Replace and realign existing culvert with 180 feet of 120-inch storm drain by bore and jack under BNSF RR (assumes open cut not permitted); backfill replacement culvert with 3 feet of streambed gravel substrate; remove excess streambed sediment from sediment from upstream and downstream channel
Recommended improvement	Alternative 2
Other project dependencies	None
Key benefits	Reduces upstream Mill Creek flood levels, provides for more efficient hydraulic condition to minimize future channel sedimentation, and improves fish passage
Property, easement acquisition needs	No—however, BNSF RR approval is required
Estimated implementation cost	$1,203,000
Implementation priority	Medium
Photographs	

Project A-7, Basin A, Subbasin A14E ***Mill Creek Culverts Replacement, Relocation/Restoration – 76th Avenue Corridor***	
Figure reference	7-7
Drainage problems addressed	LMC-6, PM-12, PM-21
Problem type, description, conditions	Frequent and extensive flooding potential along Mill Creek 76th Avenue arterial transportation corridor including adjacent commercial area and structures; emergency access limitations; flooding on west side of Union Pacific Railroad (UPRR) and 72nd Avenue at GRNRA diversion channel; excessive sediment accumulation in Mill Creek in this reach; low habitat value of creek crossing active agricultural land without riparian buffer
Solution needs, opportunities	Improve flood protection level; expand channel capacity and complexity; remove accumulated sediments; improve water quality; enhance potential fish use/habitat; relocate/restore Mill Creek; add riparian buffer
Solution alternatives	Alternative 1 – Replace and re-align 76th Avenue stream crossing and three downstream commercial access stream crossings with 15-foot by 6-foot three-sided box culverts; relocate and restore 1,230 feet of Mill Creek to east side of UPRR east through private agricultural land (maintain existing channel connection to GRNRA diversion weir); install 270 feet of 15-foot by 6-foot three-sided box culvert with connection back to existing Mill Creek channel east of UPRR downstream crossing; fill downstream section of existing Mill Creek channel west of UPRR and add berms as required; replace weir plate on GRNRA diversion weir; extend 76th Avenue TSD outfall 900 feet downstream; construct stormwater treatment pond and connection to restored Mill Creek channel Alternative 2 – Partial Alternative 1 improvements including 76th Avenue crossing and downstream commercial access crossings; remove excess sediment from Mill Creek channel, but no relocation/restoration of Mill Creek; no extension of 76th Avenue TSD outfall or water quality treatment improvements
Recommended improvement	Alternative 1
Other project dependencies	None
Key benefits	Restores larger flood protection level to 76th Avenue corridor and commercial businesses; creates habitat-friendly restored channel and riparian corridor along Mill Creek; improves functionality of GRNRA diversion; improves water quality, fish habitat, and adds wetland value/complexity; potential for public access/education
Property, easement acquisition needs	Yes
Estimated implementation cost	$5,649,000
Implementation priority	High
Photographs	 

Project B-1, Basin B, Multiple Subbasins **Springbrook Creek Channel Flood Containment Berms – North of South 212th Street**	
Figure reference	7-9
Drainage problems addressed	SBC-1
Problem type, description, conditions	Frequent and extensive flooding potential along sections of Springbrook Creek north of South 212th Street; sediment accumulation in sections of channel (particularly at 90 degree bends); low banks in certain reaches result in flood event overflows; limited habitat value and riparian buffers
Solution needs, opportunities	Improve flood protection level; provide containment berms at low bank locations; remove accumulated excess sediments; provide riparian buffer revegetation
Solution alternatives	Alternative 1 – Construct flood containment berms along channel at seven identified locations extending north from South 212th Street to the Springbrook/Mill Creek confluence; target (minimum) level-of-protection of 25-year plus 2-feet freeboard; improve or add local drainage outfalls (where berm placement affects local drainage) and add flap gates; revegetate berms (and adjacent areas where possible) with native species
Recommended improvement	Alternative 1
Other project dependencies	None
Key benefits	Provides flood containment along Springbrook Creek to reduce extent of existing overbank flooding in developed areas and associated risk to commercial structures flooding; provides localized vegetative buffer enhancement along creek sections improved by berms addition
Property, easement acquisition needs	Yes
Estimated implementation cost	$988,000
Implementation priority	High
Photographs	

Project G-3, Basin G, Subbasin G05E ***Upper Mill Creek Diversion to Detention Dam – East of 104th Avenue Southeast***	
Figure Reference	7-19
Drainage Problems Addressed	UMC-1
Problem Type, Description, Conditions	Existing diversion structure to Upper Mill Creek Detention Dam has inadequate capacity for diversion of large event flows from Upper Mill Creek resulting in potential for higher flows delivered to existing channel (bypassing detention facility); only low flows should remain in creek for downstream habitat maintenance; existing structure design with channel drop structure is not conducive to fish passage except possibly at very high flows.
Solution Need, Opportunities	Increase diversion flow capacity to existing channel leading to detention dam (up to 500-year level-of-protection required); restore Upper Mill Creek fish passage
Solution Alternatives	Alternative 1 – Replace existing diversion structure with a fully reconstructed diversion structure consisting of an elevated channel section, a minimum 40-foot length lateral concrete weir with adult fish barrier (bar rack or grating) and three downstream 10-foot by 4-foot box culverts at maintenance road crossing; install an instream adjustable notch weir plate (fish passable) to restrict low flows to downstream Upper Mill Creek channel; partially fill existing Upper Mill Creek channel downstream to 104th Avenue Southeast with appropriate streambed substrate mix using a roughened channel design approach
Recommended Improvement	Alternative 1
Other Project Dependencies	G-4 (implement jointly)
Key Benefits	Divert additional flow to the detention dam to reduce downstream Mill Creek flooding risk and potential (particularly for larger events); restores fish passage through diversion structure to upstream sections of Upper Mill Creek
Property, Easement Acquisition Needs	Yes
Estimated Implementation Cost	$563,000
Implementation Priority	High
Photographs	 

Project G-4, Basin G, Subbasin G05E Upper Mill Creek Detention Dam, Outlet Modifications – 104th Avenue Southeast	
Figure reference	7-20
Drainage problems addressed	UMC-1 (also benefits lower Mill Creek problem areas)
Problem type, description, conditions	Existing detention dam with current outlet operations provides significant flood flow control but less than minimum 25-year level-of-protection to spillway overflow to downstream reaches of Mill Creek; outlet works do not fully meet current EDS standards (non-encased corrugated metal pipe outlet pipe, no primary spillway, and emergency spillway over embankment)
Solution needs, opportunities	Raise dam embankment to provide additional flood storage and allow more restrictive outlet flow control; improve outlet works to meet current EDS standards; mitigate for potential effects on wetlands; consider alternative large diameter micro-tunnel to provide high flow gravity bypass to the South 277th Street corridor and ultimately to the Green River (discharges to the Green River may be limited at high Green River stages)
Solution alternatives	Alternative 1 – Raise existing dam 5.5 feet to dam crest elevation 351 by earth filled embankment extending upstream into current reservoir area; install chimney drain in expanded embankment; replace existing outlet piping and gates with 36-inch and 48-inch concrete encased TSD with motorized sluice gates in vault; add primary spillway (30-foot length assumed at elevation 347.5) in vault, construct emergency spillway (100-foot assumed length at elevation 348.5) south outside of dam embankment section; adjust south maintenance access road; connect to diversion channel embankment to north; mitigate around perimeter of reservoir for wetland impacts Alternative 2 – Construct approximate 2,100-foot length, 60-inch diameter (assumed) TSD micro-tunnel from the Upper Mill Creek Detention Reservoir to the South 277th Street road corridor including outlet works controls at the reservoir; install approximately 2,000 feet of 60-inch TSD downstream along South 277th Street (or alternative stabilized open channel) with energy dissipator and new outfall to the Green River
Recommended improvement	Alternative 1
Other project dependencies	G-3 (implement jointly)
Key benefits	Increases detention dam flood storage by approximately 50 acre-feet (a 55 percent increase); improves downstream level of flood protection, particularly for larger events; reduces duration of flood flows delivered to Lower Mill Creek; Alternative 1 restricts outflows effectively for larger events (up to 500-year), improves dam safety to current standards and lowers risk for potential dam failure; Alternative 2 lowers downstream flood risks by diversion of higher reservoir outflows directly to the Green River
Property, easement acquisition needs	Yes
Estimated implementation cost	$2,341,000
Implementation priority	High
Photographs	 

Project H-1, Basin H, Subbasin H19 ***Meridian Valley Creek Restoration – Meridian Valley Country Club***	
Figure Reference	7-24
Drainage Problems Addressed	PM-7, PM-18
Problem Type, Description, Conditions	Stream bank erosion and fish passage/habitat limitations along Meridian Valley Creek; sanitary sewer in/along creek channel; manhole in channel causing stream bank erosion and localized flooding
Solution Need, Opportunities	Bank stabilization; channel realignment; sediment removal; improve fish passage/habitat; planting of native riparian species
Solution Alternatives	Alternative 1 – Stabilize approximately 100 feet of channel banks just south of South 243 Place using bioengineered soft armoring methods near eroding banks and around the sanitary sewer manhole; preserve existing trees or remove dangerous trees in coordination with WDFW, Meridian Valley Country Club, and affected homeowners Alternative 2 – Realignment and restoration of approximately 230 feet of existing channel just south of South 243 Place; selected enhancements of Meridian Valley Creek channel between Southeast 240th Street and Southeast 256th Street including removal of excess sediment, streambed and bank stabilization (where erosion is occurring), creation of pools/riffles, placement of LWD for fish habitat, and selective bank and riparian corridor revegetation (where not affecting golf course playability)
Recommended Improvement	Alternative 2
Other Project Dependencies	None
Key Benefits	Adds vegetative buffer between channel and the golf course (shading/stream temperature reduction and stream access isolation); stabilizes channel banks; improves fish passage/habitat and potential spawning use; reduces localized streambed and bank erosion and flooding from displaced flow by sanitary sewer manhole
Property, Easement Acquisition Needs	Yes
Estimated Implementation Cost	$1,214,000
Implementation Priority	Medium
Photographs	 

Project H-4, Basin H, Subbasin H30 **TSD Improvements – 132nd Avenue Southeast to Lake Meridian Outfall**	
Figure Reference	7-27
Drainage Problems Addressed	LMT-2
Problem Type, Description, Conditions	Existing TSD under Lake Meridian Estates Park is in poor condition and is reported to be failing; also, its restrictive capacity results in flooding potential to a mobile home park and along the adjacent public road
Solution Need, Opportunities	Abandon failing TSD; divert flows to existing parallel TSD; reconnect existing catch basins to adjacent TSD
Solution Alternatives	Alternative 1 – Plug and abandon approximately 780 feet of existing TSD under Lake Meridian Estates (mobile home) Park; replace deficient section of adjacent TSD with approximately 920 feet of 42-inch TSD; replace approximately 770 feet of 30-inch equivalent TSD along Southeast 257th Court; replace approximately 570 feet of 30-inch TSD 135th Avenue Southeast; and install approximately 330 feet of 12-inch TSD along Southeast 258th Street and Southeast 258th Court to connect to adjacent TSD
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces flooding potential at mobile home park and adjacent public road by eliminating that portion of TSD that is reportedly failing and providing connections to adjacent TSD with improved hydraulic capacity; allows for improved TSD maintenance access
Property, Easement Acquisition Needs	No
Estimated Implementation Cost	$1,585,000
Implementation Priority	Medium
Photographs	

Project H-5, Basin H, Subbasin H133 ***Big Soos Creek Bridge Replacement – Southeast 256th Street***	
Figure Reference	7-28
Drainage Problems Addressed	BSC-1
Problem Type, Description, Conditions	Frequent road flooding potential due to restrictive bridge section at Southeast 256th Street Crossing of Soos Creek
Solution Need, Opportunities	Improve flood protection level and emergency access; improve use of existing habitat
Solution Alternatives	Alternative 1 – Replace existing bridge with larger bridge section (approximately 38-foot span by 4.25-foot height); raise road grade of Southeast 256th Street approximately 2.5 feet at bridge to minimum elevation 332 as part of Southeast 256th Street roadway TIP project; restore disturbed streambed and banks local to bridge replacement
Recommended Improvement	Alternative 1
Other Project Dependencies	Yes (Southeast 256th Street TIP project)
Key Benefits	Reduces flooding potential and associated emergency response at Southeast 256th Street crossing of Soos Creek; improves use of existing habitat
Property, Easement Acquisition Needs	No
Estimated Implementation Cost	$2,058,000
Implementation Priority	High
Photographs	 

Project H-6, Basin H, Subbasin H15 ***Soosette Creek Culvert Replacement – 144th Avenue Southeast***	
Figure Reference	7-29
Drainage Problems Addressed	SC-1, PM-11
Problem Type, Description, Conditions	Frequent road flooding potential at 144th Avenue Southeast Crossing of Soosette Creek; wetlands upstream and downstream of culvert; road in dip section and not adequately elevated
Solution Need, Opportunities	Improve flood protection level, emergency access, fish passage, and use of existing stream and wetland habitats upstream of culvert
Solution Alternatives	Alternative 1 – Replace culvert to 7-foot by 4-foot three-sided box culvert; raise road elevation of 144th Avenue Southeast approximately 2 feet to minimum elevation of 360; restore disturbed streambed and banks local to culvert replacement
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces flooding potential and improves emergency access along 144th Avenue Southeast at Soosette Creek stream crossing; improve use of existing stream and wetland habitats upstream of road crossing
Property, Easement Acquisition Needs	Yes (acquisition of right-of-way)
Estimated Implementation Cost	$292,000
Implementation Priority	High
Photographs	 

Project H-7, Basin H, Subbasin H113 **East Fork Soosette Creek Culvert Replacements – Southwest of Southeast 276th Street**	
Figure reference	7-30
Drainage problems addressed	EFSC-1, EFSC-2
Problem type, description, conditions	Frequent flooding potential at 144th Avenue Southeast and private culvert has insufficient capacity for future area development
Solution needs, opportunities	Improve flood protection level; upgrades private culvert to reduce flood potential; improves fish passage
Solution alternatives	Alternative 1 – EFSC-1: Replace existing culvert with 14-foot by 4-foot three-sided box culvert; EFSC-2: Replace existing culvert with a 14-foot by 3-foot three-sided box culvert southwest of Southeast 276th Street
Recommended improvement	Alternative 1
Other project dependencies	H-6 (implement jointly or first)
Key benefits	Reduces flooding potential at 144th Avenue Southeast, upgrades private driveway culvert for future area development; improves fish passage
Property, easement acquisition needs	No
Estimated implementation cost	$143,000
Implementation priority	Low
Photographs	

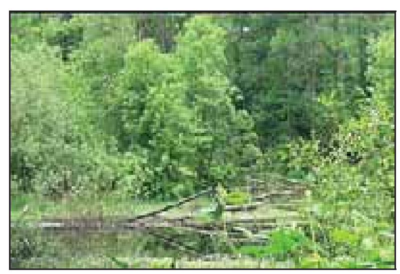
Project H-8, Basin H, Subbasins H61, H62 ***West Fork North Branch Soosette Creek Channel Widening – South of Southeast 256th Street***	
Figure Reference	7-31
Drainage Problems Addressed	WFNB-1, WFNB-2
Problem Type, Description, Conditions	Frequent and extensive flooding potential along West Fork North Branch Soosette Creek due to stream section hydraulic restrictions
Solution Need, Opportunities	Expand channel capacity; improve flood protection level; enhance fish use/habitat
Solution Alternatives	Alternative 1 – WFNB-1: Widen 600 feet of stream channel to approximate geometry of 3-foot bottom width, 3:1 side slopes, and 2-foot depth; WFNB-2: Widen 400 feet of stream channel to 15-foot bottom width, 3:1 side slopes, and 1-foot depth; create low flow channel (both sections) and restore streambed gravel substrate; revegetate disturbed stream banks
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces frequency and magnitude of flooding; improves fish habitat
Property, Easement Acquisition Needs	Yes
Estimated Implementation Cost	$646,000
Implementation Priority	Low
Photographs	 

Project H-9, Basin H, Subbasin H50 ***West Fork West Branch Soosette Creek Culvert Replacements – 116th Avenue Southeast***	
Figure Reference	7-32
Drainage Problems Addressed	WFWB-1, WFWB-2, WFWB-3, WFWB-4
Problem Type, Description, Conditions	Flooding potential of 116th Avenue Southeast and at upstream residential neighborhood locations due to undersized driveway culverts and fish passage limitations; City has recently replaced the downstream crossings with 18-inch culverts that meet hydraulic capacity needs
Solution Need, Opportunities	Improve flood protection level and fish passage along creek
Solution Alternatives	Alternative 1 – Replace all four driveway culverts to 8 foot by 3 foot three-sided box culverts; restore disturbed streambed and banks in proximity to replacement culverts
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces flooding potential along 116th Avenue Southeast, at private driveways, and at apartment complex; improves fish passage conditions along creek
Property, Easement Acquisition Needs	Yes
Estimated Implementation Cost	$470,000
Implementation Priority	Low
Photographs	 

Project H-10, Basin H, Subbasin H09 **North Fork Meridian Valley Creek Restoration Repair – South of Southeast 240th Street**	
Figure Reference	7-33
Drainage Problems Addressed	None Identified; City condition assessment
Problem Type, Description, Conditions	Log weirs previously installed along approximately 450 feet of channel downstream from Southeast 240th Street are being undercut and are not fully providing the intended channel bed stabilization function. An outfall from the off-channel existing detention ponds to the east requires stabilization at the channel confluence.
Solution Need, Opportunities	Restore or replace existing channel bed stabilization features along the affected channel reach
Solution Alternatives	Alternative 1 – Restore or replace existing log weirs or possibly eliminate affected weirs with roughened channel design. Add additional large woody debris to improve sediment retention, create/maintain pools, and to provide increased channel habitat complexity.
Recommended Improvement	Alternative 1
Other Project Dependencies	H-1 (Implement jointly)
Key Benefits	Reduces erosion and downstream sediment delivery; improves fish passage and habitat conditions along creek
Property, Easement Acquisition Needs	Yes (acquisition of property from King County, currently in progress)
Estimated Implementation Cost	$150,000 (Allowance)
Implementation Priority	Medium
Photographs	

Project H-11, Basin H, Subbasin H11 North Fork Meridian Valley Creek Restoration – Southeast 236th Place Culvert Replacement	
Figure Reference	7-34
Drainage Problems Addressed	None Identified; City condition assessment
Problem Type, Description, Conditions	The existing double 54-inch by 36-inch corrugated metal pipe arches are undersized resulting in potential overflows during larger storm events. The culverts are also corroding and are at risk to potential structural failure affecting the Southeast 236th Place roadway.
Solution Need, Opportunities	Improve flood protection level, structural integrity of culvert crossing, and fish passage along creek
Solution Alternatives	Alternative 1 – Replace the existing culverts with a 12-foot by 5-foot (4-foot hydraulic height) three-sided box culvert designed for fish passage with natural streambed substrate. Restore disturbed streambed and banks local to culvert replacement.
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces flooding potential and reduces risk of potential culvert failure at Southeast 236th Street; improves fish passage conditions at crossing
Property, Easement Acquisition Needs	No
Estimated Implementation Cost	$205,000
Implementation Priority	High (risk of culvert structural failure affecting roadway)
Photographs	

Project I-1, Basin I, Subbasin I1 Lower Garrison Creek Sediment Removal at South 218th Street, Upstream Erosion Controls	
Figure Reference	7-35
Drainage Problems Addressed	GC-1
Problem Type, Description, Conditions	Bank erosion upstream of the crossing of Garrison Creek and South 218th Street; channel sedimentation and braiding through those sediments; upstream stream corridor erosion
Solution Need, Opportunities	Improve fish passage and habitat; control upstream stream channel erosion
Solution Alternatives	Alternative 1 – Remove excess sediment in Garrison Creek, restore streambed for fish passage, and replant stream banks to protect banks and reduce bank erosion
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces potential for bank erosion and improves fish passage and habitat
Property, Easement Acquisition Needs	Yes
Estimated Implementation Cost	$61,000
Implementation Priority	Medium
Photographs	 

Projects L-2, L-3, Basin L, Subbasins L01 Lake Fenwick Aeration and Constructed Wetland Treatment Systems	
Figure reference	7-37
Drainage problems addressed	LF-1, LF-2
Problem type, description, conditions	High total phosphorus levels in Lake Fenwick with regulated TMDL loading allocation; existing hypolimnetic aeration system in lake is not large enough to meet treatment demand; existing constructed wetland upstream of lake cannot fully assimilate total phosphorus loading delivered to it from upstream developed residential areas
Solution needs, opportunities	Expand lake hypolimnetic aeration system and annually harvest constructed wetland vegetation prior to die-back (partially releases assimilated phosphorus back to lake)
Solution alternatives	Alternative 1 – L-2: Annually harvest constructed wetland vegetation prior to winter die-back; implement upstream total phosphorus source control and treatment to control total phosphorus influent loadings (see Project L-1); continue to monitor to demonstrate compliance or potential compliance issues with TMDL requirements; L-3: Install improved (more powerful) hypolimnetic aeration system as an upgrade to the existing treatment system
Recommended improvement	Alternative 1
Other project dependencies	L-1 (implement jointly)
Key benefits	Provides total phosphorus loading reduction to Lake Fenwick for improved lake water quality, compliance with TMDL requirements, and to minimize risks of affecting public recreational uses of the lake
Property, easement acquisition needs	No
Estimated implementation cost	L-2: \$100,000; L-3: \$400,000
Implementation priority	Medium
Photographs	 

Projects Q-2, Q-3, Basin Q, Subbasins Q01 **Green River Natural Resource Area Outlet at Maintenance Improvements**	
Figure reference	7-40, 7-41
Drainage problems addressed	GRNRA-1, GRNRA-2
Problem type, description, conditions	GRNRA is operating at a lagoon low stage approximately 2 feet higher than design target resulting in approximately 25 percent loss of active detention storage; sediment in outlet ditch is obstructing lagoon outflows; control weir plates and fencing are missing or needing repair; excess sediment in pre-settling basins affecting treatment performance
Solution needs, opportunities	Restore GRNRA lagoon outlet, detention, and water quality treatment functionality consistent with design; replace missing components; improve flow control to Mill Creek
Solution alternatives	Alternative 1 (Q-2) – Install replacement weir plates (alternate materials) on GRNRA control weirs (4 to 5 locations); remove excess sediment from GRNRA pre-settling basins; repair and replace GRNRA fencing where damaged or missing Alternative 1 (Q-3) – Replace and realign the South 212th Street crossing of the lagoon outlet channel for more efficient hydraulic condition; remove excess sediment from and expand ditch section along South 212th Street (along Boeing property segment); add low flow channel with lowered invert elevation (1 to 2 feet typical) for entire reach along South 212th Street and West Valley Highway; remove excess channel vegetation in close proximity to adult fish screen above Mill Creek confluence Alternative 2 (Q-3) – Similar to Alternative 1, except realign lagoon outlet channel along south side of South 212th Street for section fronting Boeing property; install new box culvert crossing of South 212th Street with outlet on east side of 64th Avenue South; same downstream improvements to outlet channel as with Alternative 1 Alternative 3 (Q-3) – Install new 48-inch TSD in 64th Avenue South (tie to existing TSD near outfall, and make connection to GRNRA outlet with existing channel west of 64th Avenue South; same downstream improvements for outlet channel as with Alternative 1 Alternative 4 (Q-3) – Add new pump station (assumed 30 cfs capacity), outfall force main, and new Green River outfall to provide required lagoon drawdown
Recommended improvement	Q-2: Alternative 1; Q-3: Alternative 3
Other project dependencies	A-5 (implement jointly)
Key benefits	Restores active detention storage in GRNRA lagoon providing improved flow control to Mill Creek; provides improved functionality of other lagoon features including water quality treatment; limits public access and improves public safety consistent with City intent
Property, easement acquisition needs	No
Estimated implementation cost	Q-2: $1,330,000; Q-3: $1,669,000
Implementation priority	High
Photographs	 

7.2 Trunk Drainage System Improvement Opportunities and Recommended Projects

This section describes the identified project improvement needs along trunk drainage systems evaluated in the DMP. These improvements are proposed for integration into the City's updated Stormwater CIP as guidance for projects implementation after DMP approval by the City Council. All projects are targeted to provide flood reduction benefits to a minimum 25-year level-of-protection standard unless otherwise identified as a higher standard. The basis for recommended projects estimated implementation cost opinions at this planning level of analysis included in the project tables is discussed in Section 7.3.

