Clear/Clarks Creek Basin Plan

Volume 1 - Basin Plan & SEIS

CLEAR/CLARKS CREEK BASIN PLAN

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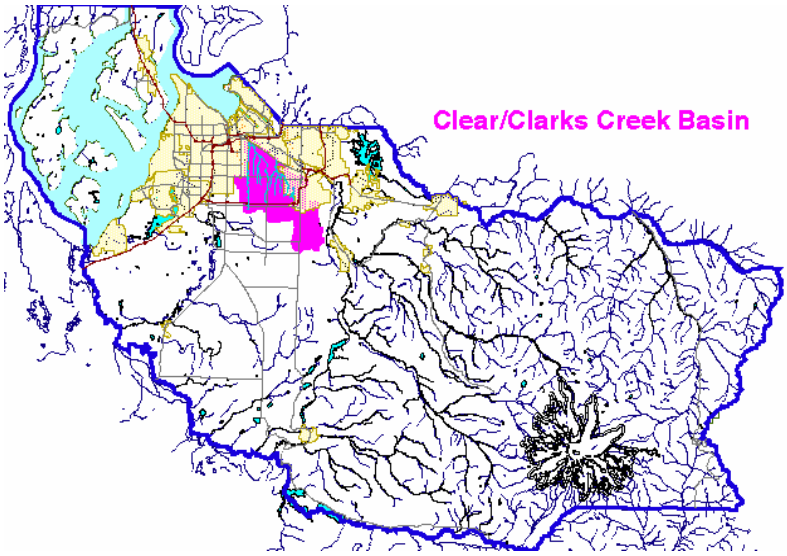
As Adopted PCC 2005-115s
May 2006



Pierce County
Public Works and Utilities
Water Programs Division

Clear / Clarks Creek Basin Plan

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CLEAR/CLARKS CREEK BASIN PLAN EXECUTIVE SUMMARY

ES.1 Introduction and Purpose

The Clear/Clarks Creek Basin Plan (Basin Plan) is intended to serve as a comprehensive guide to storm drainage and surface water management in unincorporated parts of the Roosevelt Ditch drainage area, Clear Creek drainage basin, Clarks Creek drainage basin, and the Potholes drainage area. The Basin Plan addresses many aspects of surface water management with emphasis on flooding, erosion, water quality, and habitat problems and solutions to the problems identified.

The purpose of the Clear/Clarks Creek Basin Plan is to establish the actions Pierce County Public Works and Utilities, Water Programs Division will take over the next ten years to reduce flood hazards, to protect water quality, and to protect associated riparian and aquatic habitat in the basin. Recommended actions are based on the physical characteristics of the basin; the laws, policies, and regulations that apply to storm drainage and surface water management in unincorporated Pierce County; the preferences of citizens in the County and in the Clear/Clarks Creek Basin; and the character of existing land use and planned growth as set out in the Comprehensive Plan for Pierce County, Washington. The Basin Plan will guide annually updated work plans for capital improvement projects and programmatic measures of Water Programs. ("Programmatic" refers to non-structural actions, such as changes to regulations, policies, programs, and how they are administered.) The Basin Plan also identifies key supportive actions needed from other parts of county government and other jurisdictions to ensure that flooding, habitat, and water quality issues in this basin are addressed in a coordinated manner. Water Programs managers will convey these needs to appropriate programs (e.g., Transportation Division, Planning and Land Services Department, Tacoma-Pierce County Health Department, Pierce Conservation District, community planning boards and forums, and Washington State Department of Transportion.

This Basin Plan has been developed as part of Water Program's basin planning program. The program updates the *Pierce County Storm Drainage and Surface Water Management* (1991 Plan) by developing ten basin-specific plans. The 1991 Plan has guided storm drainage and surface water management facilities and services for over a decade and much of the 1991 Plan has been implemented. The 1991 Plan studied the Clear/Clarks Creek Basin and recommended $11.2 million dollars in improvements, many that have been constructed. Clear/Clarks Creek is one of 26 Pierce County drainage basins (see *Figure ES-1*).