Project A-5, Basin A, Subbasin A13W ***TSD Improvements – Partial Subbasin A13W Diversion to GRNRA***	
Figure reference	7-5
Drainage problems addressed	LMC-6, PM-12
Problem type, description, conditions	Highly developed Subbasin A13W discharges runoff to Mill Creek at the priority problem flooding area on 76th Avenue South (see Project A-7); existing connection under BNRR to 76th Avenue TSD adds significantly to hydraulic and water quality loading to Mill Creek
Solution needs, opportunities	Improve local flood protection level, downstream Mill Creek water quality and improve fish habitat improvement; coordinate with South 228th Street TIP UPRR under crossing project
Solution alternatives	All alternatives would divert approximately 50 percent of Subbasin A13W runoff directly to the GRNRA (pre-settling and constructed wetland treatment systems, then to lagoon detention storage). Alternative 1 – Install approximately 3,200 feet of 8-foot by 4-foot box culvert from UPRR to existing conveyance channel outfall west of West Valley Highway west along and within the South 228th Street road corridor; replace two crossings (rail spur and roadway) along channel with double 10-foot by 7-foot three-sided box culverts; excavate sediments and restore channel Alternative 2 – Install approximately 4,800 feet of 72-inch TSD from UPRR directly to GRNRA southeast pre-settling pond west along the periphery of South 228th Street, north along periphery of 68th Avenue South, and west to GRNRA Alternative 3 – Re-grade approximately 1,050 feet of existing open channel along UPRR south from South 228th Street, then west to 68th Avenue South; install 72-inch TSD at 68th Avenue South; construct 1,500 feet of vegetated channel west of 68th Avenue South (within wetland area); install 850 feet of 72-inch TSD through commercial development area and under West Valley Highway with outfall to existing channel; downstream channel improvements same as Alternative 1 Alternative 4 – Install approximately 4,400 feet of 72-inch TSD along Interurban Trial and Puget Sound Energy transmission corridor to GRNRA Mill Creek diversion channel (alternative not further evaluated)
Recommended improvement	Alternative 3
Other project dependencies	Q-2, Q-3 (implement first or jointly); implement prior to South 228th Street TIP road under-crossing improvement of UPRR
Key benefits	Reduces local flooding potential and flood levels on Lower Mill Creek; reduces extent of required improvements for Projects A-6 and A-7; improves downstream Mill Creek water quality and fish habitat; expands use/benefits of prior GRNRA project
Property, easement acquisition needs	Yes
Estimated implementation cost	$3,864,000
Implementation priority	High
Photographs	 

Project A-6, Basin A, Subbasin A13W TSD Improvements – 4th Avenue North, Smith Street to near South 228th Street	
Figure reference	7-6
Drainage problems addressed	LMC-6
Problem type, description, conditions	Flooding potential in downtown corridor due to undersized TSD along 4th Avenue North
Solution needs, opportunities	Improve flood protection level and emergency access within the downtown corridor; reduce economic impact associated with flooding potential
Solution alternatives	Alternative 1 – Replace trunk system with 3,110 feet of 60-inch TSD and 1,280 feet of 48-inch TSD along 4th Avenue North; approximately 250 feet of bore and jack (or micro-tunnel) is required due to SR 167 crossing in upgrade area
Recommended improvement	Alternative 1
Other project dependencies	A-5 (implement first or jointly)
Key benefits	Reduces flooding potential and improves emergency access under flooding conditions in downtown corridor; provides economic benefit to local businesses
Property, easement acquisition needs	No
Estimated implementation cost	$5,672,000
Implementation priority	Medium
Photographs	 

Project A-8, Basin A, Subbasin A04W TSD Improvements – South 190th Street and South 196th Street	
Figure reference	7-8
Drainage problems addressed	None identified (the City has received drainage complaints in these areas)
Problem type, description, conditions	Flooding potential along South 190th Street and South 196th Street between Mill Creek and the Green River due to inadequately sized TSD systems
Solution needs, opportunities	Improve flood protection level and emergency access
Solution alternatives	Alternative 1 – Replace deficient sections of existing TSD with 1,800 feet of 36-inch TSD along South 196th Street and with 1,270 feet of 36-inch TSD along South 190th Street
Recommended improvement	Alternative 1
Other project dependencies	None
Key benefits	Reduces flooding potential and improves emergency access under flooding conditions in the improvements area and upstream reaches; provides economic benefit to local businesses
Property, easement acquisition needs	No
Estimated implementation cost	$2,590,000
Implementation priority	Low
Photographs	 

Project B-2, Basin B, Subbasin B04W TSD Improvements – South 196th Street and 84th Avenue South	
Figure reference	7-10
Drainage problems addressed	SBC-1
Problem type, description, conditions	Frequent flooded roadways and commercial businesses; hydraulic analysis demonstrates that the existing TSD systems did not have adequate capacity; also inadequately sized pump station at Hexcel site adds to flooding problems (recirculation appears to occur under high creek tail water conditions)
Solution needs, opportunities	Improve flood protection level and emergency access in commercial development area through improved conveyance and pumping systems; potential for partial gravity bypass of pumping system; reduce water quality degradation
Solution alternatives	Replace capacity deficient TSD systems in South 196th Street and 84th Avenue South with enlarged gravity TSD totaling approximately 7,100 feet of 18-inch to 72-inch TSD; due to shallow cover, some segments may need to be constructed with reinforced concrete boxes or ductile iron pipe; upgrade the pump station at the Hexcel site for increased capacity; intercept and divert some stormwater that is currently served by the pump to the 196th Street TSD by gravity bypass; install new low head flap gates on at TSD outfalls
Recommended improvement	Alternative 1
Other project dependencies	None (the TSD for each system can be completed independently)
Key benefits	Reduces flooding potential and improves emergency access under flooding conditions in the improvements area and upstream reaches; provides economic benefit to local businesses (eliminates frequent flooding of Hexcel site) Reduces potential for flooding of private property, traffic interruptions, and water quality degradation
Property, easement acquisition needs	Yes, may require easements from private property owners
Estimated implementation cost	$4,612,000
Implementation priority	High
Photographs	 

Project B-3, Basin B, Subbasin B03E _TSD Improvements – North Side of South 180th Street_	
Figure reference	7-11
Drainage problems addressed	None identified (flooded extensively in December 3, 2007 flooding)
Problem type, description, conditions	Flooding potential along South 180th Street and 80th Avenue South due to inadequately sized TSD system; TSD in Renton, but affects flooding in the City
Solution needs, opportunities	Improve flood protection level and emergency access; coordinate with Renton on solution, cost-sharing, and implementation schedule
Solution alternatives	Alternative 1 – Replace approximately 1,400 feet of existing TSD with 54-inch TSD; realign discharge to Mill Creek to prevent bank erosion
Recommended improvement	Alternative 1
Other project dependencies	None
Key benefits	Reduces flooding potential and improves emergency access under flooding conditions in the improvements area and upstream reaches
Property, easement acquisition needs	Yes – Project improvements located in City of Renton (coordination needed to implement)
Estimated implementation cost	$1,836,000
Implementation priority	Low
Photographs	

Project C-1, Basin C, Subbasin C02 **TSD Improvements – South of Kent-Des Moines Road, East of SR 167**	
Figure reference	7-12
Drainage problems addressed	None identified
Problem type, description, conditions	Flooding potential in residential area near Kent-Des Moines Road (east of SR 167) due to inadequately sized TSD
Solution needs, opportunities	Improve flood protection level of residential area; SR 167 crossing TSD size is marginal, but not recommended for improvement due to cost of bore and jack (or micro-tunnel)
Solution alternatives	Alternative 1 – Replace deficient sections of existing TSD with 660 feet of 24-inch TSD along West Willis Street and Sixth Avenue South and with 150 feet of 30-inch TSD in playground area between railroad and 6th Avenue South
Recommended improvement	Alternative 1
Other project dependencies	None
Key benefits	Reduces flooding potential of local residential area
Property, easement acquisition needs	No
Estimated implementation cost	$341,000
Implementation priority	Low
Photographs	

Project C-2, Basin C, Subbasin C05 **TSD Improvements – 1st Avenue South and 3rd Avenue South Extensions**	
Figure reference	7-13
Drainage problems addressed	None identified
Problem type, description, conditions	Flooding potential in residential areas due to lack of TSD south of West Crow Street between 5th Avenue South and 1st Avenue South
Solution needs, opportunities	Extend TSD system to improve flood protection level for residential areas
Solution alternatives	Alternative 1 – Extend existing TSD system with 580 feet of 18-inch TSD in 3rd Avenue South and with 580 feet of 12-inch TSD in 1st Avenue South
Recommended improvement	Alternative 1
Other project dependencies	None
Key benefits	Reduces flooding potential and extends storm drain service to residential areas previously without improved drainage systems
Property, easement acquisition needs	No
Estimated implementation cost	$485,000
Implementation priority	Low
Photographs	 

Project C-3, Basin C, Subbasin C07 ***TSD Improvements – 79th Avenue South, South 266th Street to Detention Pond***	
Figure reference	7-14
Drainage problems addressed	None identified
Problem type, description, conditions	Flooding potential due to lack of existing TSD on 79th Avenue South and inadequately sized TSD between South 266th Street and detention pond near Green River outfall; potential outfall gravity discharge limitations at high river stages
Solution needs, opportunities	Improve flood protection level and extend storm drainage service
Solution alternatives	Alternative 1 – Replace existing TSD system between South 266th Street and detention pond with 550 feet of 24-inch TSD Alternative 2 – Extend existing TSD along 79th Avenue South with 500 feet of 12-inch TSD
Recommended improvement	Alternatives 1 and 2
Other project dependencies	None
Key benefits	Reduces flooding potential and expands TSD service area
Property, easement acquisition needs	No
Estimated implementation cost	Alternative 1: $245,000; Alternative 2: $148,000
Implementation priority	Low
Photographs	 

Project C-4, Basin C, Subbasin C08 TSD Improvements – Central Avenue South, South 259th Street, Extensions, and Pump Station	
Figure reference	7-15
Drainage problems addressed	PM-1, PM-6, PM-9
Problem type, description, conditions	Potential flooding along Central Avenue South due to inadequately sized TSD and outfall pumping system capacity limitations; frequent flooding along private parking lots and driveways in Maple Lane South due to lack of drainage infrastructure
Solution needs, opportunities	Improve flood protection level provided by TSD system and outfall pumping; extend TSD service to frequent flooding problem areas
Solution alternatives	Alternative 1 – Replace deficient sections of existing TSD along Central Avenue South, totaling approximately 1,430 feet of 30-inch TSD, 260 feet of 36-inch TSD, and 1,720 feet of 42-inch TSD; replace deficient section of South 259th Street TSD with 780 feet of 24-inch TSD; replace existing TSD along South Alder Lane and Maple Lane South with 620 feet of 18" TSD Alternative 2 – Replace outfall pump station inlet piping with 610 feet of 60-inch TSD, replace various sections of Central Avenue South TSD, totaling approximately 1,130 feet of 30-inch TSD, 570 feet of 36-inch TSD, and 490 feet of 42-inch TSD; replace TSD along South Alder Lane and Maple Lane South with 620 feet of 18-inch TSD Alternative 3 – Replace outfall pump station inlet piping with 610 feet of 72-inch TSD; replace various sections of Central Avenue South TSD, totaling approximately 1,130 feet of 30-inch TSD, 650 feet of 36-inch TSD, and 180 feet of 48-inch TSD; replace trunk system along South Alder Lane and Maple Lane South with 620 feet of 18-inch TSD Alternative 4 – Extend TSD system along Maple Lane South with 560 feet of 18-inch TSD and 900 feet of 12-inch TSD; along South 266th Street, extend system with approximately 640 feet of 18-inch TSD and 130 feet of 12-inch TSD Alternative 5 – Add a 4th pump and associated equipment (rated capacity of 22 cfs at design head) in existing extra pump bay at TSD outfall pump station to Green River; confirm force main capacity to deliver additional rated flow at design head
Recommended improvement	Alternatives 3, 4, and 5
Other project dependencies	None
Key benefits	Reduces flooding potential by removing TSD restrictions; increases the TSD discharge capacity to the Green River at outfall; expands service area to areas of frequent flooding problems
Property, easement acquisition needs	No
Estimated implementation cost	Alternative 3: $2,483,000; Alternative 4: $623,000; Alternative 5: $550,000
Implementation priority	Medium
Photographs	 

Project F-1, Basin F, Subbasin F01 **TSD Improvements – Outfall Pump Station**	
Figure reference	7-16
Drainage problems addressed	LDS-1
Problem type, description, conditions	Potential flooding of roadway and local commercial service area due to insufficient pumping capacity to Green River
Solution needs, opportunities	Improve flood protection level through pump station upgrade
Solution alternatives	Alternative 1 – Increase pumping capacity by expanding pump station with larger pumps and force main as required (information on existing pump station was not available for DMP evaluation)
Recommended improvement	Alternative 1
Other project dependencies	None
Key benefits	Reduces flooding potential and increases upstream drainage system capacity (predominately open channel) through increased outfall discharges to Green River
Property, easement acquisition needs	No
Estimated implementation cost	$2,225,000 (allowance for 50 cfs pump station capacity upgrade)
Implementation priority	Medium
Photographs	 

Project G-1, Basin G, Subbasin G05E **_TSD Improvements – 110th Place Southeast, Southeast 256th Street, 109th Avenue Southeast_**	
Figure Reference	7-17
Drainage Problems Addressed	None Identified
Problem Type, Description, Conditions	Flooding potential along public roadways including major arterial and in multi-family residential area due to inadequately sized TSD system
Solution Need, Opportunities	Improve flood protection level and emergency access; limit potential flood damages to high-density residential area
Solution Alternatives	Alternative 1 – Replace deficient sections of existing TSD with new piping totaling approximately 940 feet of 36-inch TSD along 110 Place Southeast, 830 feet of 36-inch TSD along Southeast 256 Street, and 1,360 feet of 18-inch to 36-inch TSD along 109th Avenue Southeast
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces flooding potential and improves emergency access under flooding conditions; reduces risk to multi-family residential development flood damages
Property, Easement Acquisition Needs	No
Estimated Implementation Cost	$2,051,000
Implementation Priority	Medium
Photographs	 

Project G-2, Basin G, Subbasin G05E TSD Improvements – 104th Avenue Southeast, Southeast 260th Street to Southeast 256th Street	
Figure Reference	7-18
Drainage Problems Addressed	None Identified
Problem Type, Description, Conditions	Flooding potential along public roadways and in commercial development area west of 104th Avenue Southeast, and south/north of Southeast 260th Street due to shallow, inadequately sized TSD system
Solution Need, Opportunities	Improve flood protection level and emergency access; limit potential flood damages in commercial development areas
Solution Alternatives	Alternative 1 – Replace deficient sections of existing TSD with new piping totaling approximately 1,000 feet of 60-inch TSD along 104th Avenue Southeast, 660 feet of double 42-inch TSD along 104th Avenue Southeast, 350 feet of 48-inch TSD along Southeast 260th Street, 1,350 feet of 48-inch TSD between Southeast 256th Street and Southeast 260th Street, and 170 feet of 18-inch TSD along Kent-Kangley Road
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces flooding potential and improves emergency access under flooding conditions; reduces risk to commercial development area flood damages
Property, Easement Acquisition Needs	No
Estimated Implementation Cost	$3,488,000
Implementation Priority	Medium
Photographs	 

Project G-5, Basin G, Subbasin G04E ***TSD Improvements – 97th Place South to Outfall***	
Figure Reference	7-21
Drainage Problems Addressed	None Identified
Problem Type, Description, Conditions	Flooding potential to public roadway due to inadequately sized TSD extending to outfall
Solution Need, Opportunities	Improve flood protection level and emergency access; protect outfall from erosion and damage
Solution Alternatives	Alternative 1 – Replace deficient sections of existing TSD with new piping totaling approximately 350 feet of 24-inch TSD along 97th Place South and 220 feet of 30-inch TSD extending to its outfall at Upper Mill Creek
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces flooding potential and improves emergency access under flooding conditions; reduces risk to outfall creek erosion
Property, Easement Acquisition Needs	No
Estimated Implementation Cost	$288,000
Implementation Priority	Medium
Photographs	

Project G-6, Basin G, Subbasin G03E TSD Improvements – Southeast 248th Street, 100th Avenue Southeast	
Figure Reference	7-22
Drainage Problems Addressed	None Identified
Problem Type, Description, Conditions	Flooding potential to public roadways and adjacent residential area due to inadequately sized TSD system
Solution Need, Opportunities	Improve flood protection level and emergency access; limit potential flood damages in residential development areas
Solution Alternatives	Alternative 1 – Replace deficient sections of existing TSD with approximately 170 feet of 18-inch TSD along 100th Avenue Southeast and with 70 feet of 18-inch TSD along South 248th Street
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces flooding potential and improves emergency access under flooding conditions; reduces risk to residential development area flood damages
Property, Easement Acquisition Needs	No
Estimated Implementation Cost	$169,000
Implementation Priority	Medium
Photographs	 

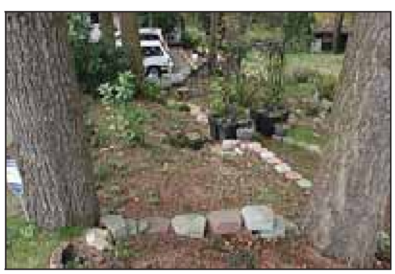
Project G-7, Basin G, Subbasin G02E **TSD Improvements – Canyon Drive Southeast to Outfall**	
Figure Reference	7-23
Drainage Problems Addressed	None Identified
Problem Type, Description, Conditions	Flooding potential to public roadway due to inadequately sized TSD extending to outfall
Solution Need, Opportunities	Improve flood protection level and emergency access; protect outfall from erosion and damage
Solution Alternatives	Alternative 1 – Replace deficient sections of existing TSD with approximately 210 feet of 30-inch TSD to its outfall at Upper Mill Creek; install energy dissipator on outfall to control potential creek erosion
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces flooding potential and improves emergency access under flooding conditions; reduces risk to outfall creek erosion
Property, Easement Acquisition Needs	No
Estimated Implementation Cost	$120,000
Implementation Priority	To be determined
Photographs	

Project H-2, Basin H, Subbasin H11 Meridian Valley Creek TSD Conveyance Improvements – 132nd Avenue SE to 136th Avenue SE	
Figure Reference	7-25
Drainage Problems Addressed	MVC-2
Problem Type, Description, Conditions	Flooding potential to public roadway due to inadequately sized TSD extending to outfall; extent of deficiency depends on upstream detention storage pond size and operation
Solution Need, Opportunities	Consider expansion in upstream detention pond size to achieve for more restrictive outlet flow control; improve system conveyance capacity by enlarging TSD
Solution Alternatives	Alternative 1 – Increase storage in existing detention/retention pond at 132nd Avenue Southeast and Southeast 244th Street by approximately 10,000 cubic feet Alternative 2 – Same as Alternative 1 but also replace deficient sections of the existing TSD with approximately 1,200 feet of 18-inch to 30-inch TSD extending from the detention pond to and along 133rd Avenue Southeast to its outfall with energy dissipator at Meridian Valley Creek
Recommended Improvement	Alternative 2
Other Project Dependencies	None
Key Benefits	Reduces flooding potential and improves emergency access under flooding conditions; reduces risk to outfall creek erosion
Property, Easement Acquisition Needs	No
Estimated Implementation Cost	$883,000
Implementation Priority	Medium
Photographs	 

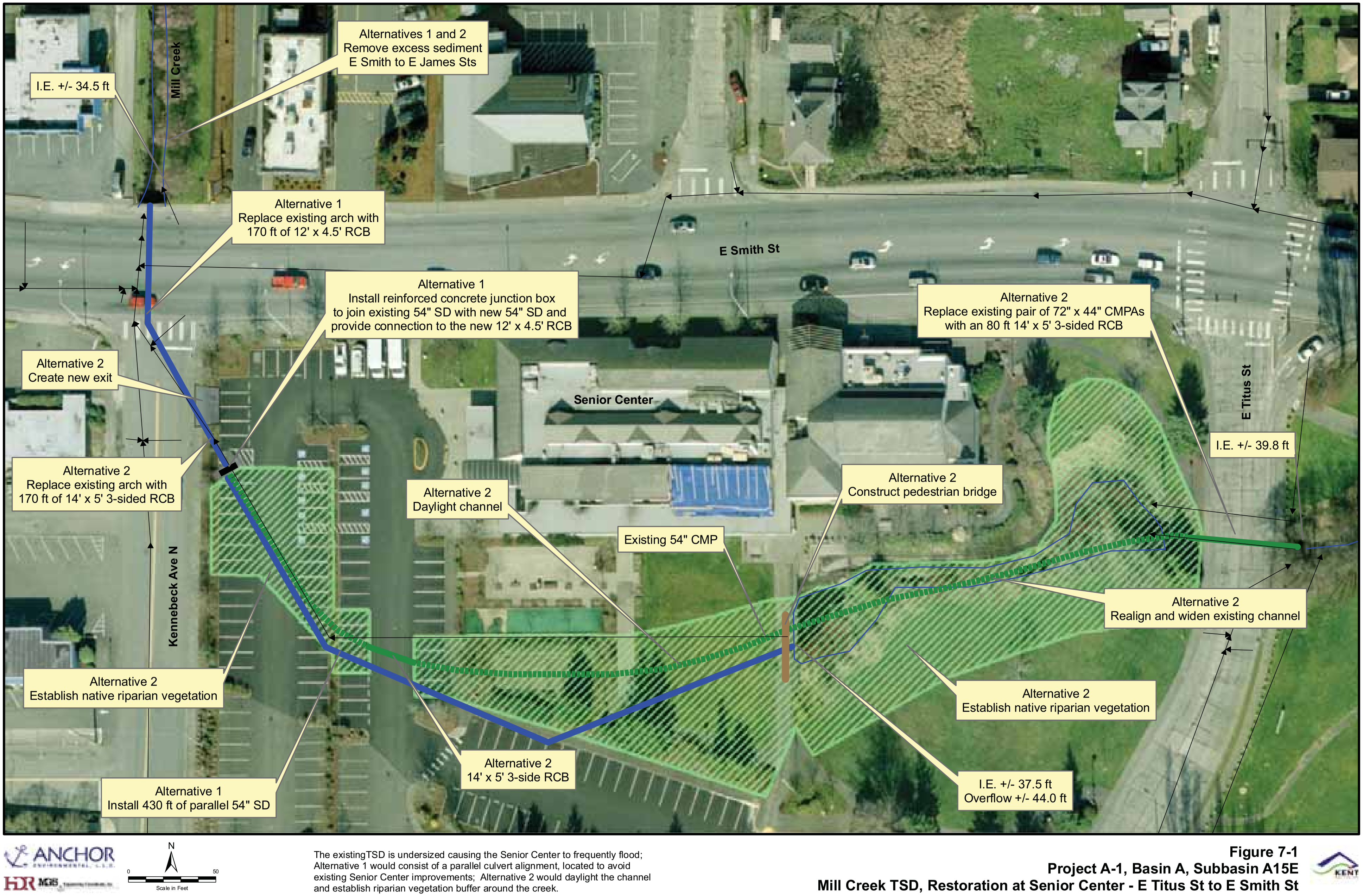
Project H-3, Basin H, Subbasin H131 TSD Improvements – 145th Place Southeast and 146th Avenue Southeast	
Figure Reference	7-26
Drainage Problems Addressed	MVC-3
Problem Type, Description, Conditions	Runoff from a public drainage system is routed through a TSD on private property and with resulting flooding potential
Solution Need, Opportunities	Fully establish adequately sized TSD system within public right-of-way to improve maintenance access; protect outfall from erosion as creek
Solution Alternatives	Alternative 1 – Install approximately 390 feet of new 18-inch TSD in 145th Place Southeast; install approximately 166 feet of replacement 18-inch TSD along 146th Avenue Southeast and install energy dissipator at its outfall
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Eliminates interface of public drainage system with private system; reduces flooding potential and improves emergency access under flooding conditions; reduces risk to outfall creek erosion
Property, Easement Acquisition Needs	No
Estimated Implementation Cost	$304,000
Implementation Priority	Low
Photographs	