The Basin Plan supports or furthers Pierce County's:

- Compliance with its federal "Clean Water Act" National Pollution Discharge Elimination System (NPDES) municipal stormwater permit
- Compliance with the "Endangered Species Act" (ESA) by eliminating or reducing existing or potential habitat issues that could cause "jeopardy" for protected species
- Upgrade to a "Class 4," rating or better under the Federal Emergency Management Agency's (FEMA) "Community Rating System" (CRS)

ES.2 Goals of the Clear/Clarks Creek Basin Plan

Specific goals and objectives of the Clear/Clarks Creek Basin Plan are as follows:

Reduce Flood Hazards

- Incidents of property loss and repeat damage are reduced
- Streams will not be adversely affected by flood events
- Pierce County's standing under the FEMA Community Rating System is improved
- New development is located outside of flood prone areas

Improve Water Quality

- State Surface Water Quality Standards (WAC 173-201a) are met or exceeded
- Number of impaired (303d listed) water bodies is reduced
- Pierce County is in compliance with its NPDES permit for stormwater by meeting permit terms and conditions to the maximum extent practicable
- Risk of groundwater contamination is reduced
- Rates of erosion are reduced

Improve Associated Fish and Wildlife Habitat

- Number of stream miles available for wild, native fish populations is increased
- Population numbers of species listed as "endangered" or "threatened" under the Federal Endangered Species Act are maintained or increased
- Quality and quantity of available wetland, riparian, and upland habitat is improved

Demonstrate coordinated and responsible use of public resources

- Cost of maintaining stormwater facilities is reduced
- Project value is favorable when measured against costs and benefits
- Polls demonstrate that public awareness of flooding, habitat, and water quality issues has increased
- Monitoring and enforcement programs demonstrate an increase in services per dollar spent
- Basin plan implementation also implements elements of other Pierce County plans.
- Basin plan findings are used by other agencies and jurisdictions in planning their activities.

Influence location and methods for new development

- New development in flood-prone, riparian, or significant habitat areas is prohibited.
- Low Impact Development techniques are widely used.
- Effective storm drainage best management practices (BMPs) are identified and widely used.

ES.3 Basin Description

The Clear/Clarks Creek Basin is composed of the drainage areas tributary to the south side of the Puyallup River between River Mile- (RM)-2.8 and RM-7. Like the Mid-Puyallup Basin, it excludes the main stem of the Puyallup River (see *Figure ES-2*). The main stem of the Puyallup River is covered in the Puyallup River Comprehensive Flood Control Management Plan. Major flooding concerns related to the levee system along the lower Puyallup River are principally addressed in the Puyallup River Comprehensive Flood Control Management Plan.

The entire Clear/Clarks Creek Basin encompasses 32.9 square miles of which 27.4 square miles (83%) exist within unincorporated Pierce County. The remaining 5.5 square miles (17%) lay within the cities of Tacoma and Puyallup. For a description of the roles of the cities and the Puyallup Tribe in the Basin and in this Basin Plan, refer to Chapter 3, Stakeholder Involvement.

The Clear/Clarks Creek Basin is part of Washington State Water Resource Inventory Area (WRIA) 10, the Puyallup-White River Basin. Clear/Clarks Creek Basin contains two major tributaries plus a small area called the Roosevelt Ditch drainage area and an area that is internally drained called the Potholes. The Clear/Clarks Creek Basin Plan includes the Roosevelt Ditch and Potholes drainage areas because they are adjacent areas that do not fall logically into any other drainage basin, they are not large enough for the cost-efficient preparation of individual basin plans, and the areas were included in the Clear/Clarks Creek study area of the 1991 Plan.

ROOSEVELT DITCH DRAINAGE AREA: Flows into the City of Tacoma & the T Street drainage

CLEAR CREEK BASIN:
Swan Creek
Squally Creek
Clear Creek
Canyon Creek

CLARKS CREEK BASIN:
Rody Creek
Diru Creek
Woodland Creek
Clarks Creek

POTHOLES:

- Afdem
- Black Swamp
- Capital
- Heritage Glen
- Tip Top
- 128th Street
- Meridian Street
- 135th Street
- Candlewood-Manorwood
- 117th Street
- Lower 144th Street
- Alderwood
- Upper 144th Street
- Springfield
- South Central
- 110th Avenue

Figure ES-1
Study Area

repeat of County figure 1-2 from Chapter 1

ES.4 Problems, Proposed Solutions and the Prioritization Process

Problems identified in the Basin Plan include: flooding of property and roads, impaired water quality, stream channel incising, erosion and sedimentation, loss of floodplain, and degraded aquatic habitat. The Basin Plan addresses the adverse effects of these problems and issues, such as: property damage from flooding; violations of federal, state, and local regulations; and threats to public health and safety. It explores the causes behind the problems

Each potential Capital Improvement Project (CIP) and programmatic recommendation was evaluated for its net natural resource management benefit and then prioritized based on cost-to-benefit considerations.