Project H-4, Basin H, Subbasin H30 **TSD Improvements – 132nd Avenue Southeast to Lake Meridian Outfall**	
Figure Reference	7-27
Drainage Problems Addressed	LMT-2
Problem Type, Description, Conditions	Existing TSD under Lake Meridian Estates Park is in poor condition and is reported to be failing; also, its restrictive capacity also results in flooding potential to a mobile home park and along the adjacent public road
Solution Need, Opportunities	Abandon failing TSD; divert flows to existing parallel TSD; reconnect existing catch basins to adjacent TSD
Solution Alternatives	Alternative 1 – Plug and abandon approximately 780 feet of existing TSD under Lake Meridian Estates (mobile home) Park; replace deficient section of adjacent TSD with approximately 200 feet of 24-inch TSD; replace approximately 110 feet of 18-inch TSD along Southeast 257th Court to connect to adjacent TSD; install approximately 330 feet of 12-inch TSD along Southeast 258th Street and Southeast 258th Court to connect to adjacent TSD
Recommended Improvement	Alternative 1
Other Project Dependencies	None
Key Benefits	Reduces flooding potential at mobile home park by eliminating that portion of TSD that is reportedly failing and providing connections to adjacent TSD with adequate hydraulic capacity; allows for improved TSD maintenance access
Property, Easement Acquisition Needs	No
Estimated Implementation Cost	$1,585,000
Implementation Priority	Medium
Photographs	

Project L-1, Basin L, Subbasin L01 ***TSD Improvements – Conveyance, Erosion Protection, Water Quality Treatment***	
Figure reference	7-36
Drainage problems addressed	None identified in upper basin (LF-1 and LF-2 are affected in lower basin)
Problem type, description, conditions	Hydraulic analysis shows that several segments of the existing TSD have inadequate capacity; TSD discharges near the top of a steep slope; existing detention systems provide limited flow control
Solution needs, opportunities	Improve level flood protection level; reduce erosion; and improve water quality discharged to Lake Fenwick
Solution alternatives	Alternative 1 – Replace deficient sections of existing TSD with approximately 4,000 feet of 12- to 42-inch TSD; install new 570 feet of TSD tightline to convey stormwater to the bottom of the steep slopes; construct sand filters on drainage systems that discharge to the Lake Fenwick treatment wetland; add or replace energy dissipators at outfalls; modify the existing detention basins to provide water quality treatment and/or LID benefit at low flows
Recommended improvement	Alternative 1
Other project dependencies	L-2, L-3 (implement jointly)
Key benefits	Provides improved conveyance in tributary TSD systems; reduces erosion in steeper tributary drainages to control sediment load to constructed wetland and Lake Fenwick; reduces phosphorus loading to Lake Fenwick for assistance in TMDL compliance
Property, easement acquisition needs	No
Estimated implementation cost	$3,688,000
Implementation priority	Medium
Photographs	 

Project L-4, Basin L, Subbasin L01 ***TSD Improvements – Conveyance, Erosion Protection, Water Quality Treatment***	
Figure reference	7-38
Drainage problems addressed	PM-2, PM-3, PM-4, PM-5
Problem type, description, conditions	Preliminary hydraulic analyses did not identify TSD capacity problems; site reconnaissance suggested that PM-2 and PM-5 are related to roadside ditch maintenance; PM-4 could be rectified by changing the catch basin lids; PM-3 needs a pipe extension to convey roadway runoff down gradient of several structures
Solution needs, opportunities	Conduct maintenance activities; update catch basins with vaned grates to increase roadway runoff capture; reduce potential water damage to structures
Solution alternatives	Alternative 1 – PM-2: Re-grade shoulder of Military Road so that flow to ditch is not obstructed and pave the shoulder; PM-3: extend the existing 18-inch TSD culvert under Military Road approximately 520 feet to the wetland area at the bottom of the slope; install catch basins and an energy dissipator to prevent erosion; PM-4: replace catch basin grates on South 259th Place between 34th Avenue South and Military Road with vaned grates; PM-5: clean and re-grade roadside ditch to restore its proper function
Recommended improvement	Alternative 1
Other project dependencies	None
Key benefits	Reduces potential for nuisance drainage problems affecting private property (from public roadway runoff)
Property, easement acquisition needs	Yes (several easements may be required from private property owners)
Estimated implementation cost	$150,000
Implementation priority	Low
Photographs	 

Project Q-1, Basin Q, Subbasin Q05 TSD Improvements – 54th Avenue South and South 226th Street	
Figure reference	7-39
Drainage problems addressed	None identified
Problem type, description, conditions	Potential flooding due to inadequately sized TSD system
Solution needs, opportunities	Improve flood protection level and emergency access under flooding conditions; minimize risk to flood damages in commercial development area
Solution alternatives	Alternative 1 – Replace deficient sections of existing TSD along South 226th Street with 440 feet of 36-inch TSD and 660 feet of 54-inch TSD; replace existing TSD system along 54th Avenue South with 1,700 feet of 48-inch TSD
Recommended improvement	Alternative 1
Other project dependencies	None
Key benefits	Reduces flooding potential and emergency access in commercial development area
Property, easement acquisition needs	No
Estimated implementation cost	$2,630,000
Implementation priority	Low
Photographs	 



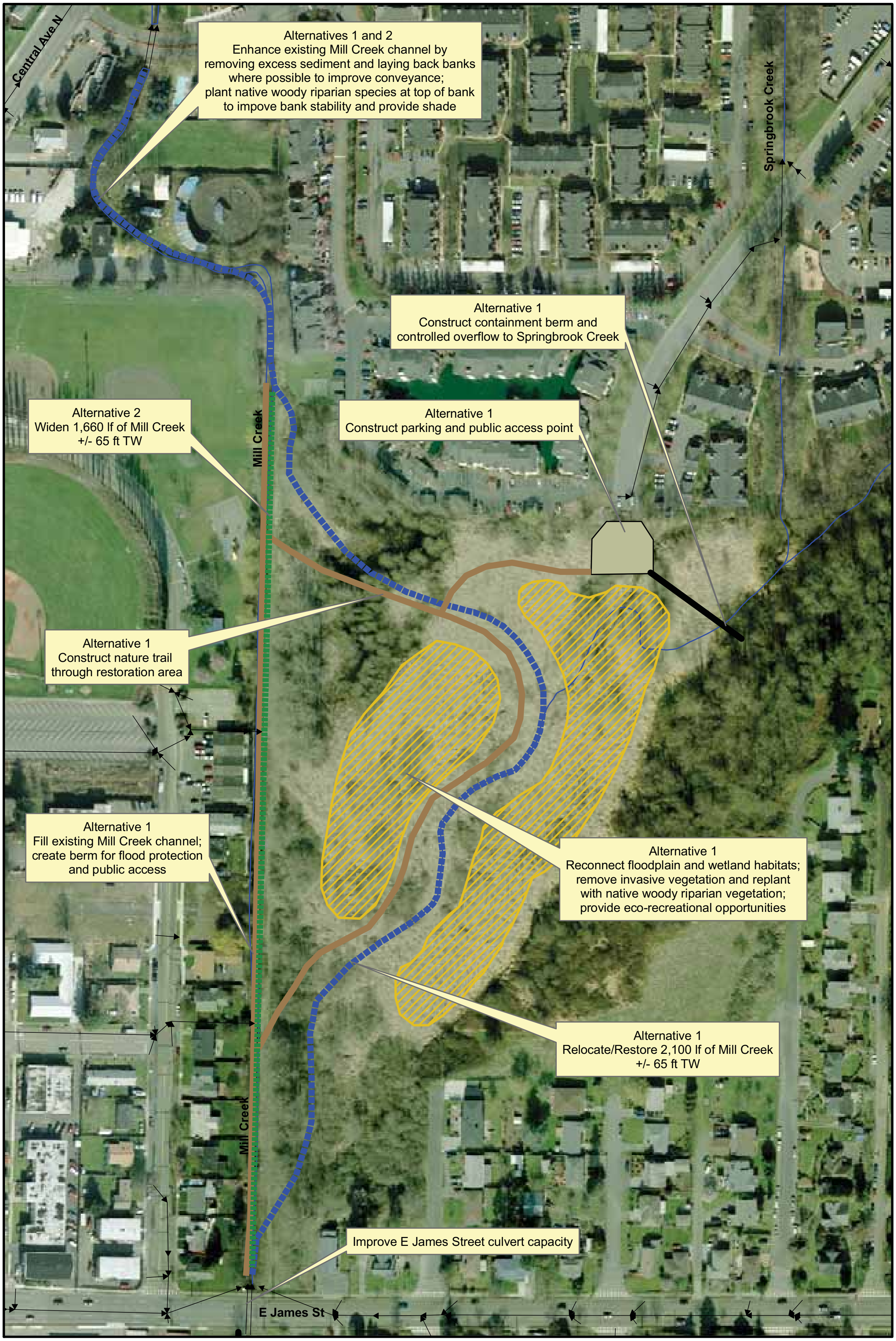
The existingTSD is undersized causing the Senior Center to frequently flood; Alternative 1 would consist of a parallel culvert alignment, located to avoid existing Senior Center improvements; Alternative 2 would daylight the channel and establish riparian vegetation buffer around the creek.

Figure 7-1
Project A-1, Basin A, Subbasin A15E
Mill Creek TSD, Restoration at Senior Center - E Titus St to E Smith St

N
0 100
Scale in Feet

The channel banks between E Smith and E James Sts are below estimated flood elevations; to contain Mill Creek to the channel, improvements must be made to increase the bank elevations.

Figure 7-2
Project A-2, Basin A, Subbasin A15E
Mill Creek Restoration - E Smith St to E James St



Creating a new channel in the adjacent wetland would provide mitigation for other stormwater projects and provide educational and recreational opportunities.

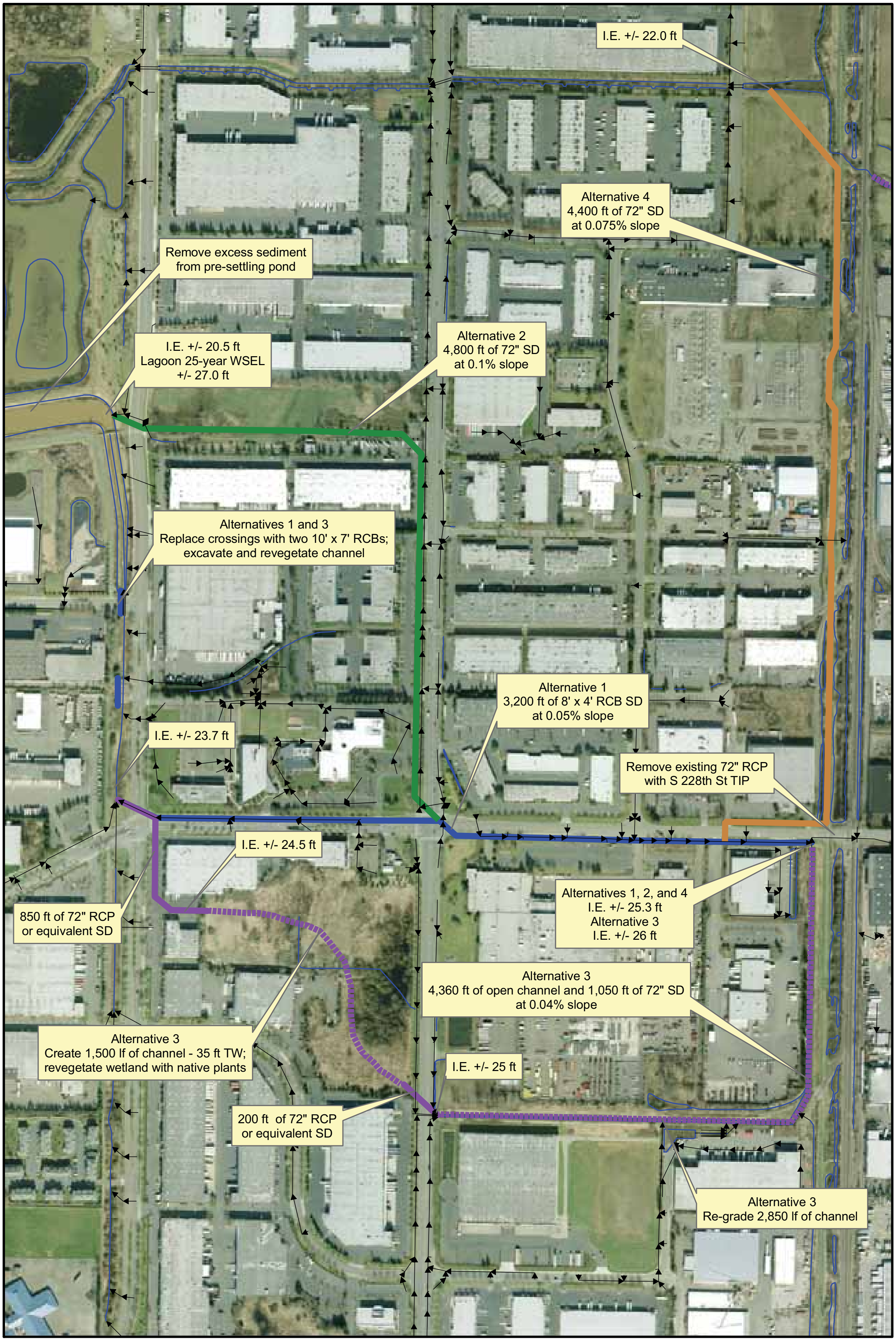
Figure 7-3
Project A-3, Basin A, Subbasin A14E
Mill Creek Restoration - E James St to Chandler Bay Dr

ANCHOR ENVIRONMENTAL, L.L.C.

HDR MGS

Replace restrictive BNSF RR culverts to decrease the WSEL upstream to SR 167.

Figure 7-4
Project A-4, Basin A, Subbasin A14W
Mill Creek Culvert Replacement - BNSF Railroad



N

0 400
Scale in Feet

Partial diversion of Subbasin A13W to GRNRA to offload Mill Creek and reduce flooding along the 76th Ave corridor; coordinate with S 228th St TIP project.

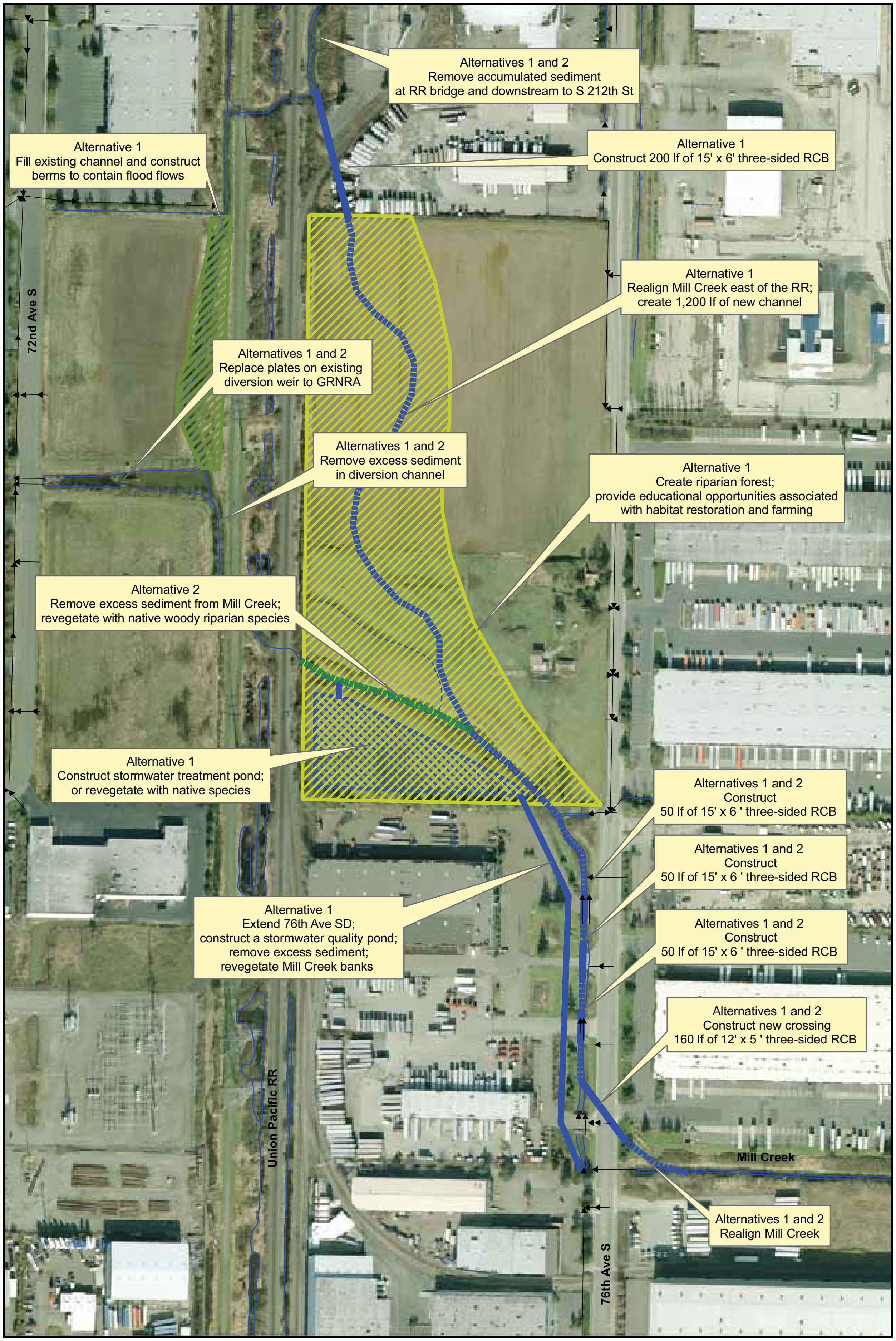
Figure 7-5
Project A-5, Basin A, Subbasin A13W
Partial Subbasin A13W Diversion to GRNRA

N

0 600
Scale in Feet

Replace Subbasin A13W trunk system along 4th Ave N to reduce flooding potential in downtown corridor; requires crossing under SR 167.

Figure 7-6
Project A-6, Basin A, Subbasin A13W
TSD Improvements - 4th Ave N, Smith St to near S 228th St



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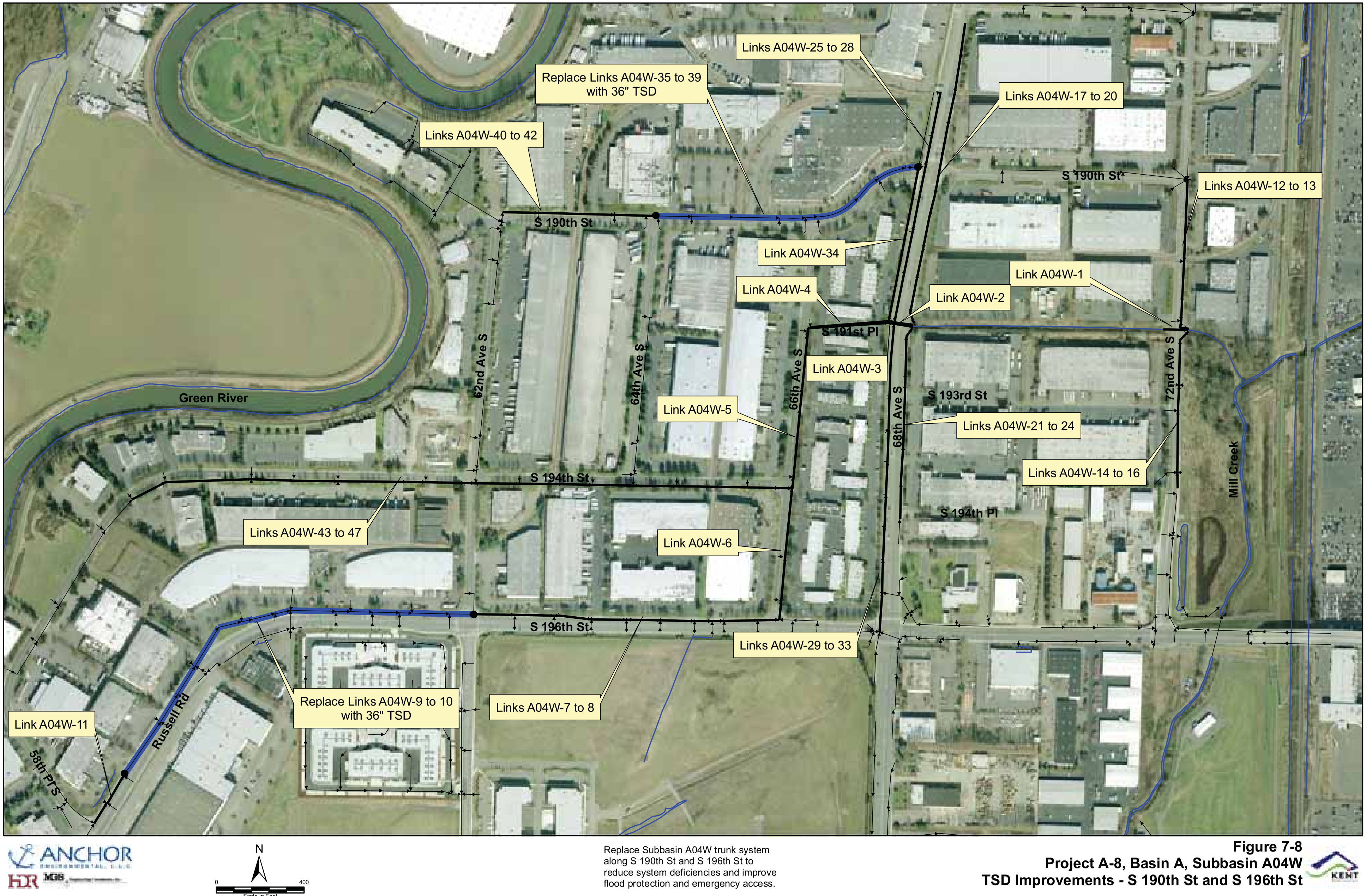
Remove accumulated sediments
Revise 76th Ave S and driveway
culverts. Revegetate with native
woody riparian species.

Figure 7-7
Project A-7, Basin A, Subbasins A13W and A09E
Mill Creek Culverts Replacement, Relocation/Restoration

KENT



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Replace Subbasin A04W trunk system along S 190th St and S 196th St to reduce system deficiencies and improve flood protection and emergency access.

Figure 7-8
Project A-8, Basin A, Subbasin A04W
TSD Improvements - S 190th St and S 196th St

KENT

N

0 820

Scale in Feet

Add additional material to berms at selected locations to contain flood flows between the S 212th St off- ramp to SR167 and S 180th St

Figure 7-9
Project B-1, Basin B, Multiple Subbasins
Springbrook Creek Flood Containment Berms

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S 196th St frequently floods in the vicinity of 81st Ave S; upsize the TSDs in S 196th St and 84th Ave S, upgrade pump station, and re-route private systems to reduce flooding.