In determining net benefit, each project and program was scored using a system that assigned points for the project or program's potential for various aspects of flood reduction, water quality protection or improvement, natural resource improvement, and other factors such as economic development, multiple use, education, and recreation. Each project and program was reviewed and scored using approximately 40 specific criteria. Recommended CIPs and programs were then put in rank order, based on their numeric benefit score, and grouped by "High," "Medium," and "Low" priority order. In total, the Basin Plan recommends $65,557,000 of projects, programs, and studies for the Clear/Clarks Creek Basin. This includes $33,114,000 of "High Priority" projects; $27,612,000 of "Medium Priority" projects; and $4,607,000 of "Low Priority" projects. Additionally, the Basin Plan recommends gathering more information in various studies estimated to cost $224,000.

ES.4.1 Recommended Actions

The Clear/Clarks Creek Basin Plan contains 65 capital improvement projects, 12 programmatic measures, and four studies to remedy flooding, erosion, water quality, and stream habitat problems resulting from surface water runoff in the Basin.

Table ES-1 Estimated Costs of Plan Recommendations

Project Type	*High Priority*	*Medium-Priority*	*Low-Priority*
Capital Improvement Projects	$30,474,000	$27,591,000	$4,585,000
Programmatic Measures	$2,716,000	$21,000	$22,000
Studies	$224,000		
Total Estimated Cost	**$65,595,000**		

Capital improvement projects and programmatic measures have been divided into "High-Priority," "Medium-Priority," and "Low-Priority"[1] groups. Priorities were not established for studies. Estimated costs of recommendations by priority group are as follows:

Table ES-2

HIGH-PRIORITY RECOMMENDED PROJECTS			
ID Code	**Project Title**	**Rating Score**	**Estimated Cost**
PRG00-02	Update Stormwater Management Standards (Manual)	380	$6,200 *
PRG00-01	Low-Impact Development	346	27,600 *
PRG00-11	Enhanced Cooperative Arrangements with Cities & Other Jurisdictions	315	38,000 *
PRG00-08	Establish a BMP Manual for Surface Water Maintenance Activities	427	43,600 *
PRG00-09	Invasive Species Management Program	420	43,600 *
PRG00-04	Land Management Program for Flood Hazard Reduction & Storm Drainage Practices Impact Mitigation	389	56,000 *
PRG00-06	Create an Education, Outreach, & Technical Assistance Program	325	212,000 *
PH-IP01	128th Street East Infiltration Pond	346	469,000
PRG00-05	Riparian & Wetland Restoration Program to Restore Flood Storage & Maintain Water Quality	325	692,000 *
PRG00-07	Surface Water Monitoring Program Clear/Clarks Creek Basin Monitoring	244	985,000 * 422,000
CL-RST01	Clear Creek Stream Corridor Restoration	261	Segment 1: 402,000 Segment 2: 402,000 Segment 3: 402,000 TOTAL: 1,207,000
RY-RST01	Rody Creek Stream Corridor Restoration	303	Segment 1: 410,000 Segment 2: 410,000 Segment 3: 410,000 TOTAL: 1,231,000
PRG00-03	Increase Enforcement Inspections	398	1,272,000 *
PH-PL04	144th and 94th Avenue Pipeline	252	1,282,000

[1] "Low-Priority" does not mean "not a priority." "No Priority" actions have already been excluded from this Basin Plan. Rather, "Low-Priority" means the project rated lower than other needs in the Basin. Examples of these include projects with only a single-benefit; the rating system is weighted toward multiple benefits.