Figure 7-10
Project B-2, Basin B, Subbasin B04W
TSD Improvements - S 196th St and 84th Ave S

The downstream portion of the existing trunk system is undersized; coordinate with the City of Renton to upgrade the existing TSD to a 54" RCP to match the upstream system.

Figure 7-11
Project B-3, Basin B, Subbasin B03E(north)
TSD Improvements - North Side of S 180th St

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N

0 250 Scale in Feet

Replace Subbasin C02 trunk system along 6th Ave S and W Willis St to reduce potential flooding of local residential area.

Figure 7-12
Project C-1, Basin C, Subbasin C02
TSD Improvements - S of Kent-Des Moines Rd, E of SR 167

KENT

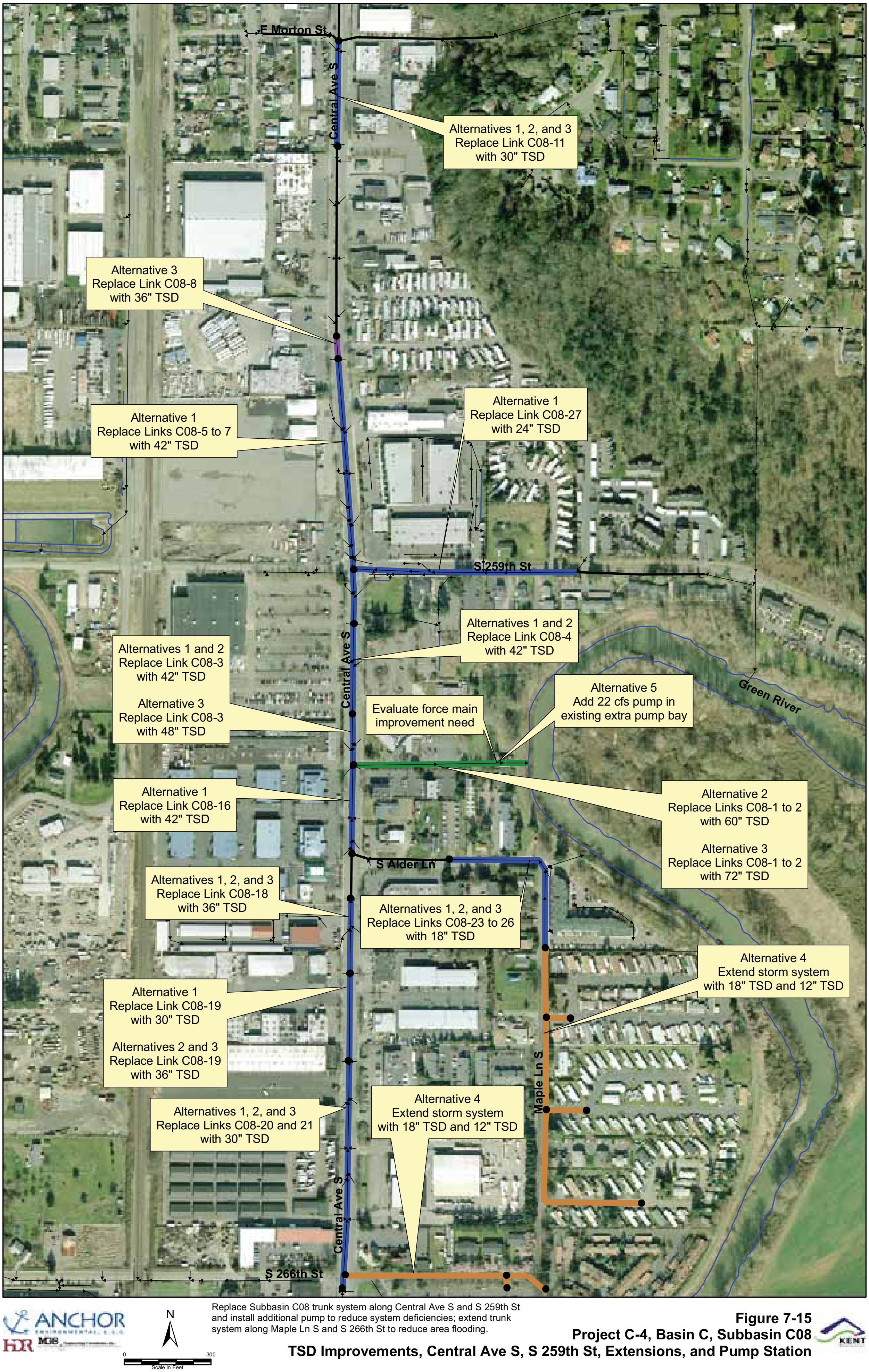
N
0 200
Scale in Feet

Extend Subbasin C05 trunk system along 1st Ave S and 3rd Ave S to reduce flooding potential and extend storm drain service to residential areas.

Figure 7-13
Project C-2, Basin C, Subbasin C05
TSD Improvements - 1st Ave S and 3rd Ave S Extensions

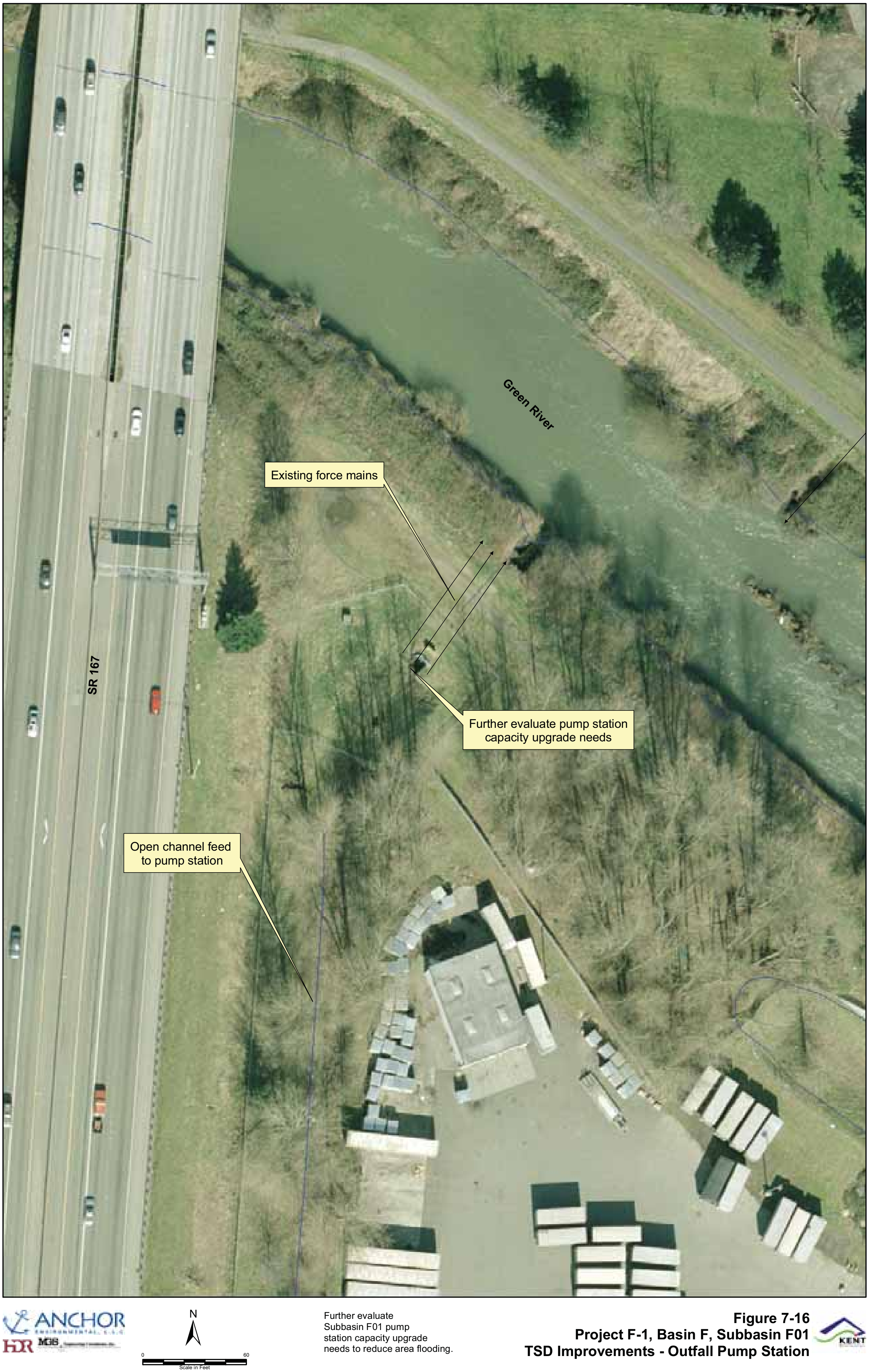
Extend C07 trunk system along 79th Ave S to reduce flooding and expand service area; replace system between pump and detention pond to reduce flooding potential.

Figure 7-14
Project C-3, Basin C, Subbasin C07
TSD Improvements - 79th Ave S, S 266th St to Detention Pond



Replace Subbasin C08 trunk system along Central Ave S and S 259th St and install additional pump to reduce system deficiencies; extend trunk system along Maple Ln S and S 266th St to reduce area flooding.

Figure 7-15
Project C-4, Basin C, Subbasin C08
TSD Improvements, Central Ave S, S 259th St, Extensions, and Pump Station



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N

0 60
Scale in Feet

Further evaluate Subbasin F01 pump station capacity upgrade needs to reduce area flooding.

Figure 7-16
Project F-1, Basin F, Subbasin F01
TSD Improvements - Outfall Pump Station

KENT

Increase capacity of the trunk storm drain to improve conveyance for the 25-year storm event and reduce roadway and residential area flooding potential.

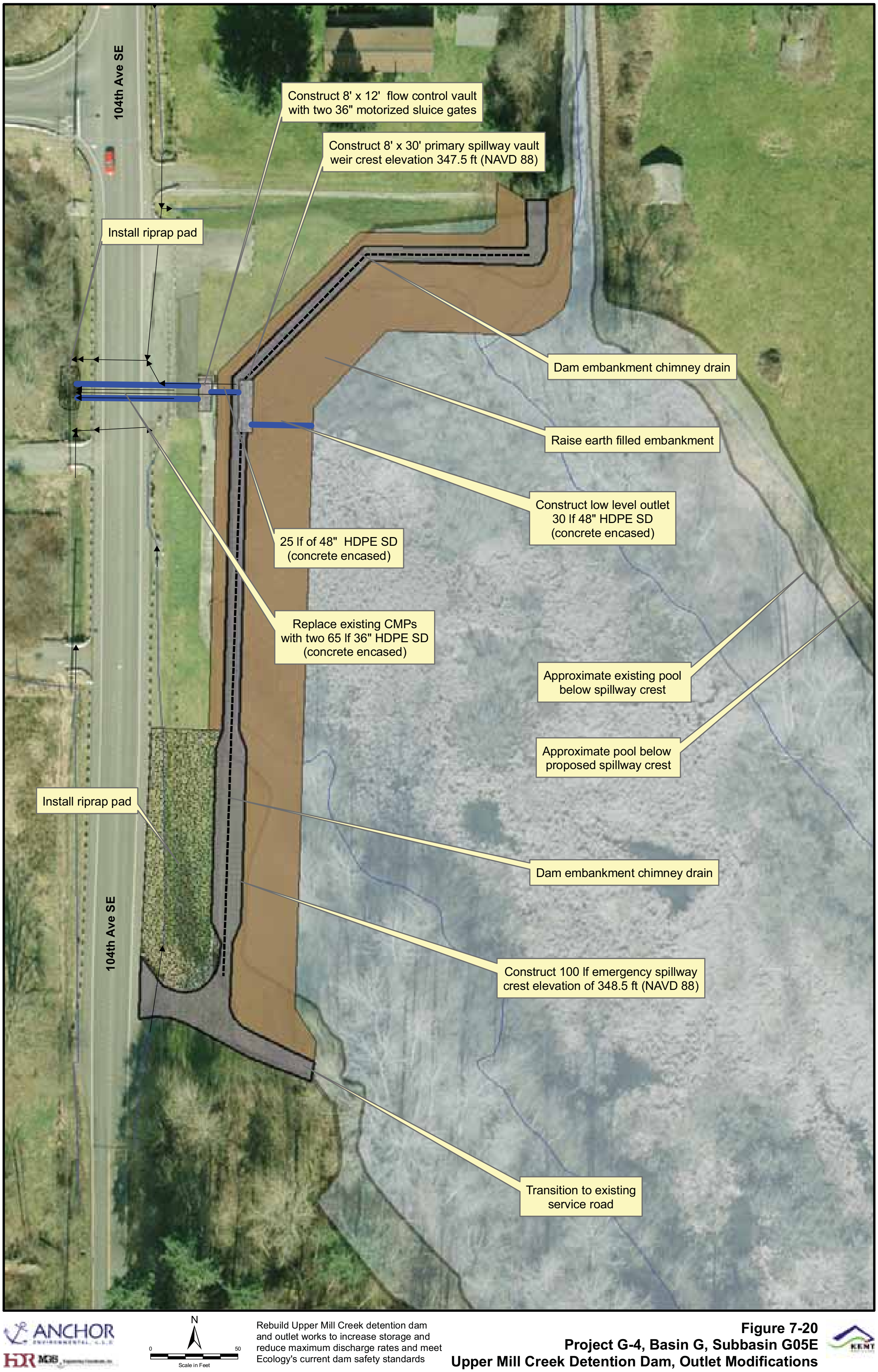
Figure 7-17
Project G-1, Basin G, Subbasin G05E
TSD Improvements - 110th Pl SE, SE 256th St, 109th Ave SE

Increase capacity of the trunk storm drain to improve conveyance for the 25-year storm event and reduce roadway and commercial area flooding.

Figure 7-18
Project G-2, Basin G, Subbasin G05E
TSD Improvements - 104th Ave SE, SE 260th St to SE 256th St

Reconstruct existing diversion structure to restrict low flow to downstream Upper Mill Creek for habitat maintenance and divert higher flows to dam for detention.

Figure 7-19
Project G-3, Basin G, Subbasin G05E
Upper Mill Creek Diversion to Detention Dam - East of 104th Ave SE



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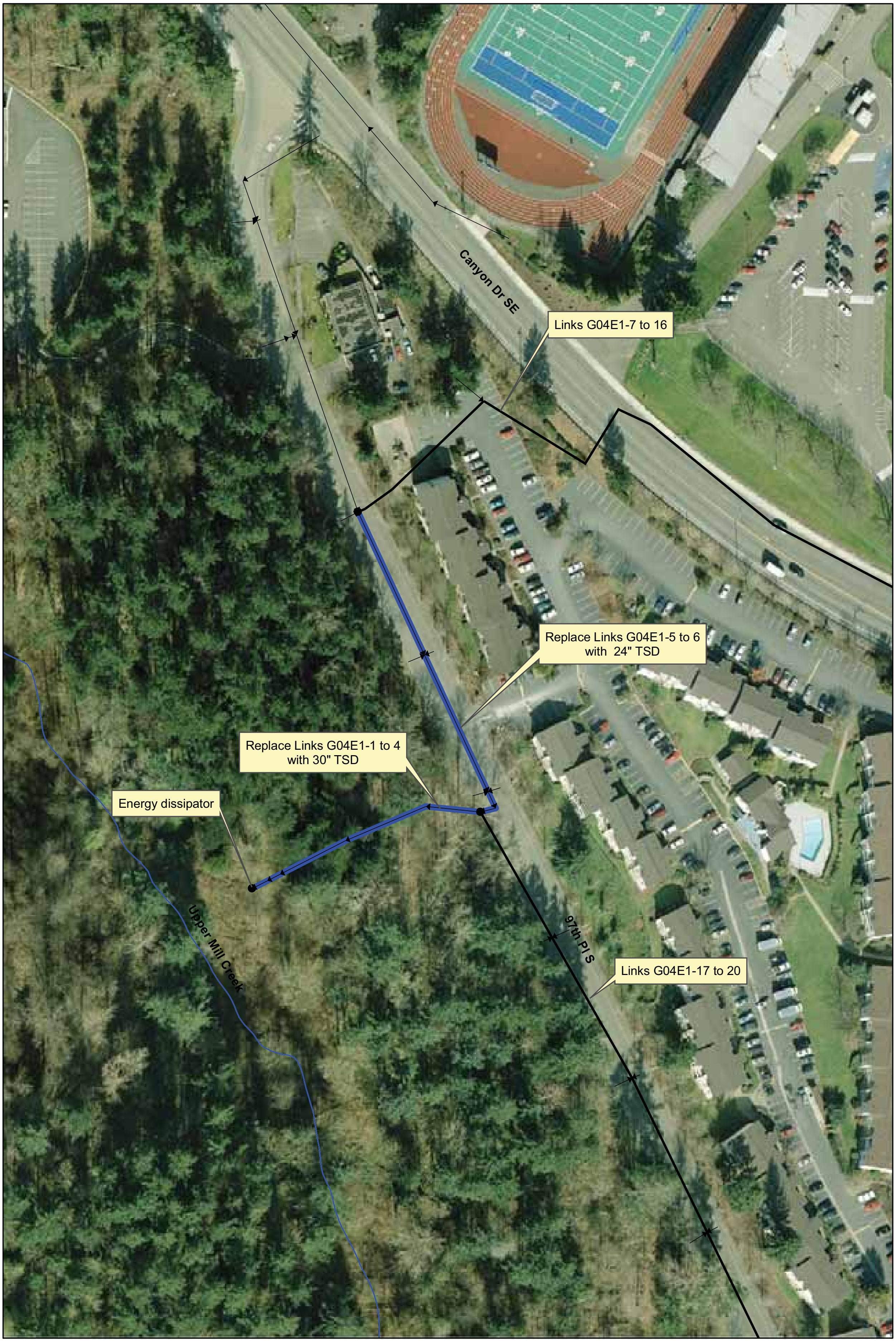
Rebuild Upper Mill Creek detention dam and outlet works to increase storage and reduce maximum discharge rates and meet Ecology's current dam safety standards

Figure 7-20
Project G-4, Basin G, Subbasin G05E
Upper Mill Creek Detention Dam, Outlet Modifications

KENT



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N

0 80

Scale in Feet

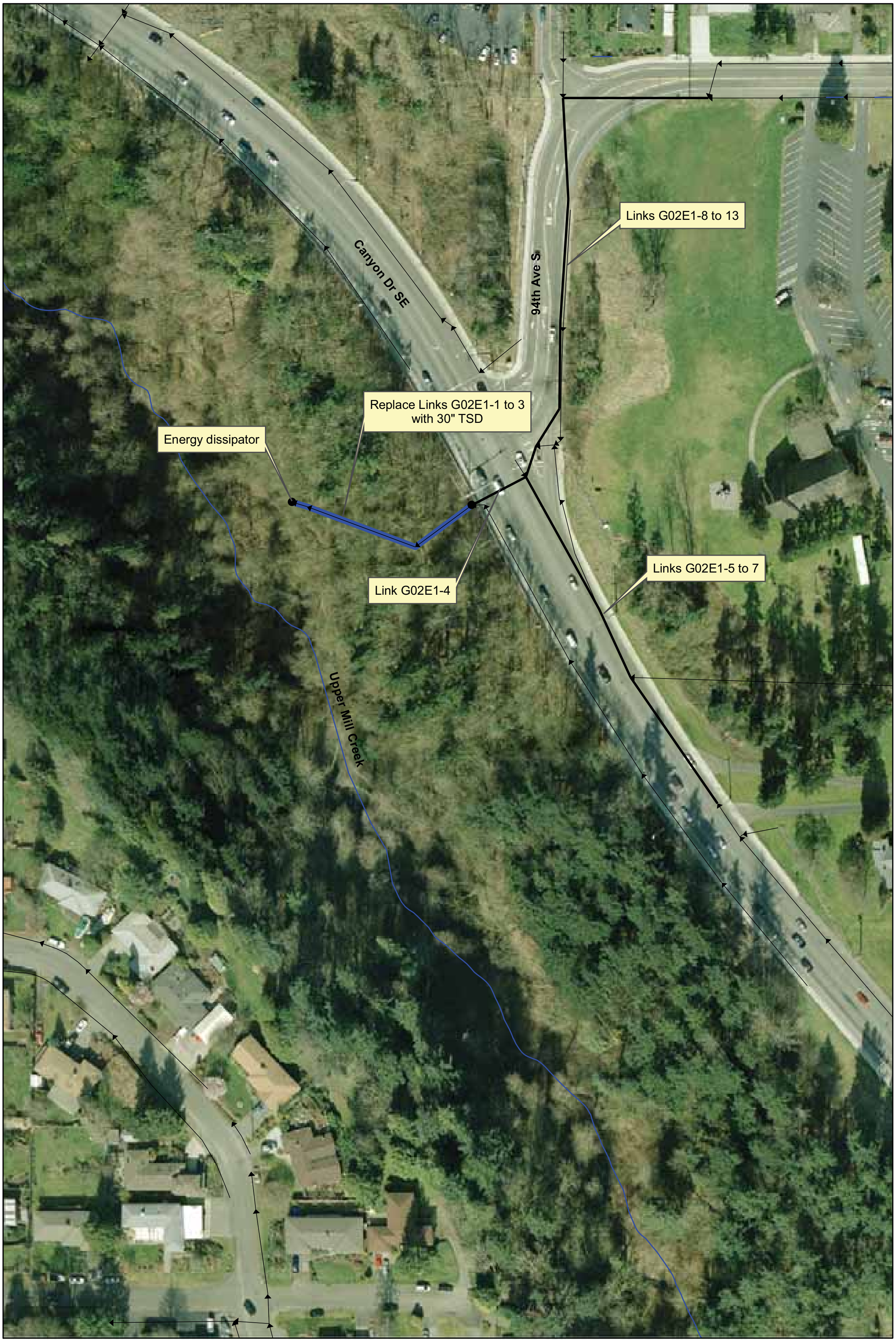
Increase capacity of the trunk storm drain
trunk to improve conveyance
for the 25-year storm event and reduce
roadway flooding.

Figure 7-21
Project G-5, Basin G, Subbasin G04E
TSD Improvements - 97th Pl South to Outfall

KENT

Increase capacity of the trunk storm drain to improve conveyance for the 25-year storm event and reduce roadway and residential area flooding potential.

Figure 7-22
Project G-6, Basin G, Subbasin G03E
TSD Improvements - SE 248th St, 100th Ave SE



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N
0 100
Scale in Feet

Increase capacity of the trunk storm drain to improve conveyance for the 25-year storm event and reduce roadway flooding.

Figure 7-23
Project G-7, Basin G, Subbasin G02E
TSD Improvements - Canyon Dr SE to Outfall

KENT

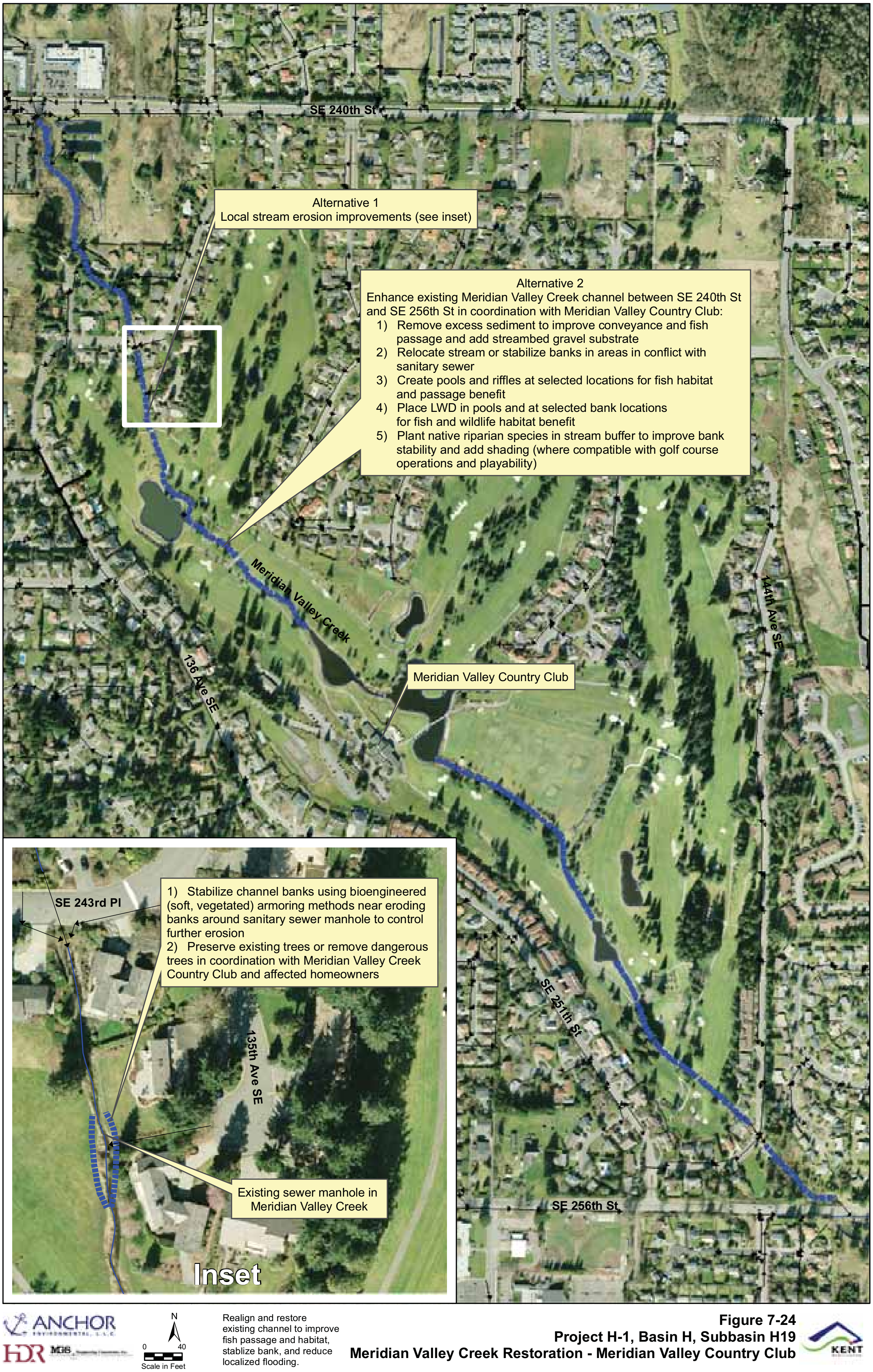

Figure 7-24
Project H-1, Basin H, Subbasin H19
Meridian Valley Creek Restoration - Meridian Valley Country Club

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N

0 80

Scale in Feet

Increase capacity of the existing detention pond and the trunk storm drain to improve conveyance for the 25-year storm event and reduce roadway flooding.

Figure 7-25
Project H-2, Basin H, Subbasin H11
Meridian Valley Cr. TSD Improvements - 132nd Ave SE to 136th Ave SE

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N

0 120

Scale in Feet

Construct new trunk storm drain in public right-of-way and reroute flows from TSD on private property to new system to improve maintenance access.

Figure 7-26
Project H-3, Basin H, Subbasin H131
TSD Improvements - 145th Pl SE and 146th Ave SE

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Abandon failing trunk storm drain under private properties, and divert flows to improve conveyance, access to strom drain system, and reduce flooding potential.

Figure 7-27
Project H-4, Subbasin H30
TSD Improvements - 132nd Ave SE to Lake Meridian Outfall

KENT

Replace existing bridge with larger bridge section and raise road elevation to reduce flooding and improve use of existing habitat.

Figure 7-28
Project H-5, Basin H, Subbasin H133
Big Soos Creek Bridge Replacement - SE 256th St

N

0 80

Scale in Feet

Raise road elevation and increase culvert capacity to reduce roadway flooding and improve use of existing habitat.

Figure 7-29
Project H-6, Basin H, Subbasin H15
Soosette Creek Culvert Replacement - 144th Ave SE

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HDR MGS

N

0 80
Scale in Feet

Increase culvert capacity
to reduce flooding upstream
and allow for area development
and improve fish passage.

Figure 7-30
Project H-7, Basin H, Subbasin H113
E. Fork Soosette Cr. Culvert Replacements - Southwest of SE 276th St

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N

0 80

Scale in Feet

Increase capacity of channel to improve conveyance, reduce flooding, and improve fish passage and habitat.

Figure 7-31
Project H-8, Basin H, Subbasins H61, H62
W. Fork N. Branch Soosette Cr. Channel Widening - South of SE 256th St

KENT

N
0 120
Scale in Feet

Increase capacity of culverts to reduce flooding potential and improve fish passage.

Figure 7-32
Project H-9, Basin H, Subbasin H50
W. Fork W. Branch Soosette Cr. Culvert Replacements - 116th Ave SE

The existing channel stabilization features (log weirs) have been undercut and are no longer fully providing the intended channel bed stabilization function.

Figure 7-33
Project H-10, Basin H, Subbasin H09
North Fork Meridian Valley Creek Restoration Repair

The existing pair of 54" x 36" CMPA culverts are undersized resulting in potential overflows during larger storm events. The culverts are also corroded and at risk of structural failure.

Figure 7-34
Project H-11, Basin H, Subbasin H04
SE 236th Place Culvert Replacement

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N

0 40

Scale in Feet

Remove excess sediment in channel and restore streambed, revegetate channel banks to reduce bank erosion and improve fish passage and habitats.

Figure 7-35
Project I-1, Basin I, Subbasin I1
Lower Garrison Cr. Sediment Removal at S 218th St, Upstream Erosion Controls

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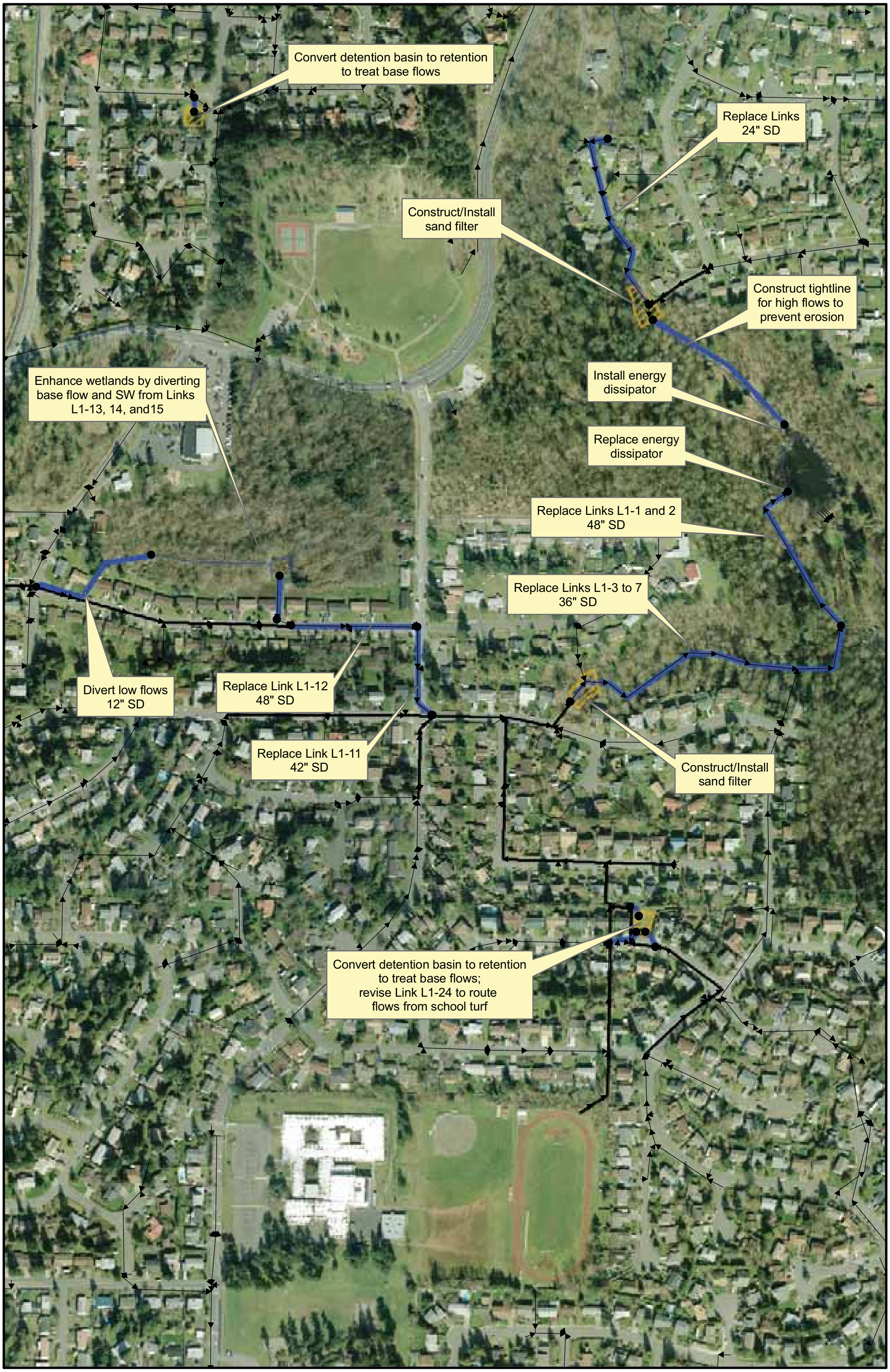

N

0 300

Scale in Feet

Lake Fenwick is on the 303d list and a TMDL has been adopted for Phosphorous. It appears that several detention facilities could be modified to retain and treat low flows. End of pipe sand filters may be capable of treating a significant portion of the stormwater.

Figure 7-36
Project L-1, Basin L, Subbasin L01
Conveyance, Erosion Protection, WQ Treatment

Figure 7-37
Project L-2 and L-3, Basin L, Subbasin L01
Lake Fenwick Aeration and Constructed Wetland Maintenance

Lake Fenwick is on the 303d list and a TMDL has been adopted for Phosphorous. Expand the lake hypolimnetic aeration system and annually harvest vegetation from the treatment wetland.

N
0 300
Scale in Feet

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HDR MGS

N

0 300

Scale in Feet

Several drainage problems were identified in West Hill at the public workshop. PM-2 and 5 appeared to be maintenance issues, PM-4 required minor upgrade of existing facilities, and PM-3 requires extension of the TSD system to convey street runoff.

Figure 7-38
Projects L-4 , Basin L, Subbasin L01
Conveyance, Erosion Protection, WQ Treatment

KENT

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HDR MGS

N

0 300

Scale in Feet

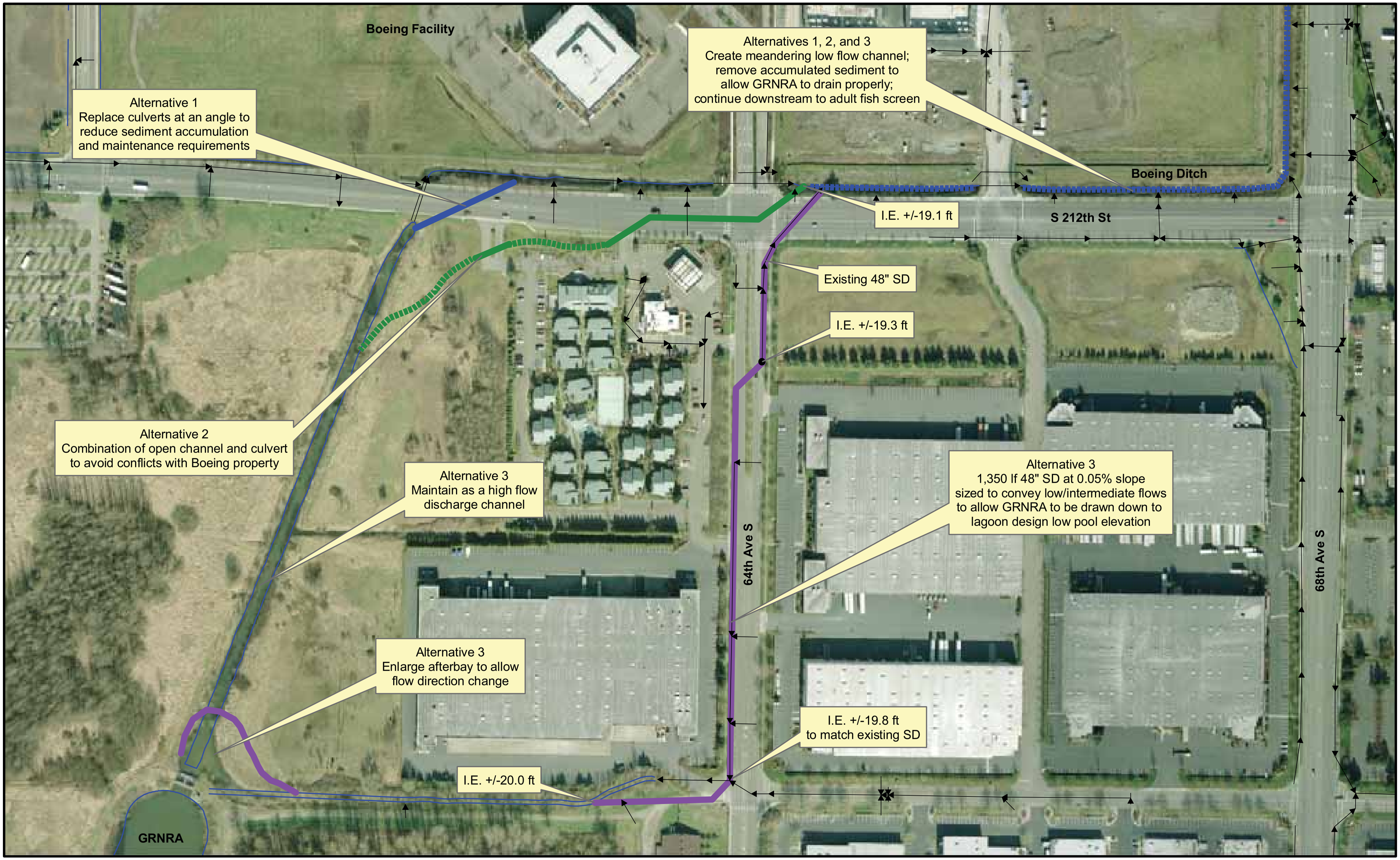
Replace Subbasin Q05 trunk system along 54th Ave S and S 226th St to reduce flooding potential in commercial development area.

Figure 7-39
Project Q-1, Basin Q, Subbasin Q05
TSD Improvements - 54th Ave S and S 226th St

KENT

Install replacement weir plates on the GRNRA control structures to restore design operations; remove and dispose of accumulated sediments inthe pre-settleing basins; and repair or replace fencing as neccesary. As Alternative 4 of Project Q-3, install a 35 cfs pump station and related facilities to draw down the GRNRA (Figure 7-41)

Figure 7-40
Project Q-2, Basin Q, Subbasin Q01
GRNRA Maintenance



The Boeing Ditch channel invert elevation is too high, preventing the GRNRA from achieving the designed low pool elevation; consequently, much of the flood storage volume is not available; these alternatives allow improved gravity drainage; a pump alternative that discharges to the Green River is also being evaluated.

Figure 7-41
Project Q-3, Basin Q, Subbasin Q01
GRNRA Outlet Improvements

7.3 Summary of Recommended Projects Estimated Costs

Estimated construction and implementation costs (June 2008 dollars) for proposed City-wide drainage infrastructure projects were evaluated at this planning level of evaluation based on the conceptual improvement layouts as illustrated in Figures 7-1 through 7-40. The estimated implementation costs are highlighted for each project in Sections 7-1 and 7-2 projects documentation. Table 7-1 summarizes those planning level cost opinions for all proposed improvement projects.

For the cost opinions, approximate quantities were estimated, and unit costs for all major items of work were estimated based on expected or assumed installation conditions. In addition to those items, cost allowances (as percentages of construction cost) for Standard Specification (WSDOT/APWA 2006) Division 1, General Requirements were also included. An additional 10 percent cost allowance for undefined work items was included, and a 30 percent construction cost contingency was applied. To define expected implementation costs, a 25 percent cost allowance on the total estimated construction cost and a preliminary estimate of expected land or easement acquisition costs were added to the estimated construction cost. Detailed order-of-magnitude level opinions of cost for each project are included in Appendix G.

Table 7-1
Recommended CIP Drainage Improvements, Estimated Implementation Costs, and Targeted Priorities

Basin/ Project No.	Problems Addressed	Project Improvements Description	Estimated Construction Cost ($)	Estimated Implementation Cost ($)	Implementation Priority
Phase 1 – Basin A – Lower Mill Creek					
A-1	LMC-4, PM-14	Subbasin A15E – Mill Creek TSD, Restoration at Senior Center – Titus Street to Smith Street			High
		Alt. 1 – Parallel Culvert Alignment, Remove Excess Sediment	716,000	895,000	
		Alt. 2 – Daylight Channel, Establish Riparian Vegetation Buffer around Mill Creek	1,268,000	1,585,000	
A-2	LMC-3,4,5, PM-13	Subbasin A15E – Mill Creek Restoration – Smith Street to James Street	925,000	1,181,000	High
A-3	LMC-3,4,5, PM-10,13	Subbasin A14E – Mill Creek Relocation/Restoration – James Street to Chandler Bay Drive			High
		Alt. 1 – Relocate and Restore Mill Creek Channel through Wetlands East of Mill Creek	3,338,000	4,672,000	
		Alt. 2 – Widen and Restore Existing Mill Creek Channel along East Bank	2,245,000	2,949,000	
A-4	None Identified	Subbasin A14W - Mill Creek Culvert Replacement - Burlington Northern Railroad			Medium
		Alt. 1 – Open Trench Culvert Replacement Coordinated with 228th TIP	350,000	437,000	
		Alt. 2 – Bore and Jack Replacement Culvert without Interrupting Rail Service	962,000	1,203,000	
A-5	LMC-6, PM-12	Subbasin A13W - TSD Improvements – Partial Subbasin A13W Diversion to GRNRA			High
		Alt. 1 – Install Box Culvert in South 228th Street to Conveyance Channel with Box Culvert Crossing Improvements	5,421,000	6,551,000	
		Alt. 2 – Install 72-inch Culvert in South 228th Street and in Frontage along 68th Avenue South, West to Presettling Pond	4,597,000	5,746,000	
		Alt. 3 – Regrade Channel to 68th Avenue South, 72nd Culvert and TSD, Conveyance Channel Box Culvert Improvements	2,612,000	3,864,000	
		Alt. 4 – North along Union Pacific Railroad/Bike Trail/PSE Easement to GRNRA Diversion Weir – Not Further Evaluated			
A-6	LMC-6	Subbasin A13W – TSD Improvements – 4th Avenue North, Smith Street to near South 228th Street	4,538,000	5,672,000	Medium
A-7	LMC-6, PM-12,21	Subbasin A14E – Mill Creek Culverts Replacement, Relocation/Restoration – 76th Avenue Corridor			High
		Alt. 1 – Full Improvements	4,295,000	5,649,000	
		Alt. 2 – Partial Improvements (not including Mill Creek restoration downstream of private crossings)	1,717,000	2,227,000	
A-8	None	Subbasin A04W – TSD Improvements – South 190th Street and	2,072,000	2,590,000	Low

Basin/ Project No.	Problems Addressed	Project Improvements Description	Estimated Construction Cost ($)	Estimated Implementation Cost ($)	Implementation Priority
	Identified	South 196th Street			
		Total – Basin A	**19,458,000**	**25,726,000**	
Phase 1 – Basin B – Springbrook Creek					
B-1	None Identified	Multiple Subbasins – Springbrook Creek Channel Flood Containment Berms – North of South 212th Street	671,000	988,000	High
B-2	SBC-1	Subbasin B04W – TSD Improvements – South 196th Street and 84th Avenue South	3,690,000	4,612,000	High
B-3	None Identified	Subbasin B03E – TSD Improvements – North Side of South 180th Street	1,469,000	1,836,000	Low
		Total – Basin B	**5,830,000**	**7,436,000**	
Phase 2 – Basin C – Horseshoe Acres/Green River					
C-1	None Identified	Subbasin C02 – TSD Improvements – South of Kent-Des Moines Road, East of State Route 167	272,000	341,000	Low
C-2	None Identified	Subbasin C05 – TSD Improvements – 1st Avenue South and 3rd Avenue South Extensions	388,000	485,000	Low
C-3	None Identified	Subbasin C07 – TSD Improvements – 79th Avenue South, South 266th Street to Detention Pond			Low
		Alt. 1 – TSD Improvements from South 266th Street to Detention Pond	196,000	245,000	
		Alt. 2 – TSD Conveyance Service Extension in 79th Avenue South	118,000	148,000	
C-4	PM-1,6,9	Subbasin C08 – TSD Improvements – Central Avenue South, South 259th Street, Extensions, and Pump Station			Medium
		Alt. 1 – No Pump Intake TSD Improvements	2,618,000	3,272,000	
		Alt. 2 – 60-inch Diameter Pump Intake TSD Improvement	1,988,000	2,485,000	
		Alt. 3 – 72-inch Diameter Pump Intake TSD Improvement	1,987,000	2,483,000	
		Alt. 4 – TSD Conveyance Service Extensions in Maple Lane South, South 266th Street	498,000	623,000	
		Alt. 5 – Pump Station and Force Main Upgrade at Existing Outfall (22 Cubic Feet Per Second Pump Addition in Existing Extra Pump Bay)	440,000	550,000	
		Total – Basin C	**3,899,000**	**4,875,000**	
Phase 2 – Basin F – Green River					
F-1	LDS-1	Subbasin F01 – TSD Improvements – Outfall Pump Station (allowance)	1,800,000	2,225,000	Medium
		Total – Basin F	**1,800,000**	**2,225,000**	
Phase 1 – Basin G – Upper Mill Creek					
G-1	None Identified	Subbasin G05E – TSD Improvements – 110th Place Southeast, Southeast 256th Street, 109th Avenue Southeast	1,640,000	2,051,000	Medium
G-2	None Identified	Subbasin G05E – TSD Improvements – 104th Avenue Southeast, Southeast 260th Street to Southeast 256th Street	2,790,000	3,488,000	Medium