HIGH-PRIORITY RECOMMENDED PROJECTS - *continued*			
ID Code	**Project Title**	**Rating Score**	**Estimated Cost**
SW-AC01	Swan Creek at 112th Street Floodplain Storage/Headwaters Preservation	302	Segment 1: 343,000 Segment 2: 442,000 Segment 3: 442,000 TOTAL: 1,306,000
WO-RST01	Woodland Creek Stream Corridor Restoration	265	Segment 1: 490,000 Segment 2: 490,000 Segment 3: 490,000 TOTAL: 1,470,000
CY-RST01	Canyon Creek Stream Corridor Restoration	238	Segment 1: 472,000 Segment 2: 472,000 Segment 3: 472,000 Segment 4: 472,000 Segment 5: 472,000 Segment 6: 472,000 TOTAL: 2,834,000
CK-RST01	Clarks Creek Stream Corridor Restoration	231	Segment 1: 470,000 Segment 2: 470,000 Segment 3: 470,000 Segment 4: 470,000 Segment 5: 470,000 Segment 6: 470,000 Segment 7: 470,000 TOTAL: 3,287,000
RD-DP01	Portland Avenue Regional Detention Facility, Roosevelt Ditch Area	276	3,884,000
CL-AC01	Clear Creek Floodplain Repetitive Loss Land Acquisition	345	6,455,000
SW-DP01	Swan Creek Regional Detention Facility	259	6,455,000
	Total Estimated Cost		**$33,152,200**

* indicates the Clear/Clarks Creek Basin share (21.2%) of the estimated cost of a program of County-wide applicability

Table ES-3

MEDIUM-PRIORITY RECOMMENDED PROJECTS			
ID Code	Project Title	Rating Score	Estimated Cost
PRG00-12	Stormwater Facility Design Process	206	21,200 *
SW-SBS03	Swan Creek 64th Street East Culvert Outfall Repair .	152	24,000
RD-SWL01	20th Avenue East Drainage Swale, Roosevelt Ditch	214	29,000
CL-SBS03	Clear Creek Streambank Stabilization in vicinity of 49th Street	194	35,000
CL-SBS04	Clear Creek Streambank Stabilization on West Fork Clear Creek Downstream of 64th Street E	194	35,000
DU-SBS01	Diru Creek Streambank Stabilization at 72nd St East	164	35,000
RY-SBS01	Rody Creek Streambank Stabilization at 72nd Street East	155	35,000
CL-CR01	Clear Creek 88th Street E Culvert Replacement	161	53,000
CL-VC01	Clear Creek at 104th Street E Vegetation Control	203	54,000
RY-SBS02	Rody Creek Streambank Stabilization at 80th Street East	160	66,000
CK-SP01	Clarks Creek State Hatchery Sedimentation Basin Retrofit	174	73,000
CL-SBS05	Clear Creek Streambank Stabilization 5000 block of Vickery Avenue East	153	92,000
SW-SBS01	Swan Creek Streambank/Channel Stabilization at 72nd Street E Outfall	157	100,000
SQ-VC01	Squally Creek at Pioneer Way E Vegetation Control	165	150,000
CL-SBS02	Clear Creek Streambank Stabilization on East Fork Downstream of 72nd Street E	194	161,000
CY-SBS03	Canyon Creek Streambank Stabilization on Reach Upstream of Second Canyon Road Crossing	163	161,000
CY-SBS01	Canyon Creek Streambank Stabilization on Reach Downstream of 80th Street East	158	161,000
CY-SBS02	Canyon Creek Streambank Stabilization on Reach Downstream of 72nd Street East	153	161,000
CK-PL01	112th Street East Drainage Improvement (Woodland Elementary School)	133	180,000

MEDIUM-PRIORITY RECOMMENDED PROJECTS - *continued*

ID Code	Project Title	Rating Score	Estimated Cost
CL-SBS01	Clear Creek Streambank Stabilization on West Fork Downstream of 72nd Street E	194	187,000
CK-AC01	Clarks Creek Property Acquisition at 104th Street East	168	188,000
SW-SBS02	Swan Creek Streambank/Channel Stabilization from 72nd Street E to 64th St E	203	283,000
WO-SBS01	Woodland Creek Streambank/Channel Stabilization at 84th Street East	150	305,000
CY-SBS04	Canyon Creek Streambank Stabilization Downstream of Second Canyon Road Crossing	163	322,000
WO-SBS02	Woodland Creek Streambank Stabilization at 80th Street E	142	357,000
PH-PL05	Springfield Pothole Pipeline	124	379,000
CK-PL02	Fruitland Avenue Drainage Improvement - 104th Street E to 96th Street E, Clarks Creek	164	399,000
PH-PL03	136th Street Pipeline, 135th Street Pothole	190	509,000
CY-SL01	Canyon Creek 58th Avenue East Setback Levee	165	552,000
SW-SBS04	Swan Creek Streambank Stabilization Downstream of 64th Street East	222	Segment 1: 380,000 Segment 2: 380,000 Segment 3: 380,000 TOTAL: 1,140,000
DU-RST01	Diru Creek Stream Corridor Restoration Downstream of Pioneer Way East	226	Segment 1: 410,000 Segment 2: 410,000 Segment 3: 410,000 TOTAL: 1,231,000
RY-DP01	Rody Creek Regional Detention Facility Expansion	123	1,313,000
CY-DP02	Canyon Creek 90th Street East Detention (D138-003)	184	1,586,000
PH-PL06	South Hill Pump Station Pipeline to Puyallup River	181	2,466,000
WO-DP01	Woodland Avenue Flood Control Phase II CIP	155	2,960,000
CL-DP01	West Fork Clear Creek Regional Detention	163	3,021,000
CY-DP01	Canyon Creek Regional Detention	174	3,930,000
CL-DP02	East Fork Clear Creek Regional Detention	163	4,858,000
	Total Estimated Cost		**$27,612,200**