Basin/ Project No.	Problems Addressed	Project Improvements Description	Estimated Construction Cost ($)	Estimated Implementation Cost ($)	Implementation Priority
G-3	UMC-1	Subbasin G05E – Upper Mill Creek Diversion to Detention Dam – East of 104th Avenue Southeast	409,000	563,000	High
G-4	UMC-1	Subbasin G05E – Upper Mill Creek Detention Dam, Outlet Modifications – 104th Avenue Southeast			High
		Alt. 1 – Raise Dam for Added Storage, Replace Outlet Works and Restrict Outflow, Reconstruct Spillway	1,753,000	2,341,000	
		Alt. 2 – Upper Mill Creek Diversion Micro-tunnel (60-inch Diameter) South to South 277th Street Conveyance, West to New Green River Outfall	5,800,000	7,250,000	
G-5	None Identified	Subbasin G04E – TSD Improvements – 97th Place South to Outfall	231,000	288,000	Medium
G-6	None Identified	Subbasin G03E – TSD Improvements – Southeast 248th Street, 100th Avenue Southeast	135,000	169,000	Medium
G-7	None Identified	Subbasin G02E – TSD Improvements – Canyon Drive Southeast to Outfall	96,000	120,000	Medium
		Total – Basin G	**7,054,000**	**9,020,000**	
Phase 2 – Basin H – Soos Creek/Meridian Valley					
H-1	PM-7,18	Subbasin H19 – Meridian Valley Creek Restoration – Meridian Valley Country Club			Medium
		Alt. 1 – Meridian Valley Creek Local Stream Erosion Improvements South of Southeast 243rd Street	35,000	43,000	
		Alt. 2 – Meridian Valley Creek Stream Restoration Improvements, Southeast 240th Street to Southeast 256th Street	891,000	1,214,000	
H-2	MVC-2	Subbasin H11 – Meridian Valley Creek TSD Conveyance Improvements – 132nd Avenue Southeast to 136th Avenue Southeast	706,000	883,000	Medium
H-3	MVC-3	Subbasin H131 – TSD Improvements – 145th Place Southeast and 146th Avenue Southeast	243,000	304,000	Low
H-4	LMT-2	Subbasin H30 – TSD Improvements – 132nd Avenue Southeast to Lake Meridian Outfall	1,268,000	1,585,000	Medium
H-5	BSC-1	Subbasin H133 – Big Soos Creek Bridge Replacement – Southeast 256th Street	1,646,000	2,058,000	High
H-6	SC-1, PM-11	Subbasin H15 – Soosette Creek Culvert Replacement – 144th Avenue Southeast	229,000	292,000	High
H-7	EFSC-1,2	Subbasin H113 – East Fork Soosette Creek Culvert Replacements – Southwest of Southeast 276th Street	115,000	143,000	Low
H-8	WFNB-1,2	Subbasins H61, H62 – West Fork North Branch Soosette Creek Channel Widening – South of Southeast 256th Street	517,000	646,000	Low
H-9	WFWB-1,2,3,4	Subbasin H50 – West Fork West Branch Soosette Creek Culvert Replacements – 116th Avenue Southeast	336,000	470,000	Low

Basin/ Project No.	Problems Addressed	Project Improvements Description	Estimated Construction Cost ($)	Estimated Implementation Cost ($)	Implementation Priority
H-10	None Identified	Subbasin H09 – North Fork Meridian Valley Creek Restoration Repair – South of Southeast 240th Street	120,000	150,000	Medium
H-11	None Identified	Subbasin H11 – North Fork Meridian Valley Creek Restoration – South 236th Place Culvert Replacement	164,000	205,000	High
		Total – Basin H	**6,270,000**	**7,993,000**	
Phase 2 – Basin I – Garrison Creek					
I-1	GC-1	Subbasin I1 – Lower Garrison Creek Sediment Removal at South 218th Street, Upstream Erosion Controls	49,000	61,000	Medium
		Total – Basin I	**49,000**	**61,000**	
Phase 2 – Basin L – Lake Fenwick					
L-1	None Identified	Subbasin L01 – TSD Improvements – Conveyance, Erosion Protection, Water Quality Treatment	2,950,000	3,688,000	Medium
L-2	LF-2	Subbasin L01 – Lake Fenwick Constructed Wetland Annual Vegetation Harvesting (5 years)	75,000	100,000	Medium
L-3	LF-1	Subbasin L01 – Lake Fenwick Hypolimnetic Aeration System Improvements	280,000	400,000	Medium
L-4	PM-2,3,4,5	Subbasin L01 – TSD Improvements – Conveyance, Erosion Protection, Water Quality Treatment	112,000	150,000	Low
		Total – Basin L	**3,417,000**	**4,338,000**	

Basin/ Project No.	Problems Addressed	Project Improvements Description	Estimated Construction Cost ($)	Estimated Implementation Cost ($)	Implementation Priority
Phase 1 – Basin Q – GRNRA					
Q-1	None Identified	Subbasin Q05 – TSD Improvements – 54th Avenue South and South 226th Street	2,104,000	2,630,000	Low
Q-2	GRNRA-1	Subbasin Q01 – Restore Diversion Weir, Pre-settling Ponds Sediment Removal, Replace GRNRA Fencing	1,064,000	1,330,000	High
Q-3	GRNRA-2	Subbasin Q01 – GRNRA Outlet Improvements – Lagoon Outlet to Mill Creek Confluence			High
		Alt. 1 – Replace Culvert at South 212 Street, Widen Boeing Ditch, Excavate Low Flow Channel Downstream	1,441,000	1,801,000	
		Alt. 2 – New Channel along South 212th Street and New Culvert Crossing, Excavate Low Flow Channel Downstream (Not Evaluated)			
		Alt. 3 – Tie GRNRA Outlet to New TSD in 64th Avenue South, link to Existing 48-inch TSD, Excavate Low Flow Channel Downstream	1,336,000	1,669,000	
		Alt. 4 – Pump Station and Force Main with New Outfall to Green River for Lagoon Drawdown (30 Cubic Feet Per Second Pump Station Assumed)	1,800,000	2,250,000	
		Total – Basin Q	**4,504,000**	**5,629,000**	
		Phase 1 Projects Total – Basins A, B, G, and Q	**36,846,000**	**47,811,000**	
		Phase 2 Projects Total – Basins C, F, H, I, and L	**15,435,000**	**19,492,000**	
		Phase 1 and 2 Projects Total	**52,281,000**	**67,303,000**	
		Estimated Green-Duwamish ERP Projects (next 5 years)	**400,000**	**500,000**	High
		Total Estimated CIP Project Costs (June 2008)	**52,681,000**	**67,803,000**	

Grey lettering = Alternatives improvements considered or evaluated, but not recommended

8 CRITICAL AREAS RESTORATION OPPORTUNITIES

This section summarizes opportunities for Critical Areas river and stream and wetland habitat restoration that have been identified within the DMP planning area, including properties potentially affected, to allow those targeted projects to be implemented. Habitat restoration includes opportunities for instream fish passage and habitat enhancement, associated wildlife habitat enhancement, wetlands restoration and enhancement, and riparian corridor revegetation. With many of these projects, public access and education opportunities exist to help demonstrate the importance of the City's protection of these Critical Area water resources to its residents. In addition to reducing flooding risks, Critical Area restoration projects can provide multiple environmental restoration benefits, thus making the projects' multi-objective consistent with primary restoration goals and creating more opportunities for external grant funding to help leverage City stormwater utility funding for projects implementation.

8.1 City-identified River, Stream, and Wetland Restoration Opportunities

Habitat restoration within the City limits is an important factor in the overall health of the City's local streams and wetlands. Many streams and wetlands within the City have been impacted by past development and over-run by invasive species. Development has channelized, straightened, and removed native vegetation from stream banks and buffers. Wetlands have been filled, degraded, and encroached upon. Habitat has also been fragmented, reducing its utility for many wildlife species. Restoring as many of these areas as is possible is critical to maintaining cool, unpolluted, and high quality water—goals targeted by the Green/Duwamish (WRIA 9) Salmon Habitat Plan that the City has adopted (King County 2005). Improving connectivity between natural areas and reducing invasive species will enhance wildlife usage by providing a wider variety of forage, shelter, and water sources, as well as attract species requiring larger home ranges.

The City Code Section 11.06, Critical Areas, states that "these critical areas perform a variety of valuable and beneficial biological physical and economic functions that benefit the city and its residences." Any alteration to a property, granted by the above code, can have an impact on the overall function of the wetlands or streams. The use of this code is one reason that the City continues to identify restoration opportunities through property acquisition.

To achieve the goals of water quality protection and habitat enhancement within its Critical Areas, the City has identified properties that would be conducive to stream or wetland corridor protection and restoration. These sites or properties typically are encumbered with sensitive areas such as wetlands, streams, and floodplains and their required buffers. Under City Code, portions of many of these properties are likely undevelopable or marginally developable, and stream or wetland restoration on them would fall under reasonable use. Criteria have been developed by City staff to identify properties within Critical Areas for acquisition including:

- For its use for levee repair and potential levee setbacks along the Green River
- For potential regional or road corridor stormwater facility and wetland mitigation improvements
- For water quality improvements
- For wetland restoration potential
- For salmonid habitat enhancement

Specific project stream and wetland restoration opportunities that have been identified as part of the DMP update are described in Section 7. Those include projects along the Lower and Upper Mill Creek, Springbrook Creek, Meridian Valley Creek, Big Soos Creek, Soosette Creek, Lake Fenwick, and the GRNRA.

8.2 Properties Potentially Affected by Critical Areas Restoration Solutions

The properties on the City's potential Natural Resource Acquisition List are a compilation of properties throughout the City's corporate limits, typically within Critical Areas, that are needed to implement various stormwater program projects. Table 8-1 identifies those properties currently on that list, the water bodies that they are associated with, and the parcel areas. Figure 8-1 shows the locations of those parcels. Those properties include parcels that would provide stream restoration opportunities, wetland restoration, and reduction of flooding of public roadways within the City's major drainage basins, including those properties that are linked to the various restoration project opportunities presented in Section 7. The City will continue to identify additional Critical Area property acquisition needs in response to other project-specific needs, including those associated with roadway TIP project stormwater facilities, LID opportunities, and wetland mitigation needs.

Table 8-1
Properties Targeted for Acquisition for River, Stream, and Wetlands Critical Areas Habitat Restoration Opportunities

No.	Basin	Property Owner	Location	Assessors Parcel Number (APN)	Total Area (acres)
1	A	Little	North of James, across from Mill Creek School	1822059023, 1822059022	18.5
2	A	Barnier	22103 76th Avenue South	1222049018, 1222049019	20.0
3	A	Barnier	21600 72nd Avenue South	1222049127, 1222049128	11.2
4	G	City of Kent – Parks	Southwest of Canyon, south side of road	1922059067, 1922059077	8.4
5	N	Matelich	Frager Road, west of Green River	2222049029	10.2
6	Q	Lotto	Frager Road, south dead end	2322049020	1.7
7	D	Koch	25430 68th Avenue South	2422049067	6.2
8	E	Kohr	25802 West Valley Highway	2522049014	3.3
9	E	Polk	6830 South 262nd Street	200000140	1.2
10	E	Hennelly	26138 68th Avenue South	0200000005, 0200000024	0.2
11	E	Thomas	261XX 68th Avenue South	020000045, 0200000050	0.0
12	E	Whatmore	261XX 68th Avenue South	020000004	0.0
13	O	Midway Sand and Gravel	272nd and Pacific Highway	768280125, 76282800205,7682800215, 7682800135,2822049017,7682800085,2822049180	40.0
				Total Area	**120.8**

Figure 8-1
Potential Natural Resource Aquisition Properties
For Critical Areas Restoration Opportunities

A number of these properties are critical for local flood control as well. A few properties are currently undeveloped due to limited buildable area under current Critical Area and associated buffer designations. On other parcels, significant development that has occurred prior to current Critical Areas Codes has left many natural resources encroached upon by development. In addition, the City sees a potential for achieving water quality benefit at some of these sites that will assist in meeting the existing and expected future NPDES Phase II and TMDL requirements (see Section 9). The City will continue to identify additional Critical Area property acquisition needs in response to other project-specific needs, including those associated with roadway TIP project stormwater facilities, LID facilities (to reduce or minimize size of stormwater facilities otherwise needed), and associated wetland mitigation/restoration.

8.3 Property Acquisition

As specific projects within the DMP are designed, City staff will conduct appraisals for purchase of targeted properties (or required portions thereof) and/or easement needs. At that time, the City will coordinate with affected property owners about solutions and negotiate equitable costs for those properties acquisition.

The City actively competes for grants to offset the cost of acquiring properties containing streams, wetlands, or other critical areas and their buffers. However, these grants are very competitive with fewer dollars being diverted to those funds annually. The City, while actively pursuing grants, realizes that a portion of the property acquisition costs will need to be funded from City revenues.

8.4 Maintenance Implications

As more property is acquired and projects are completed for wetland and stream restoration, the need also increases to maintain these projects. This includes the need for removing debris, watering the planted vegetation, and continuing to remove invasive plants. The City's vegetation crew, under the direction of the City Street Superintendent within the Public Works Operation Department, currently has its resources stretched in the care of sensitive area tracts and stream restoration projects. As the City continues to acquire properties and completes improvements on these sites, additional staffing will be needed to maintain and operate these properties and restoration areas. With more expected emphasis and focus put on LID solutions to drainage management problems, some associated reductions in maintenance requirements for those projects may occur. The additional staff resources identified in Section 9 (for O&M) will have a significant role in fulfilling these needs.

8.5 Recommendations

It is strongly recommended that the City continue to pursue the acquisition of properties for levee repair and levee setback along the Green River, potential regional or road corridor stormwater facility improvements, water quality improvements and wetland restoration, and salmonid passage and habitat enhancements. Those acquisitions will enable implementation of proposed restoration components of projects identified in the DMP; similar restoration features of Green River levees and salmon habitat projects; and stormwater, LID, and wetland mitigation components of TIP improvement projects.

9 STORMWATER PROGRAMS AND MODIFICATION NEEDS

This section presents an assessment of the City's existing water quality and stormwater O&M programs along with findings of a gap analysis conducted for each program. That analysis was used to define supplemental service needs and recommended program adjustments along with associated staffing and equipment needs for each program. The estimated costs for these adjusted stormwater program components developed in consultation with City staff are also provided.

9.1 Existing Water Quality Program

The City has been proactive in developing a water quality program, which includes water quality monitoring and education of the public on impacts of activities on receiving water quality. The City currently has specialists on staff who manage the water quality monitoring for the City, the GRNRA, and the requirements of the NPDES Phase II Permit (Ecology 2007a). The City also employs an Environmental Conservation Supervisor on staff whose duties include supervising the NPDES program, well head protection program, critical areas, solid waste recycling, and water conservation programs. Since the adoption of the 2002 Surface Water Design Manual, the City has also required an enhanced level of water quality protection for new development within much of the City.

In the 1990s, the City converted approximately 300 acres of abandoned lagoon cells for sewage treatment into the GRNRA, created a regional stormwater treatment, and created a wetland facility. The GRNRA treats stormwater prior to discharge back into Mill Creek. The planning for this project started in 1979. This facility provides many additional benefits such as preservation of open space, habitat enhancement, public education, and volunteer opportunities.

Past studies and water quality monitoring conducted by the City, King County, Ecology, and the U.S. Geological Survey have indicated that water quality within many of the City's streams is typical of residential and urbanized areas. The principal water quality concerns include elevated levels of fecal coliform, low dissolved oxygen, high temperature, and excessive levels of turbidity and sediments. These water quality issues are a concern primarily for fish and other aquatic life, and for recreational uses of these water bodies.

The City has conducted various water quality monitoring programs over many years. The monitoring program has changed depending on the program's focus. The City's current water quality monitoring program includes temperature monitoring in several streams and lakes. The City's current water quality monitoring and associated public education program are described as follows:

- Temperature monitoring – Since 1999, the City has conducted temperature monitoring of most streams within the City limits for purposes of baseline monitoring of stream conditions. Chronic stream temperature problems exist primarily in the lower reaches of Mill Creek, Garrison Creek, and Meridian Valley Creek.
- Lake monitoring – Since 2005, the City has conducted water quality monitoring at Clark Lake, Lake Meridian, and Lake Fenwick. The purpose of the monitoring is to establish long-term lake water quality trends and to ascertain compliance with the established Lake Fenwick total phosphorus TMDL. The lakes are sampled biweekly to monthly in the spring, summer, and early fall. King County provided water quality monitoring on these lakes prior to the City incorporating the areas.
- Education – The City provides numerous educational opportunities for residents, including but not limited to the annual Water Festival for elementary students starting in 2000, workshops on Natural Yard Care, participation in the King County Hazardous Waste Mobile program, native tree planting events, and BMP education through the private stormwater inspection program. The City also provides educational opportunities on water conservation, recycling, and solid waste management issues.

The City currently has an Environmental Conservation Supervisor on staff whose duties include supervising the NPDES Program among other duties.

9.2 Water Quality Program Needs and National Pollutant Discharge Elimination System Phase II Requirements

This section summarizes the City's DMP water quality program needs based on the City's current water quality program and the water quality requirements for the NPDES Phase II Permit. The requirements primarily fall under Condition S5, SWMP. In addition, the NPDES Phase II Permit includes additional water quality reporting requirements as part of its annual reporting special condition (S9 – Reporting Requirements). Sampling is also included as a potential approach to detect illicit discharges (S5.C.3 – Illicit Discharge and Elimination); however, the City routinely evaluates illicit discharges by their routine inspections of the MS4s as part of its O&M program.

The following sections provide additional specific requirements under the NPDES Phase II Permit Conditions S5, S7, S8, and S9.

9.2.1 Condition S5 – Stormwater Management Program

The NPDES Phase II Permit requires the development of an SWMP consisting of the following elements:

- S5.C1: Public Education and Outreach – The City shall develop an education and outreach program by February 15, 2009, for the general public, homeowners, property managers, and developers on impacts of stormwater on receiving waters and BMPs. The City shall track and maintain all records of public education and outreach activities.
- S5.C2: Public Involvement and Education – There shall be ongoing opportunities for public involvement to provide feedback on activities that impact stormwater. The City will create opportunities for the public to participate in the development of the City's SWMP and will make it available for the public.
- S5.C3: IDDE – The City shall develop and implement an IDDE Program to detect and remove illicit connections, discharges, and improper disposal of pollutants into the MS4s owned or operated by the City. The program shall include the following:
  - Update and maintain a current separate storm sewer base map
  - Develop and implement an IDDE Ordinance and ongoing program to detect and address illicit connections and spills
  - Provide training for field staff on the identification of illicit discharges
- S5.C4: Controlling Runoff from New Development, Redevelopment, and Construction Sites – The City shall develop, implement, and enforce a program to reduce pollutants in stormwater runoff to the storm sewer system, which includes the development and implementation of an ordinance; implementing a permit process with plan review, inspection, and enforcement capability; and

verification of long-term O&M of stormwater facilities and BMPs. The program will include the following:

- Keep records of inspections and enforcement actions, and projects disturbing more than 1 acre
- Verify that all staff responsible for implementing the program are properly trained to conduct the activities and provide follow-up training as needed
- Document and maintain records of the training

The fifth requirement, pollution prevention and O&M, will be addressed in the O&M program (Section 9.6).

9.2.2 Condition S7 – Compliance with Total Maximum Daily Load Requirements

The TMDL is the amount of a pollutant loading that a given water body (river, marine water, wetland, stream, or lake) can receive and still meet water quality standards. In Washington State, Ecology establishes TMDLs for specific water bodies. For each TMDL, Ecology establishes wasteload allocations for the NPDES Phase II Permit holders; the allocation specifies how much pollutant the permit holder can discharge to a specific water body. To meet TMDL requirements, permit holders typically employ stormwater BMPs or other controls and implement other activities, such as monitoring and reporting.

The NPDES Phase II Permit includes the following three TMDL-related requirements:

- It requires that municipal permittees follow the requirements of the applicable TMDLs specified in Appendix 2 (TMDL Requirements) of the NPDES Phase II Permit.
- For applicable TMDLs that are not listed in Appendix 2, Ecology considers compliance with the NPDES Phase II Permit as compliance with those TMDLs.
- For TMDLs that are approved after the NPDES Phase II Permit is issued, Ecology may establish specific TMDL-related permit requirements through future modifications to the NPDES Phase II Permit.

There are no new TMDLs identified in the NPDES Phase II Permit. However, Lake Fenwick is currently required to comply with a TMDL. As part of TMDL compliance, the City performs bi-weekly sampling at Lake Fenwick during much of the year. The City also has enhanced and currently maintains a wetland upstream from the lake that treats much of the storm drainage into the lake. The City has constructed and currently operates and maintains a hypolimnetic aeration system that serves to control phosphorous levels in the deepest portion of the lake during the summertime. The City is also initiating a program that will add Grass Carp to Lake Fenwick in an attempt to manage the invasive weeds that are prevalent within the lake. That program will start in the summer of 2008.

It is possible that TMDL requirements will be established for additional water bodies within the City by the end of the term of the current permit. Ecology has indicated that upon the re-issuance of the NPDES Phase II Permit in 2012, additional TMDLs will be identified and incorporated into Appendix 2 of the permit. This will require specific monitoring within the City. NPDES Phase II Permit holders are encouraged to participate in the development of TMDLs within their jurisdictions.

9.2.3 Condition S8 – Monitoring

NPDES Phase II Permit holders are not required to conduct water quality sampling during the effective term of the current permit (February 15, 2012), except to monitor as required for TMDLs and to characterize illicit discharges. The permit holder is required to establish a long-term monitoring program by the end of 2010 to:

- Identify specific stormwater outfalls to characterize stormwater runoff from three types of land use (commercial, high-density residential, and industrial)
- Evaluate the effectiveness of the permit holder's SWMP; the monitoring program should be used to determine the effectiveness of the SWMP and whether it is achieving specific targets
- Identify two stormwater-related questions and select sampling locations that will provide future monitoring data or other information in response to those questions such as effectiveness of source control or treatment measures

9.2.4 Condition S9 – Reporting Requirements

NPDES Phase II Permit requires the City to submit an annual report documenting the progress made toward compliance with the NPDES Phase II Permit. The reports shall be submitted no later than March 31 of each year. At a minimum, the annual report will need to include:

- A copy of the City's SWMP
- Submittal of Appendix 3 (Annual Report Form for Cities, Towns, and Counties)
- Changes to Permit Coverage Area (due to annexations, etc.)

The City has prepared an SWMP for 2008, the written documentation of the City's surface water management program that is intended to reduce the discharge of pollutants from the City's MS4.

9.3 Water Quality Program Gap Analysis

There are gaps in the City's water quality program, due to the requirements of the NPDES Phase II Permit. The City has taken a proactive approach in assessment and monitoring of their outfalls and stream systems. The NPDES Phase II Permit does not currently require stormwater quality monitoring with the exception of monitoring for applicable TMDLs or sampling to characterize illicit discharges. The City is currently conducting monitoring and implementing other water quality measures for the only applicable TMDL (Lake Fenwick). The NPDES Phase II Permit requires the City to implement an ongoing IDDE program by August 2009.

There are several water bodies within the City's jurisdiction that receive drainage from the City's stormwater outfalls. These water bodies may require a TMDL study in the future. The studies may lead to load allocations to meet water quality standards. The required action varies with the parameter, the characteristics of the receiving water, the pollutant sources, and the results of the study indicating the source of the pollutant. The potential TMDL requirements are discussed in greater detail below.

Table 9-1 summarizes the City's water quality program activities in relation to the NPDES Phase II Permit requirements and notes any gaps between the two service levels. For each permit requirement, information is presented to indicate the associated minimum permit requirements, the City's current water quality practices, and recommended actions to meet the minimum standards.

S5.C.3 provides guidance and regulatory standards for implementation of an IDDE program to detect and remove illicit connections, discharges, and improper disposal of pollutants into the MS4s owned or operated by the City. The City currently identifies illicit discharges during normal inspection activities but does not have a formal IDDE program in place. The City must develop an IDDE program, which includes procedures for inspection for illicit discharges, tracing illicit discharges, removing the source, and training field staff on the identification and reporting of illicit discharges. In addition, an IDDE ordinance to prohibit non-stormwater discharges or dumping to the City's MS4 must be adopted.

Another aspect of the NPDES Phase II Permit is Section S5.C.4, Controlling Runoff from New Development, Redevelopment, and Construction Sites. Within this section is "Subsection b" that will be a crucial additional step to be taken by the City. This section stipulates that the permitting processes must also comply with inspection and enforcement in the inspection of construction activities within the City. The City's current staff levels cannot meet the level of inspection required of the NPDES Phase II Permit, and an additional two full-time employees will be required to meet this requirement. These staff members would be dedicated to inspection of erosion and sedimentation control BMPs on construction sites. Two additional full-time employees in the Engineering Department will be needed to manage the planning, design, and inspection of capital projects completed by the City. The additional capital projects proposed within the DMP are significantly larger than what the City is currently completing, and current staff levels can not meet this increased workload.

Though the City currently has ongoing educational efforts regarding water quality, the NPDES Phase II Permit requires ongoing educational opportunities for the general public, homeowners, businesses, landscapers, property managers, and contractors on impacts of stormwater on receiving waters and BMPs. The City also needs to develop an ongoing internal training program for water quality.

The City will be required to track and document all efforts of the NPDES Phase II Permit implementation from training to inspection for inclusion in the annual report and SWMP.

9.4 Recommended Water Quality Program Adjustments

The recommended adjustments to the City's water quality program include:

- Implement the program needs for the two TMDL studies[1] currently under development (Green River and Soos Creek) along with upcoming water quality elements of the NPDES Phase II Permit reporting and long-term monitoring requirements.
  - One additional full-time equivalent employee; this employee would also be heavily involved in the education, tracking, and reporting requirements of the NPDES Phase II Permit
- Continue participation in Ecology's two TMDL studies currently under development as are expected to be completed in 2009 with implementation by the City to begin in 2010 or 2011.
- Plan for additional stormwater monitoring under the NPDES Phase II Permit as will likely be required of the City after 2012 (planning for long-term monitoring is required by the end of 2010).
- Additional stormwater water quality sampling equipment will likely be required in 2010 or 2011 to implement the Green River and Soos Creek TMDL monitoring requirements. The necessary sampling equipment will depend on the results of the TMDL studies.
- Monitor and inspect all construction sites within the City's jurisdiction for water quality BMPs and TESCs more frequently.
  - Two full-time employees (erosion control inspectors) to monitor construction sites and other public facilities
- Develop an annual training program for all staff responsible for implementing the program to control runoff from construction sites by August 2009.
- Adopt an IDDE ordinance by August 2009.

[1] Additional staff may be required to implement future TMDLs for the water bodies on Ecology's 303(d) list of impaired water bodies; however, this need would likely occur after the 2012 expiration date of the NPDES Phase II Permit.

- Train staff that may be responsible for detecting and eliminating illicit discharges by August 2009.
- Develop an annual training program for staff that might observe an illicit discharge by February 2010.
- Develop and implement and IDDE program by August 2011.

9.5 Existing Operations and Maintenance Program

The City's current Stormwater O&M program is well organized and relatively effective for managing maintenance tasks. City documentation indicates that key targets used to measure performance have been met for effectiveness, efficiency, and workload objectives since 2005. The program is generally successful in meeting its current mission to provide for the O&M of the City's storm drainage systems.

As permit implementation draws closer, it is necessary to compare current O&M practices with the permit requirements to identify compliance gaps. Currently, the City does not routinely track maintenance activities in a manner specific to the NPDES Phase II Permit requirements. However, the City maintenance staff does document all maintenance activities through their computer tracking system called Hansen System, and careful review of the City's Hansen System output and correspondence with City O&M officials has provided enough information to evaluate the City's current O&M practices in relation to permit requirements.

The City currently manages a program for stormwater O&M activities that includes a training component with an ultimate goal of preventing or reducing pollutant runoff from municipal operations. Although this program has not yet been tailored to the NPDES Phase II Permit requirements, many of the normal and established practices of the O&M group are directly related to the permit's prescribed performance measures. A discussion of the City's current O&M practices in relation to the permit requirements is provided.

Routine maintenance is performed on permanent water quality and flow control facilities owned or operated by the City. A formal program for tracking each facility has not been fully established at this time as required by the NPDES Phase II Permit. City O&M staff report that many new facilities have been added in recent years as part of new development projects, and regular maintenance has fallen behind. The City currently does not perform all maintenance activities in strict adherence to Chapter 4 of Volume V of the SWMMWW (Ecology 2005); however, many of items listed in these guidelines are typically performed during routine facility maintenance activities. The SWMMWW provides the Ecology-specified requirements for stormwater facilities maintenance that the City needs to achieve under the NPDES Phase II Permit.

Annual inspections of all permanent stormwater treatment and flow control facilities are not currently achieved. While each inspector typically completes an average of more than 300 inspections per year for various stormwater-related features, the City's capability to meet the inspection levels needed to attain Phase II compliance is limited by current staffing levels. Maintenance of these facilities is also limited by staffing and equipment levels, and typically focuses on problem areas and priority projects.

Routine maintenance also includes periodic spot checks of potentially damaged permanent stormwater facilities following heavy rains. Spot checks of locations or facilities, also referred to as "hot spots," are usually focused on areas of facilities that are prone to flooding or malfunction. Subsequent maintenance is provided as needed. Spot check activities are not currently tracked.

Inspection of the stormwater infrastructure is also a high priority of the Public Works Operations department. The City currently has a goal of inspecting each foot of pipe, manhole, or other stormwater facility once every 5 to 7 years. O&M uses three vactor trucks and one television (TV) crew working full time to inspect and clean pipes and structures. Based on the current rate of cleaning and inspection, the City will not meet the requirement to inspect every catch basin or inlet structure within the permit-allotted time (5 years). Vactor and decant operations are managed in accordance with City Public Works Operations, *Standard Operating Procedure,* Chapter 7.0 Utilities. This Standard Operating Procedure (SOP) has recently been updated to meet the NPDES Phase II Permit Appendix 6 requirements.

The City's current inspection program includes documentation and tracking of services performed. The program is not currently designed to achieve a 95 percent inspection rate for all sites, which is required under Section S5.C.4.b of the NPDES Phase II Permit and must be completed by February 2010.

The Hansen System is currently used to track maintenance activities by multiple City departments. The Hansen System can be used to query and report on specified maintenance activities. The City currently tracks and records inspection and maintenance activities in accordance with Section S9 of the NPDES Phase II Permit, although tracked items are not necessarily tailored to the permit compliance measures.

Maintenance training activities are typically on-the-job. Training is generally focused on safety, but some formal training is provided for selected activities and service areas. O&M training covers various topics, but is not necessarily tailored to the NPDES Phase II Permit requirements. Documentation of training activities is provided by the City for each employee.

The City does not currently have an SWPPP for its heavy equipment maintenance and storage yards. An SWPPP is required under the NPDES Phase II Permit Section S5.C.5.i and is required to be completed by the 2010 deadline imposed by the permit.

9.6 Operations and Maintenance Program Needs and National Pollutant Discharge Elimination System Phase II Requirements

This section summarizes the City's O&M program needs based on the City's current O&M program and practices and the requirements for the NPDES Phase II Permit and applicable TMDLs. The NPDES Phase II Permit provides the regulatory requirements that targeted communities must follow to comply with the NPDES Phase II Permit. Section S5.C.5 of the NPDES Phase II Permit focuses on the requirements related to O&M for municipal operations and forms the basis for evaluations presented below.

Section S5.C.5 permit standards require qualifying communities to develop and implement a consistent O&M program within 3 years of the effective permit date (by February 2010). The O&M program must address a list of individual requirements set forth by the standard. In summary, the permit standard for O&M includes the following components:

- Develop and implement maintenance standards for stormwater facilities in compliance with guidelines set forth by Ecology; the purposes of the maintenance standards are to determine if maintenance is required and to provide a protocol for scheduling-related maintenance activities
- Conduct annual inspections of all municipally owned or operated permanent stormwater facilities (other than catch basins) and complete maintenance in accordance with the standards
- Conduct spot checks of potentially damaged permanent stormwater treatment and flow control facilities after major storm events
- Inspect all catch basins and inlets owned or operated by the City at least once before the end of the permit term (5 years), and provide cleaning or maintenance in accordance with the standards
- Develop and implement an inspection program to achieve a 95 percent inspection rate of all stormwater facility sites
- Establish and implement practices to reduce stormwater impacts associated with runoff from streets, parking lots, roads, and highways owned by the City
- Establish and implement policies and procedures to reduce pollutants in discharges from all lands owned or maintained by the City
- Develop and implement an ongoing training program for City employees whose construction, operations, or maintenance job functions may impact stormwater quality
- Develop and implement an SWPPP for all heavy equipment maintenance or storage yards and material storage facilities owned or operated by the City
- Maintain records of inspections and maintenance or repair activities conducted by the City

Each of these individual requirements includes supplementary information and/or detailed instructions to help communities understand and meet the intent of the permit. NPDES Phase II Permit requirements for O&M can be examined in their entirety in Section S5.C.5.

9.7 Operations and Maintenance Program Gap Analysis

Comparison of City O&M practices with the requirements listed in Section S5.C.5 of the NPDES Phase II Permit guidelines provides the basis for determination of anticipated effects on City O&M practices and required supplemental actions, gaps in service levels, additional staffing and equipment needs, and associated costs. Table 9-2 lists the identified City O&M activities in relation to the essential elements of the permit standards. For each permit standard listed, information is presented to indicate the associated minimum permit requirements, the City's current O&M practices, the associated gaps in compliance, and recommended actions to meet the minimum standards.

9.8 Recommended Operations and Maintenance Program Adjustments

Based on results of the gap analysis, the following activities are recommended to bring the City stormwater O&M practices into compliance with the NPDES Phase II Permit requirements. Additional detail on these activities can be found in Table 9-2, which lists current measures taken by the City, along with identifying needs in relation to the NPDES Phase II Permit.

- Develop SOPs for maintenance operations of permanent stormwater facilities; the SOPs should include the provisions of Chapter 4 of Volume V of the SWMMWW maintenance standards; additionally, the City may consider using a standardized checklist to address individual maintenance tasks; a checklist would help maintenance workers complete individual tasks and demonstrate compliance with required permit activities tracking and documentation
- Update staffing and equipment levels to address NPDES Phase II Permit requirements for increased inspections and shorter maintenance response times for stormwater detention and water quality facilities; City O&M staff estimate that the following staff level increases are needed to meet these permit requirements; these staffing levels are based on existing staff and inspection schedules, and the amount of additional staff needed to increase the inspection and maintenance schedule to meet the NPDES Phase II Permit requirements; additional staffing and equipment needs have also been identified that are specifically tied to the potential annexation area of Panther Lake, and have been included in the future maintenance needs estimate
  - Nine full-time employees – (three crews of three maintenance workers) to achieve pond maintenance response times

  - Three full-time employees (one crew of three maintenance workers) if additional service areas are added by annexation (e.g., potential Panther Lake annexation area)
  - Three full-time employees – (one crew of three maintenance workers) for additional TV inspections of pipes and underground stormwater facilities
  - One TV truck
  - Two service trucks
- Update inspection program to meet annual inspection requirements for permanent stormwater facilities and initiate maintenance activities; additional staff and equipment needs to meet this requirement as follows:
  - One full-time employee – inspector for permanent stormwater facilities
  - One full-time employee – if additional service areas are added by annexation (e.g., potential Panther Lake annexation area)
  - Four full-time employees – (one crew of three to five workers) to service stormwater treatment vaults
  - One vactor truck
  - Two service trucks
  - One utility tool truck
- Develop an SOP for performing spot checks of permanent stormwater facilities after major storm events; include a method for tracking and documenting these inspections and initiating subsequent follow-on maintenance activities
- Update staffing and equipment levels to address Phase II requirements for increased inspections of catch basins and inlets at least once before the end of the permit term (5 years); City O&M staff estimate additional staff and equipment needs to meet this requirement as follows:
  - Two part-time (temporary) maintenance employees to inspect catch basins and inlets
  - One service truck
- Update the inspection program to include tracking and documentation of all sites visited to demonstrate a minimum 95 percent inspection rate
- Develop and implement a recurring training program for O&M workers whose job function may impact stormwater quality; the training program should address the importance of protecting water quality, requirements of the NPDES Phase II Permit,

O&M standards, inspection procedures, selection of appropriate BMPs, and ways for workers to perform their job activities to prevent or minimize impacts to water quality

- Develop and implement an SWPPP for all heavy equipment maintenance or storage yards and for material storage facilities owned or operated by the City

9.9 Stormwater Water Quality and Operations and Maintenance Program Additional Service Cost Implications

The City's current (2008) water quality program costs are expected to total approximately $208,000, which includes two full-time employees, equipment, and architecture and engineering services related to Lake Fenwick and other monitoring/reporting. The following additional staffing and equipment costs are anticipated to be needed to support the water quality program:

- One full-time employee at $90,000 per year in 2010 to implement the anticipated requirements for the Green River and Soos Creek TMDLs, as well as to plan the required long-term water quality monitoring program needs of the NPDES Phase II Permit (Table 9-1). This employee would also be heavily involved in the education, tracking, and reporting requirements of the NPDES Phase II Permit.
- Two full-time employees at $180,000 combined per year for the Engineering Department to provide for CIP projects implementation inclusive of water quality components beginning in 2009.
- Two full-time employees at $160,000 combined per year to hire two erosion control inspectors to support the increased oversight and inspection of water quality control BMPs at construction sites within the City's jurisdiction.
- The Environmental Conservation Supervisor is currently funded under the Water Utility. Since the responsibility of this employee is to supervise the NPDES Program for the City, a portion of this employee's cost (estimated at one-half time, or $45,000 per year) should be funded by the Drainage Utility.
- Water quality sampling equipment and laboratory fees budgeted as $80,000 that is expected to be needed for TMDL compliance monitoring

Therefore, the total estimated supplemental cost water quality program cost (based on current labor rates) is estimated to be $475,000 annually plus a one-time capital cost for water quality equipment needs estimated at $80,000.

Table 9-3 shows the estimated costs for the recommended water quality and O&M service areas, staffing, and maintenance equipment/vehicles additions. It should be noted that these values do not reflect a phased approach to increased staffing and equipment levels; instead, they represent the permit cycle additional need the City can reasonably anticipate stemming from the NPDES Phase II Permit implementation. Estimated unit costs for equipment and staff were provided by City O&M staff. Annualized costs for equipment were estimated by approximating miles and operating factors. Escalation for wages and operating factors is not included; however, inflation and escalation are considered within the utility rate adjustments. The following additional staffing and equipment costs are anticipated to be needed to support the O&M program adjustments:

- A total of 23 full-time employees and two temporary employees are estimated to meet the NPDES Phase II Permit requirements. Based on City labor rate projections, a total of $1,789,000 will be needed annually to fund the additional staffing levels.
- Estimated needs for new equipment include one TV truck, one vactor truck, one tool truck, and six service trucks to meet Phase II requirements, resulting in a total capital cost increase of $775,000.
- Estimated annual expenditures for equipment operations total $52,500.

The City's 2008 O&M program budget is $4,265,000 and covers all labor and equipment. The supplemental annual cost (based on current labor rates) for labor and equipment is estimated to be $1,654,500. This represents an increase of approximately 39 percent.

Table 9-1
Water Quality Program NPDES Phase II Permit Needs, Gap Analysis, and Program Adjustment Recommendations

NPDES Phase II Municipal Stormwater Permit Requirements	NPDES Reference	Current Measures by the City	Recommended Actions	Notes
For applicable TMDLs listed in Appendix 2, affected permittees shall comply with the specific requirements identified in Appendix 2.	p. 30, S7.A	None	None – Not applicable	Appendix 2 of the NPDES Phase II Permit does not include applicable TMDLs for the City.
For applicable TMDLs not listed in Appendix 2, compliance with this NPDES Phase II Permit shall constitute compliance with those TMDLs.	p. 30, S7.B	The City is currently implementing the Lake Fenwick TMDL.	None – The City is currently implementing this TMDL.	Additional capital costs may be required to comply with the TMDL, such as retrofitting the Lake Fenwick aeration unit, improving the stormwater wetland treatment area, or improving the upstream stormwater facilities to reduce phosphorus loading.
For TMDLs that are approved by EPA after this NPDES Phase II Permit is issued, Ecology may establish TMDL-related permit requirements through future permit modification if Ecology determines implementation of actions, monitoring, or reporting necessary to demonstrate reasonable further progress toward achieving TMDL waste load allocations and other targets are not occurring and shall be implemented during the term of this NPDES Phase II Permit or when this NPDES Phase II Permit is reissued.	p. 30, S7.C	None	Additional staff (one full-time employee) in 2010 or 2011 to comply with TMDL requirements (and NPDES Phase II Permit stormwater monitoring requirements) that may be approved by EPA in 2010, with start of implementation in 2011.	Additional monitoring and/or stormwater improvement measures will likely be required for the two additional TMDLs (Big Soos Creek and Green River) currently under development.
Permittees are encouraged to participate in development of TMDLs within their jurisdiction and to begin implementation.	p. 30, S7.C	Currently providing data	Coordinate with Ecology on the two additional TMDLs (Big Soos Creek and Green River) currently under development.	
Permittees are not required to conduct water sampling or other testing during the effective term of this NPDES Phase II Permit, with the following exceptions: 1. Any water quality monitoring required for compliance with TMDLs, pursuant to Section S7 Compliance with TMDL Requirements and Appendix 2 of this NPDES Phase II Permit 2. Any sampling or testing required for	p. 31, S8.A	1. The City is currently monitoring for the Lake Fenwick TMDL. 2. The City is currently characterizing illicit discharges through its O&M program.	None	

NPDES Phase II Municipal Stormwater Permit Requirements	NPDES Reference	Current Measures by the City	Recommended Actions	Notes
characterizing illicit discharges				
Each annual report shall provide the following: 1. Description of stormwater monitoring or studies conducted by, or on behalf of, the permittee 2. Assessment of the appropriateness of the BMPs identified by the permittee for each component of the SWMP 3. Information required by long-term monitoring standards	p. 31, S8.B	None	Can be completed by the NPDES Phase II Permit coordinator	
Long-term Monitoring Program The program will include two components: 1. Stormwater monitoring – intended to characterize stormwater runoff quantity and quality at a limited number of locations 2. SWMP effectiveness monitoring—intended to improve stormwater management efforts that ultimately leads to refinements of the SWMP	p. 32, S8.C.1	None		
Stormwater Monitoring – Each city with population greater than 75,000 shall identify three outfalls or conveyances where stormwater sampling could be conducted, representing: 1. Commercial land use 2. High-density residential land use 3. Industrial land use Permittees shall document site selection and justify basin size. A site ideally represents a particular land use (by December 31, 2010).	p. 32, S8.C.1.a.ii and v	None	Combine TMDL monitoring requirements to satisfy this requirement; additional full-time employee required in 2010 to plan and conduct monitoring and reporting; additional monitoring equipment and water quality laboratory costs	City population was equal to 86,607 in 2006
SWMP effectiveness monitoring – Be prepared to conduct monitoring to determine the effectiveness of the permittee's SWMP. It should answer the following type of questions: • How effective is a targeted action or narrow suite of actions? • Is the SWMP achieving a targeted	p. 33, S8.C.1.b.i	None	Can be completed by the NPDES Phase II Permit coordinator	

NPDES Phase II Municipal Stormwater Permit Requirements	NPDES Reference	Current Measures by the City	Recommended Actions	Notes
environmental outcome?				
By December 31, 2010, identify at least two suitable questions and select sites where monitoring will be conducted. Each question requires a monitoring plan containing: • A statement of the question • A specific hypothesis • Specific parameters/attributes to be measured • Expected modification to management actions depending on the hypothesis' outcome	p. 33, S8.C.1.b.ii-iii	None	Combine TMDL monitoring requirements to satisfy this requirement.	At a minimum, monitoring will include plans for stormwater, sediment, or receiving water monitoring of physical, chemical, and/or biological characteristics. This may also include data collection and analysis of other measures of program effectiveness, problem identification, and characterizing discharges for planning purposes.
Fourth annual monitoring program report that contains: • Status of identification of sites for monitoring • Include a summary of proposed questions for the SWMP effectiveness monitoring and describe the status of developing the monitoring plan, including the proposed purpose, design, and methods	p. 33, S8.C.2.a.ii-ii	None	Additional reporting can be completed by the additional full-time employee.	

Table 9-2
Operations and Maintenance Program NPDES Phase II Permit Needs, Gap Analysis, and Program Adjustment Recommendations

NPDES Phase II Municipal Stormwater Permit Requirements	NPDES Reference	Current Measures by the City	Recommended Actions	Notes
Establishment of maintenance standards as protective or more than protective as those in Chapter 4, Volume 5 of 2005 SWMMWW	p. 21, S5.C.5.a	The City has not officially adopted these standards as part of their SOPs for facility maintenance. However, many of these functions are typically performed in the course of regular maintenance.	Develop SOPs for maintenance operations that include Chapter 4, Volume 5 SWMMWW maintenance standards. Consider using a standardized checklist to address individual maintenance tasks.	Chapter 4, Volume 5 of the SWMMWW contains 20 pages of requirements specific to facility maintenance. Documentation received from the City does not address details of maintenance activities.
Except for circumstances beyond permittee's control, when inspection identifies an exceedance of the maintenance standard, maintenance shall be performed: • Within 1 year for wet pool, detention/retention pond facilities • Within 6 months for typical maintenance • Within 9 months for maintenance requiring revegetation • Within 2 years for maintenance requiring capital construction of less than $25,000	p. 21, S5.C.5.a.ii	The City currently documents maintenance on individual facilities and tracks with the Hanson System. The City is currently not able to perform maintenance activities at the level needed to meet NPDES Phase II Permit requirements.	Update SOPs and training. City O&M officials estimate additional staff and equipment needs to meet this requirement: • Nine full-time employees (three crews of three workers) to achieve pond maintenance requirement • Three full-time employees (one crew of three workers) if Panther Lake is annexed • Three full-time employees (one crew of three workers) for TV inspection • One TV truck • Two service trucks	Circumstances beyond permittee's control include denial or delay of access by property owners, denial or delay of permit approvals, and unexpected reallocations of maintenance staff to perform emergency work. Each exceedance must be documented and justified.
Annual inspection of all municipally owned or operated permanent stormwater treatment and flow control facilities other than catch basins, and taking appropriate maintenance actions in accordance with the adopted maintenance standards	p. 21, S5.C.5.b	The Public Works Operations Storm Division synopsis states a goal of inspecting each foot of pipe, manhole, or other facility once every 5 to 7 years. City O&M officials indicate that current staff levels can not meet the requirement for all	Update inspection program to include annual inspections of facilities and initiate maintenance activities. City O&M officials estimate additional staff and equipment needs to meet this requirement: • One full-time employee –	Annual inspection requirement may be reduced based on inspection records. Reducing inspection frequency is based on maintenance records of double the length of time of the proposed inspection

NPDES Phase II Municipal Stormwater Permit Requirements	NPDES Reference	Current Measures by the City	Recommended Actions	Notes
		ponds, vaults, and treatment BMPs. Particularly, stormwater treatment vaults are becoming more prevalent and create a significant labor demand to service. The City currently estimates about 30 stormwater quality treatment vaults, with more added every year. The City occasionally uses temporary and seasonal labor for inspections and maintenance.	inspect stormwater facilities • One full-time employee – additional if Panther Lake is annexed • Four full-time employees (one crew of three to five workers) to service stormwater treatment vaults • One vactor truck • Two service trucks • One utility/tool truck	frequency.
Spot checks of potentially damaged permanent treatment and flow control facilities (other than catch basins) after major storm events. If spot checks show widespread damage/maintenance needs, inspect all stormwater treatment and flow control facilities that may be affected.	p. 21, S5.C.5.c	The City typically inspects stormwater facilities that are known to require service following heavy rains.	Develop an SOP as part of inspection program	NPDES defines a major storm event as greater than 24-hour 10-year recurrence interval rainfall.
Inspection of all catch basins and inlets at least once before the end of the NPDES Phase II Permit term. Catch basins cleaned to comply with maintenance standards set in the 2005 SWMMWW	p. 22, S5.C.5.d	The City currently follows a proactive inspection program, including inspection and cleaning of catch basins and pipes. The City has three vactor trucks working full time.	Implement as part of inspection program. City O&M officials estimate additional staffing and equipment needs to meet this requirement: • Two part-time employees (temporary employees) to inspect catch basins • One service truck	NPDES Phase II Permit term period is 5 years. Per NPDES – Inspections may happen on a "circuit basis" where a sampling is inspected to identify maintenance needs. Sampling must include the catch basin immediately upstream of any system outfall. SWMMWW lists 14 types of

NPDES Phase II Municipal Stormwater Permit Requirements	NPDES Reference	Current Measures by the City	Recommended Actions	Notes
				defects to be maintained for catch basins, including trash and debris, sediment, structure damage to frame, fractures or cracks in basin walls/bottom, settlement/misalignment, vegetation, catch basin cover, ladder, and metal grates (if applicable).
Decant water shall be disposed of in accordance with Appendix 6 *Street Waste Disposal*. Appendix 6's General Statements Street Waste Liquids, General Procedures: • Street waste collection should emphasize retention of solids in preference to liquids • Street waste liquids require treatment before their discharge. Street waste liquids usually contain high amounts of suspended and total solids and adsorbed metals. Treatment requirements depend on the discharge location. • Discharges to sanitary sewer and storm sewer systems must be approved by the entity responsible for O&M of the system. The following order of preference, for disposal of catch basin decant liquid and water removed from stormwater treatment facilities, is required: • Discharge of catch basin decant liquids to a municipal sanitary sewer connected to a Public-owned Treatment Works is the preferred disposal option • Discharge of catch basin decant liquids	p. 22, S5.C.5.d	City Public Works Operations, SOP, Chapter 7.0 Utilities has been updated to meet Appendix 6 requirements.	To comply with reporting procedures, records must be maintained for 5 years.	In Public Works Operations, SOPs, Chapter 7.0 Utilities: • Discharge to a municipal sanitary sewer requires the approval of the sewer authority. • Stipulation 2 allows discharge to a basic or enhanced stormwater treatment BMP if discharge to sanitary sewer is not reasonable; removal of visible oil sheen is specified as a criteria. Operating criteria for the City goes beyond this.