***** indicates the Clear/Clarks Creek Basin share (21.2%) of the estimated cost of a program of County-wide applicability

Table 9.4

LOW-PRIORITY RECOMMENDED PROJECTS			
ID Code	Project Title	Rating Score	Estimated Cost
RY-SWL01	62nd Avenue East Drainage Swale, Rody Creek	32	17,000
RY-CR01	Rody Creek at Pipeline Road & 96th Street East Culvert Replacement	65	19,000
PRG00-10	Flood Disclosure Statements on Property Titles	128	22,400 *
WO-CR02	Woodland Creek at 80th Street East Culvert Replacement	88	27,000
RY-CR02	Rody Creek at 98th Street East Culvert Replacement	89	31,000
PH-PL01	92nd Ave East Storm Drainage Pipeline, Black Swamp Pothole	115	34,000
SW-PL01	84th Street East Pipeline Storm Drain Replacement, Swan Creek	99	74,000
RY-RD01	90th Street East at Rody Creek Raise Roadway	84	75,000
CY-FP01	Canyon Creek Driveway Culvert Replacement	108	89,000
WO-CR01	Woodland Creek & 72nd Avenue East Culvert Replacement - 93rd Street East to 96th Street East	105	102,000
SW-CR01	Swan Creek 80th Street E Culvert Replacement	82	110,000
CY-RD02	104th Street East Road Raising & Culvert Replacement - East Fork of Canyon Creek	99	113,000
CY-RD01	116th Street East Road Raising - West Fork of Canyon Creek	97	137,000
CY-AC01	Canyon Creek Property Acquisition at 5600 block of 104th Street E	73	204,000
PH-PL02	156th Street East Regional Pipeline	120	288,000
RY-DIV01	85th Street East Diversion, Rody Creek	120	288,000
DU-DP01	Diru Creek Regional Detention	105	2,977,000
	Total Estimated Cost		$4,607,400

* indicates the Clear/Clarks Creek Basin share of the estimated cost of a program of County-wide applicability

ES.4.2 Programmatic Recommendations

Most of the recommended programs apply county-wide. Cost estimates for implementing the programs in the Clear/Clarks Creek Basin have been calculated based on a 21.2% share of the county-wide costs over ten years. A period of ten years was chosen for estimating costs although many programs are expected to continue indefinitely. *Table ES-4* presents the programmatic recommendations. Estimated costs with an asterisk denote the Clear/Clarks Creek Basin share of estimated countywide costs for the program.

ES.4.2 Capital Improvement Project Recommendations

Tables ES-2, ES-3, and ES-4 summarize the recommended Capital Improvement Projects (CIP). Descriptions of each CIP are provided in Chapter 9, Basin Plan.

TABLE ES-5

Recommended CIP Projects for Clear/Clarks Creek Basin By Project Type

Subbasin	Acquisition	Streambank/Channel Stabilization	Culvert Replacement	Detention Pond	Diversion	Infiltration Pond	Fish Passage	Raise Roadway	Pipeline	Setback Levee	Sedimentation Pond	Stream Corridor Restoration	Swale	Vegetation Control	Total Number of Projects	Est. Cost
Swan Creek	1	3	2	1					1						8	$ 10,086,000
Squally Creek														1	1	$ 150,000
Clear Creek	1	5	1	2								1		1	11	$ 16,158,000
Canyon Creek	1	4		2			1	2		1		1			12	$ 10,250,000
Rody Creek		2	2	1				1				1	1		8	$ 2,787,000
Diru Creek		1		1								1			3	$ 4,243,000
Woodland Crk		2	2	1								1			6	$ 5,221,000
Clarks Creek	1								2		1	1			5	$ 4,127,000
Potholes						1			6						7	$ 5,427,000
Roosevelt Ditch				1	1			1					1		4	$ 4,276,000
Basin Total	**4**	**17**	**7**	**9**	**1**	**1**	**1**	**4**	**9**	**1**	**1**	**6**	**2**	**2**	**65**	$ 65,595,000