NPDES Phase II Municipal Stormwater Permit Requirements	NPDES Reference	Current Measures by the City	Recommended Actions	Notes
may be allowed into a basic or enhanced stormwater treatment BMP, if option 1 is not available • Water removed from stormwater ponds, vaults, and oversized catch basins may be returned to the storm sewer system				
Established inspection program designed to inspect, and achieve inspection of, 95 percent of all sites	p. 22, S5.C.5.e	The City's current inspection program includes documentation and tracking of services performed.	Update the inspection program to track compliance with this requirement.	This requirement is used to determine compliance with the NPDES Phase II Permit above requirements (a through d).
Establishment/implementation of practices to reduce stormwater impacts from streets/roads, specifically: • Pipe cleaning • Cleaning of culverts that convey stormwater in ditch systems • Ditch maintenance • Street cleaning • Road repair and resurfacing, including pavement grinding • Snow and ice control • Utility installation • Pavement striping maintenance • Maintaining roadside areas, including vegetation management • Dust control	p. 22, S5.C.5.f	The Hansen System is used to track maintenance activities by multiple departments. The City currently tracks each of the listed maintenance items in this requirement. The Hansen System can be used to query and report.	Consider coordination with roads division to update SOPs for listed activities.	NPDES does not state a necessity of policies. Proof of practice should likely be sufficient.
Establishment and implementation of policies and procedures to reduce pollutants in discharges from all lands owned or maintained; policies shall address: • Application of fertilizer, pesticides, and herbicides including development of nutrient management and integrated pest management • Sediment and erosion control • Landscape maintenance and vegetation disposal	p. 22-23, S5.C.5.g	The City currently has SOPs for each listed item in this requirement.	City O&M officials estimate additional staffing needs to comply with Sediment and Erosion Control inspection requirements. Coordinate with City Parks Department to implement SOPs.	NPDES-listed (but not limited to) parks, open space, road right-or-way, maintenance yards and stormwater treatment, and flow control facilities

NPDES Phase II Municipal Stormwater Permit Requirements	NPDES Reference	Current Measures by the City	Recommended Actions	Notes
• Trash management • Building exterior cleaning and maintenance				
Develop and implement ongoing training for employees whose construction or O&M job function impact stormwater quality. Training shall address: • Importance of maintenance standards • Inspection procedures • Selecting appropriate BMPs • Ways to perform job activities to prevent/minimize impacts to water quality • Procedures for reporting water quality concerns, including potential illicit discharge Follow-up training shall be provided as needed to address changes in procedures, techniques, or requirements. Document and maintain records of training provided.	p. 23, S5.C.5.h	Staff training is currently safety focused. Maintenance training activities are typically on-the-job. Some formal training is provided for select activities or service areas.	Develop NPDES Phase II Permit training to explain and implement SOPs, policies, and programs to achieve permit compliance. Consider implementing with Kent University or University of Washington Track Training programs.	
Develop/implement an SWPPP for all heavy equipment maintenance or storage yards and material storage facilities not required to have coverage under the Industrial stormwater General Permit: • A schedule for implementation of structural BMPs shall be included in the SWPPP	p. 23, S5.C.5.i	The City does not currently have an SWPPP for their maintenance and storage yards.	Develop SWPPP for facilities as needed.	Generic SWPPPs that can be applied at multiple sites may be used to comply with this requirement. SWPPP shall include periodic visual observation of discharges from the facility to evaluate the effectiveness of BMPs.

NPDES Phase II Municipal Stormwater Permit Requirements	NPDES Reference	Current Measures by the City	Recommended Actions	Notes
Records of inspection and maintenance or repair activities shall be maintained in accordance with Section S9 Reporting Requirements.	p. 23, S5.C.5.j	The City currently tracks and records inspection and maintenance activities in accordance with Section S9.	Review Section S9 to ensure maintenance tracking is compliant.	Most Notably with Section S9 Requirements: S9A – Annual report submitted by March 31 of each year S9C – All records related to this permit kept for 5 years S9E – Lists what annual report shall include: S9E1 – A copy of the current SMP S9E2 – Submittal of Appendix 3 – which is intended to summarize compliance with the conditions of the permits (outlined in greater detail within NPDES requirements) S9E3 – With the annual report, notification of any annexation, incorporations, or jurisdictional boundary changes resulting in an increase or decrease in the geographic area of permit coverage during the reporting period.

Table 9-3
Recommended Stormwater Programs Estimated Supplemental and Existing Program Costs

NPDES Reference	Description	Annual Cost ($)	Capital Cost ($)
Water Quality			
S5.C.4.b	Erosion control inspectors		
	2- FTE	160,000	
	0.5 – FTE (Environmental Conservation Supervisor)	45.000	
	2 – FTE (Engineering Department)	180.000	
	2010 – NPDES Phase II and TMDL monitoring	90,000	80,000
	Total Recommended Supplemental – Water Quality	**475,000**	**80,000**
	Total Existing – Water Quality	**208,000**	
O&M			
S5.C.5.a.ii	Maintenance of stormwater facilities		
	15 – FTE	1,125,000	
	1 – TV truck	7,500	175,000
	2 – Service trucks	10,000	70,000
S5.C.5.b	Annual inspection of stormwater treatment and flow control facilities		
	6 – FTE	450,000	
	1 – Vactor truck	10,000	375,000
	1 – Tool truck	5,000	50,000
	2 – Service trucks	10,000	70,000
S5.C.5.d	Inspection of catch basins and disposal of decant water		
	2 – Temporary employees	32,000	
	2 – Service trucks	5,000	35,000
	Total Recommended Supplemental – O&M	**1,654,500**	**775,000**
	Total Existing – O&M	**4,265,000**	

Notes:
FTE = full-time employee

10 STORMWATER PROGRAM FUNDING NEEDS AND APPROACHES

This section of the DMP has been prepared by City staff and the City's financial utility rate consultant (FCS Group) to summarize services independently conducted by them to evaluate the City's stormwater utility funding program. Those services included assessment of current and projected program funding needs, levels of service, funding options, and stormwater utility rate structure/level needs to implement recommendations of the DMP update.

10.1 Stormwater Projects and Programs Funding Needs

The City's existing drainage utility rate was implemented by the City Council in 1985. The objective then and today is to fund the stormwater infrastructure needed to prevent localized flooding within the City, maintain the existing City stormwater system, protect water quality, preserve public safety, and enhance fish and wildlife habitat within the City.

Since 1985, many major projects have been completed, which have improved the level of flood protection in the City. The projects have included the building and improvements of regional flood control facilities on Mill and Garrison Creeks, the purchase and installation of the GRNRA as a regional stormwater facility and wildlife preserve, and numerous culvert replacement and stream restoration projects that have reduced localized and regional flooding within the City.

As the City's growth continues, stormwater project and program needs to provide flood protection, water quality, and fish and wildlife habitat, as well as to meet federal and state requirements also change. Therefore, the City decided to prepare an update to its DMP.

The City contracted with FCS Group in 2007 to review the City's current stormwater rate structure, connection charges (General Facilities Charges [GFCs]), and financial health, as well as recommend changes to the drainage rate and connect fees to fund the necessary improvements within the City's stormwater program.

The technical analysis includes both a revenue requirements analysis and a GFC analysis. The revenue requirements analysis estimates the amount of rate revenue needed to meet the utility's annual financial obligations and will be used to determine an updated schedule of monthly fees. The GFC analysis determines the up-front charges imposed on new development to recover the cost of infrastructure needed to serve that new development. The technical analysis will be included with the FCS Group final report following review by the City Council.

10.2 Level of Service

Stormwater program needs were evaluated under 10 major program elements or categories. The needs assessment and corresponding recommendation for each category are based on the stormwater program's existing and proposed service levels. These categories are described below.

10.2.1 Stormwater Capital Improvement Projects

Stormwater capital improvement projects are discussed within Section 7 of this report. Stormwater projects include localized flood control projects to reduce potential damage to homes, businesses, schools, and City streets. This category also includes improvements to the GRNRA regional detention and water quality facility and other improvements to provide protection against, at minimum, a 25-year storm event. Many of those projects involve natural resources such as streams, and enhancement and restoration of those natural resources will be included with those projects.

10.2.2 Street Capital Projects

Street capital projects include the cost of stormwater facilities associated with the TIP. The drainage component of transportation improvements reflected in the DMP includes the acquisition of property and planning, design, construction, and inspection of stormwater facilities.

10.2.3 Green River Levee Repair and Replacement

The City has been an active member of the Green River Flood Control Zone District, whose purpose includes addressing the maintenance and repair of flood protection levees throughout King County. The current level of funding for this program is staff time dedicated to participating in regional planning and design, reviewing the plan of operation for levee repair work within King County, and making recommendations to the Board of Supervisors of the King County Flood Control Zone District.

The proposed Level of Service for this category includes repair, replacement, and property acquisition for the Green River levees. The levee system within the City corporate limits consists of approximately 14 river miles of levee system. FEMA recently downgraded the levees within the Green River system because they are not certified by FEMA or the Corps. FEMA requires the levees to be repaired and set back to meet federal requirements before they are certified for flood protection. The King County Flood Control Zone District has included approximately $70 million for levee repair work within the City's corporate limits over the first 10 years of the King County Flood Control Zone District operations (2008 to 2017). However, the projected costs of repairing the levees are estimated to be substantially greater.

10.2.4 Operations and Maintenance

O&M of the Stormwater Utility includes staff, equipment, and vehicles necessary to maintain more than 425 public stormwater facilities and more than 200 miles of storm drain pipe, and respond to public requests for service due to flooding or potential flooding of properties. The O&M stormwater staff also includes three private stormwater inspectors whose directive is to inspect and direct maintenance and repairs for private stormwater systems. Section 9 of the DMP discusses the existing program in depth and recommends improvements to it. The O&M category also includes funds required for stormwater utility debt payments.

10.2.5 Engineering

The Public Works Engineering Section develops the regulations and policies related to stormwater and natural resources, and carries out the planning, design, survey, and inspection of capital improvement projects. The stormwater utility also assists development review staff to ensure all proposed new and redevelopment projects meet the criteria set within City Code 7.03 and 7.05, and in Chapter 5 of the City Construction Standards, also known as the 2002 City *Surface Water Design Manual* (City of Kent 2002).

10.2.6 Water Quality

Water quality includes staffing, monitoring, and maintenance needs for the NPDES and TMDL programs within the City. The stormwater program improvements needed to facilitate City compliance with the requirements of the NPDES Phase II Permit are documented in Section 9 of this report.

10.2.7 Critical Area Protection

Critical area protection components include the City's existing program for maintenance of sensitive area properties, including the GRNRA, and wetland and stream maintenance needs throughout the City. Another component of this service area is the continued need to acquire property for water quality improvements, potential stream and wetland enhancement projects, and land to protect against potential flooding. Section 8 of this report discusses the current level of work and recommended improvements to restore and enhance fish and wildlife habitat within the City.

10.2.8 Public Education

The public education components within the existing program are minimal. However, by 2010, the NPDES Phase II Permit will require that the City provide training to staff and educate local businesses and the public regarding supplemental stormwater control needs. Each class, presentation, or workshop will need to be tracked for attendance and measurement of effectiveness. This will require a significant increase in staffing hours. Further details of this item can be found in Section 9 of the report.

10.2.9 Administration

The administration service area includes staff that maintains the utility billing, legal counsel, and administrative support. As the NPDES Phase II Permit required implementation actions schedule proceeds, the administrative support staff will need to be increased to meet the gap analysis needs as stated in Section 9 of the DMP.

10.2.10 Repair and Replacement Funding

The Public Works Operation Section maintains a list of stormwater facilities that need to be replaced due to the potential for failure and aging of the system. The collective drainage system condition is documented by TV inspection.

The City staff recommends that the City take a proactive approach and replace facilities as they reach their respective service lives and prior to failure. Refer to Sections 7 and 9 for further discussion of the repair and replacement funding needs.

10.3 Summary of Stormwater Projects and Programs Funding Requirements

Table 7-1 in Section 7 summarizes the recommended capital improvement projects funding requirements totaling approximately $67 million and proposed for implementation over a 10-year period. In addition, City staff have identified an additional $50 million need for capital projects funding associated with stormwater, LID facilities, and mitigation components of TIP improvement projects assumed to be funded over a similar 10-year period. Other stormwater program capital project funding needs include an estimated $42 million in supplemental costs for those Green River levee improvements and setbacks located within the City, beyond the current King County Flood Control Zone District dedicated funding for those improvements. Therefore, the total stormwater program capital projects funding needs are projected to be approximately $159 million (May 2008 dollars).

Table 9-3 in Section 9 summarizes the existing and anticipated supplemental stormwater program costs for the water quality and O&M service areas that are mandated by new federal and state requirements under the NPDES Phase II Permit and associated TMDL water quality requirements. Those supplemental costs, as determined by stormwater programs gap analysis, total an estimated $2.1 million annually beyond the current stormwater program water quality and O&M costs totaling approximately $4.5 million annually (2007).

10.4 Stormwater Program Funding Options

A number of funding options are available to the City to meet the needs of a fully functional stormwater program. These options include the following:

- **Street Fund** – Drainage infrastructure is often constructed with streets, and the street department further tends to provide system maintenance in the right-of-way. However, stormwater management is not the primary function of a street department, and competing demands for these limited funds may not be the most appropriate environment to actively promote the City's ongoing objectives in stormwater management. It is important to also note that the method of funding the City's street fund does not provide the best linkage between "who pays" and who is served by the stormwater system.

Securing funding for the DMP through the street fund is not an option. The street fund currently has a significant funding gap in covering existing City needs, and this is not expected to change in the near future.

- **General Fund** – As with the street fund, non-dedicated funding for stormwater programs is subject to competing demands on an annual basis, therefore, proving to be an unreliable source for ongoing commitments to O&M. Again, the method of funding does not provide the best linkage between "who pays" and who is served by the system.

  The City currently does not use the general fund as a revenue source for the Storm Drainage Utility. Given the current unavailability of the general fund to implement the drainage program, it is assumed this will not be a source of future drainage program funding.

- **Special Assessments/Local Improvement Districts** – Special assessments, as instruments of local improvement districts, are most appropriate for specific capital improvements that benefit identifiable geographic service areas. By nature, these options are also effectively voluntary, that is, the property owners choose through a vote whether or not to implement the assessment on themselves. This possible restriction causes program funding to be unreliable; furthermore, the assessed valuation basis of charging provides only a loose nexus between the amount charged and the benefit received.

  The City currently is assuming that no funding will be secured from the use of Special Assessments or Local Improvement Districts for the DMP implementation. The City is not including this source of revenue funding for the DMP because of the difficulty with the nature of its projects in assessing the amount charged and the benefit received.

- **Special Fees** – The City could charge special fees for operating activities such as inspections. These fees, however, are best applied when they are set to recover the costs, or a portion of the costs, of the specific activity for which payment was received. Special fees are not generally intended to fund an ongoing stormwater program in its entirety; however, they would be well suited for the recovery of specific program-related costs.

The DMP is currently not funded through Special Fees, and for use of a conservative funding approach, is not included as a funding source at this time.

- **GFCs –** GFCs are one-time fees paid at the time of development and are intended to recover an equitable share of the costs of existing and planned future facilities that provide capacity for growth. They are an essential tool used to recover the cost of growth from growth.

  Estimated future revenues from the GFC are expected to average $860,000 per year. Current estimates are for a potential of approximately 13,000 additional ESUs within the City, and GFCs for those could be a source of revenue in the next 10 years assuming that the development will occur in that time period. A high estimate using the City's current GFC per ESU would generate approximately $16 million over 10 years, assuming all development would occur within the next 10 years.

- **Fees in Lieu of On-site Detention –** Another method of funding required capital projects, fees in lieu of on-site detention, is most appropriately used to fund regional facilities through the payments of developing properties. These fees are collected when a developing property determines not to construct facilities to mitigate runoff on site. As such, fees in lieu must be used in concert with requirements for on-site mitigation and a community's goals favoring regional facilities over on-site solutions. When a property does construct such facilities, the fee is not charged. While effective in funding a part of (regional) infrastructure construction, fees in lieu are not a reliable source for ongoing stormwater programs.

  An estimate of fees in lieu of on-site detention is not projected at this time. Due to the high cost of the purchase of buildings and real estate for additional new regional detention facilities, and the potential for widening of stream channels and expansion of existing regional detention facilities, additional regional detention facilities are not included in the DMP.

- **Public/Private Partnerships** – A different approach to funding stormwater capital construction is the public/private partnership resulting in joint or private funding of specific improvements. This approach helps mitigate the direct impacts of new development. While a popular idea, in practice, it is difficult to persuade private development to fund stormwater projects if other funding alternatives are available to the City.

  Estimates of future funding developed from public/private partnerships are not incorporated into the drainage fund. There would be no guarantee of a level of funding able to fund the projects and programs included within the DMP.

- **Conventional Debt –** Conventional debt, such as revenue bonds and general obligation bonds, is available to fund stormwater capital construction. While these mechanisms are well suited for funding large capital construction projects, an ongoing revenue stream is required to support the annual debt service owed on the amount borrowed.

  The low estimate for occurring conventional debt is $10 million over the next 10 years for the DMP. The high estimate is a series of new revenue bonds issued every 2 to 3 years depending on the project need over the next 10 years. The high estimate would be approximately $127 million generated in conventional debt to fund implementation of the DMP.

- **Special Grants and Loans** – As a supplement to conventional debt service, special grants and loans may be an important option for the City. Many state and federal programs are available for applications, including the Centennial Clean Water Fund, the Public Works Trust Fund, the State Revolving Fund, the Flood Control Assistance Account Program, and the Federal 319 Non-point Source Program. These programs draw more applications every year than there are available funds, and they are highly competitive. Most of the assistance programs award aid in the form of low-interest loans that still require an ongoing revenue stream to support payback.

Although the DMP will continue to pursue special grants and loans funding sources, it is risky to base future revenue funding on past success of securing grants. A low estimate of grant availability is $50,000 per year, and a high estimate is $500,000 per year.

- **Stormwater Utility Service Charges** – A significant portion of the stormwater management costs are recovered through ongoing rates to utility customers. For the most part, the utility is and would continue to be a financially independent entity, free of reliance on the other City funds, with all of its revenues dedicated to surface water management programs and capital construction.

  Currently, the City receives approximately $8.6 million in stormwater utility services charges per year, a low estimate assuming that the rate would not change. A high estimate would include future growth, as stated within the GMA, and would include an assumed increase within the utility rate to increase revenues collected to $15 million per year.

10.5 Existing Rate Structure

The City's existing rate structure features area- or basin-specific rates, a density multiplier, and an impervious surface area basis. The term impervious surface area refers to hard surface area that prevents or slows water permeation into the ground. RCW 35.67, the authorization of the stormwater utility concept, allows the imposition of service rates based on contribution of runoff. Impervious surface area is most widely accepted as an appropriate measure of a property's contribution of runoff, providing a clear relationship, or "rational nexus," to service received from a stormwater program.

Single family residential customers are charged based on the estimated average amount of impervious surface area (currently 2,500 square feet) per developed single family residential parcel—commonly referred to as an ESU. All other customer types are charged based on actual measured impervious surface area by parcel, expressed as the number of ESUs on the parcel and a density multiplier as an adjustment factor. Density of development is a supplemental measurement of runoff contribution and represents the percentage of the parcel covered by hard surface. It is used to acknowledge that, for example, 5,000 square feet of impervious surface on a 6,000-square-foot lot more directly impacts the public system than 5,000 square feet of hard surface on a 30,000-square-foot lot. As with impervious surface area, density of development is an appropriate charge basis because it adequately quantifies the relationship between the rate paid and the amount of service received.

Under the existing rate structure, all customers pay a uniform base rate, $2.57 per month. Additionally, a basin-specific rate is charged ranging from $1.68 per month to $5.05 per month. There are 17 basins. These basins are grouped into eight different basin-specific rate categories:

- Westside ($1.68 per month)
- Upper Mill Creek ($4.27 per month)
- Lower Mill Creek ($5.05 per month)
- Valley Detention ($5.05 per month)
- Upper Garrison Creek ($1.94 per month)
- Lower Garrison Creek ($2.12 per month)
- Soos Creek ($4.35 per month)
- Direct ($2.23 per month)

10.6 Analysis Assumptions

City staff and FCS Group agreed on the assumptions used within the rate study. Key assumptions include a customer base annual growth rate of 0.58 percent, an annual inflation rate of 4 percent, personnel benefits costs escalation of 6 percent per year, construction cost escalation of 5 percent per year, and an annual fund earnings rate of 2.5 percent.

The Capital Improvement Projects for stormwater systems and the drainage component of the street projects are assumed to be implemented over a 10-year period (2009 to 2018). Finally, system replacement funding will be equal to annual depreciation expense.

10.7 Drainage Funding

To meet the stormwater program needs, the City could incorporate a mix of the funding options evaluated above in Section 10.4, with utility rates as the backbone funding source, special fees for specific activities, GFCs, special grants and loans when available, conventional debt service when necessary, and public-private partnerships. A combination of these revenue sources would be sufficient to alleviate the gap between the DMP proposed stormwater program implementation costs and the current level of funding.

10.8 Conclusion

The DMP can be financed through the City's several viable options for raising the revenue. These options will be presented to the City Council for consideration. The public will have opportunities to participate in these decisions.

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APPENDIX A

PUBLIC INVOLVEMENT DOCUMENTATION

(All appendices are provided as a separately bound document)

APPENDIX B

LAND COVER ANALYSIS DOCUMENTATION

(All appendices are provided as a separately bound document)

APPENDIX C

DECEMBER 3, 2007 FLOOD PHOTOGRAPHS AND HIGH WATER MARKS

(All appendices are provided as a separately bound document)

APPENDIX D

HYDROLOGIC ANALYSIS DOCUMENTATION

(All appendices are provided as a separately bound document)

APPENDIX E

UPPER MILL CREEK STORAGE EVALUATION

(All appendices are provided as a separately bound document)

APPENDIX F

HYDRAULIC ANALYSIS DOCUMENTATION

(All appendices are provided as a separately bound document)

APPENDIX G

PROJECT COST OPINIONS

(All appendices are provided as a separately bound document)