Table ES-6

CIP Solutions to Problems Cross-Reference		
RECOMMENDED CAPITAL IMPROVEMENTS		PROBLEMS ADDRESSED
HIGH-PRIORITY		
PH-IP01	128th Street East Infiltration Pond	PH-1 (Flooding, also Water Quality – instream flows)
CL-RST01	Clear Creek Stream Corridor Restoration	CL-1 (Flooding), CL-16 (Water Quality)
RY-RST01	Rody Creek Stream Corridor Restoration	RY-16 (Habitat), RY-19 (Water Quality)
PH-PL04	144th and 94th Avenue Pipeline	PH-14 (Flooding), PH-15 (Flooding), PH-18 (Flooding)
SW-AC01	Swan Creek at 112th Street Floodplain Storage/Headwaters Preservation	SW-5 (Flooding), SW-10(Flooding), SW-27 (Water Quality-Instream Flow), SW-30 (Flooding)
WO-RST01	Woodland Creek Stream Corridor Restoration	WO-23 (Water Quality, Habitat), WO-29 (Habitat), WO-30 (Habitat), WO-31 (Water Quality)
CY-RST01	Canyon Creek Stream Corridor Restoration	CY-25 (Water Quality, Habitat), CY-26 (Habitat)
CK-RST01	Clarks Creek Stream Corridor Restoration	CK-1 (Flooding), CK-12 (Water Quality), CK-13 (Water Quality, Habitat), CK-14 (Water Quality, Habitat), CK-16 (Flooding), CK-21 (Water Quality)
RD-DP01	Portland Avenue Regional Detention Facility, Roosevelt Ditch Area	RD-7 (Flooding)
CL-AC01	Clear Creek Floodplain Repetitive Loss Land Acquisition	CL-1 (Flooding)
SW-DP01	Swan Creek Regional Detention Facility	SW-3 (Habitat), SW-4 (Flooding), SW-6 (Flooding), SW-21 (Water Quality, Habitat), SW-22 (Water Quality, Habitat), SW-23 (Water Quality, Habitat), SW-30 (Flooding), SW-35 (Water Quality, Habitat), SW-36 (Water Quality), SW-37 (Water Quality)

MEDIUM-PRIORITY		
SW-SBS03	Swan Creek 64th Street East Culvert Outfall Repair	SW-21 (Water Quality, Habitat), SW-23 (Water Quality, Habitat),
RD-SWL01	20th Avenue East Drainage Swale, Roosevelt D	RY-5 (Flooding), RY-6 (Flooding)
CL-SBS03	Clear Creek Streambank Stabilization in vicinity of 49th Street	CL-17 (Habitat, Water Quality), CL-21 (Habitat, Landslide)
CL-SBS04	Clear Creek Streambank Stabilization on West Fork Clear Creek Downstream of 64th Street E	CL-17 (Habitat, Water Quality), CL-22 (Habitat, Water Quality)
DU-SBS01	Diru Creek Streambank Stabilization at 72nd St East	DU-11 (Landslide, Habitat, Water Quality)
RY-SBS01	Rody Creek Streambank Stabilization at 72nd Street East	RY-14 (Habitat, Water Quality)
CL-CR01	Clear Creek 88th Street E Culvert Replacement	CL-5 (Flooding)
CL-VC01	Clear Creek at 104th Street E Vegetation Control	CL-4 (Flooding, Water Quality)
RY-SBS02	Rody Creek Streambank Stabilization at 80th Street East	RY-3 (Water Quality, Habitat)
CK-SP01	Clarks Creek State Hatchery Sedimentation Basin Retrofit	CK-14 (Habitat, Water Quality), CK-15 (Habitat, Water Quality)
CL-SBS05	Clear Creek Streambank Stabilization 5000 block of Vickery Avenue East	CL-33 (Habitat, Water Quality)
SW-SBS01	Swan Creek Streambank/Channel Stabilization at 72nd Street E Outfall	SW-3 (Habitat, Water Quality), SW-21 (Habitat, Water Quality), SW-35 (Habitat)
SQ-VC01	Squally Creek at Pioneer Way E Vegetation Control	SQ-4 (Habitat, Water Quality), SQ-6 (Flooding, Habitat, Water Quality)
CL-SBS02	Clear Creek Streambank Stabilization on East Fork Downstream of 72nd Street E	CL-17 (Habitat, Water Quality), CL-20 (Habitat, Water Quality)
CY-SBS03	Canyon Creek Streambank Stabilization on Reach Upstream of Second Canyon Road Crossing	CY-20 (Habitat, Water Quality), CY-23 (Habitat, Water Quality)
CY-SBS01	Canyon Creek Streambank Stabilization on Reach Downstream of 80th Street East	CY-18 (Habitat, Water Quality), CY-23 (Habitat, Water Quality)
CY-SBS02	Canyon Creek Streambank Stabilization on Reach Downstream of 72nd Street East	CY-22 (Habitat, Water Quality), CY-23 (Habitat, Water Quality)
CK-PL01	112th Street East Drainage Improvement (Woodland Elementary School)	CK-9 (Flooding)
CL-SBS01	Clear Creek Streambank Stabilization on West Fork Downstream of 72nd Street E	CL-17 (Habitat, Water Quality), CL-10 (Habitat, Water Quality)
CK-AC01	Clarks Creek Property Acquisition at 104th Street East	CK-2 (Flooding)
SW-SBS02	Swan Creek Streambank/Channel Stabilization from 72nd Street E to 64th St E	SW-4 (Habitat, Water Quality), SW-21 (Habitat, Water Quality)
WO-SBS01	Woodland Creek Streambank/Channel Stabilization at 84th Street East	WO-24 (Habitat, Water Quality), WO-25 (Habitat, Water Quality), WO-26 (Habitat, Water Quality)

MEDIUM-PRIORITY - *continued*		
CY-SBS04	Canyon Creek Streambank Stabilization Downstream of Second Canyon Road Crossing	CY-21 (Habitat, Water Quality), CY-23 (Habitat, Water Quality),
WO-SBS02	Woodland Creek Streambank Stabilization at 80th Street E	WO-26 (Habitat, Water Quality), WO-27 (Habitat, Water Quality),
PH-PL05	Springfield Pothole Pipeline	PH-7 (Flooding)
CK-PL02	Fruitland Avenue Drainage Improvement - 104th Street E to 96th Street E, Clarks Creek	CK-10 (Flooding)
PH-PL03	136th Street Pipeline, 135th Street Pothole	PH-3 & PH-4 (Flooding)
CY-SL01	Canyon Creek 58th Avenue East Setback Levee	CY-1 (Flooding), CY-5 (Flooding), CY-6 (Flooding)
SW-SBS04	Swan Creek Streambank Stabilization Downstream of 64th Street East	SW-21 (Habitat, Water Quality), SW-24 (Habitat, Water Quality), SW-35 (Habitat, Water Quality)
DU-RST01	Diru Creek Stream Corridor Restoration Downstream of Pioneer Way East	DU-9 (Water Quality), DU-10 (Water Quality, Habitat)
RY-DP01	Rody Creek Regional Detention Facility Expansion	RY-14 (Water Quality, Habitat)
CY-DP02	Canyon Creek 90th Street East Detention (D138-003)	CY-1 (Flooding), CY-6 (Flooding), CY-18 (Habitat, Water Quality)
PH-PL06	South Hill Pump Station Pipeline to Puyallup River	PH-23 (Flooding)
WO-DP01	Woodland Avenue Flood Control Phase II	WO-1 (Flooding), WO-2 (Flooding), WO-5 (Flooding), WO-24 (Habitat, Water Quality, WO-25 (Habitat, Water Quality), WO-26 (Habitat, Water Quality)
CL-DP01	West Fork Clear Creek Regional Detention	CL-5 (Flooding), CL-17 (Habitat, Water Quality, Flooding), CL-19 (Habitat, Water Quality), CL-21 (Habitat, Water Quality), CL-22 (Habitat, Water Quality)
CY-DP01	Canyon Creek Regional Detention	CY-1 (Flooding), CY-6 (Flooding), CY-18 (Habitat, Water Quality)
CL-DP02	East Fork Clear Creek Regional Detention	CL-17 (Habitat, Water Quality, Flooding), CL-20 (Habitat, Water Quality), CL-21 (Habitat, Water Quality), CL-22 (Habitat, Water Quality)

LOW-PRIORITY		
RY-SWL01	62nd Avenue East Drainage Swale, Rody Creek	RY-5 (Flooding), RY-6 (Flooding)
RY-CR01	Rody Creek at Pipeline Road & 96th Street East Culvert Replacement	RY-7 (Flooding)
WO-CR02	Woodland Creek at 80th Street East Culvert Replacement	WO-8 (Flooding, Habitat)
RY-CR02	Rody Creek at 98th Street East Culvert Replacement	RY-8 (Flooding)
PH-PL01	92nd Ave East Storm Drainage Pipeline, Black Swamp Pothole	PH-6 (Flooding)
SW-PL01	84th Street East Pipeline Storm Drain Replacement, Swan Creek	SW-16 (Flooding)
RY-RD01	90th Street East at Rody Creek Raise Roadway	RY-17 (Flooding)
CY-FP01	Canyon Creek Driveway Culvert Replacement at Pioneer Way East	CY-28 (Habitat)
WO-CR01	Woodland Creek & 72nd Avenue East Culvert Replacement - 93rd Street East to 96th Street East	WO-6 (Flooding)
SW-CR01	Swan Creek 80th Street E Culvert Replacement	SW-1 (Flooding, Habitat)
CY-RD02	104th Street East Road Raising & Culvert Replacement - East Fork of Canyon Creek	CY-10 (Flooding)
CY-RD01	116th Street East Road Raising - West Fork of Canyon Creek	CY-3 (Flooding)
CY-AC01	Canyon Creek Property Acquisition at 5600 block of 104th Street E	CY-30 (Flooding)
PH-PL02	156th Street East Regional Pipeline	PH-15 (Flooding)
DU-DP01	Diru Creek Regional Detention	DU-9 (Habitat, Water Quality

ES.4.3 Implementation Strategy

Implementation of the recommended actions will generally follow the prioritization groupings of high, medium, and low and a logical order of sequencing.

To ensure that the full benefits of all projects are realized, implementation will not follow the exact sequence of the first project to the last project in the High category, followed by the first action in the Medium category, and so forth.

Several factors exist that will result in implementation of actions that are not in the exact sequence as depicted in the projects and programs prioritized by the benefit and ranked by cost table. These factors include the following:

- Available funds
- Contingent projects[2]
- Available staff and professional service needs
- Cooperation from private landowners
- The best implementer may be an agency other than Pierce County Public Works and Utilities
- New information, regulations or emerging issues
- Coordination with other agencies and/or jurisdictions

Economic Development Criteria

Implementing projects and programs recommended in the Basin Plan is expected to reduce flood hazards, and preserve or protect water quality and floodplain habitat. Collectively and individually, these projects are aimed at protecting Pierce County's quality of life. Projects and programs in the Basin Plan will:

- Afford resource protection as the community develops
- Preserve, enhance or protect natural floodplain functions
- Balance structural and nonstructural approaches
- Reduce potential County environmental liabilities
- Help achieve environmental compliance and long term sustainability

Collectively, these attributes help make Pierce County a livable community where quality of life and natural amenities and functions offer economic incentives to businesses and individuals to locate or stay in the County.

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[2] Contingent projects include projects such as stream restoration projects intended to reduce flood hazards and improve aquatic habitat, and culvert replacement projects intended to improve fish passage. These projects will provide their full benefit after all downstream fish passage barriers are removed, and should be sequenced accordingly.

In addition to the preceding factors, Water Programs will consider the following criteria in developing its annual proposed capital facilities plan updates:

- Is the project located in an employment center zone (or handle flow from those zones)?
- Is the project located in another type of commercial zone (or handle flow from those zones)?
- Will the project reduce permitting timelines for industrial/commercial projects?
- Will the project assure access to an employment center via road and /or rail?
- Will the project increase the supply of developable property?
- Will the project reduce overall development costs?
- Are there partners willing to contribute to the development costs of the project?
- Does the project allow / provide for land development?

In light of these and other factors, following action on the Basin Plan, Pierce County will develop an implementation strategy designed to sequence, schedule, and assign resources for the various recommended actions. This implementation strategy will be developed in collaboration and coordination with other potential implementers and in consideration of available financial and staff resources. The implementation strategy will include performance measurements and provide for periodic evaluation of progress.

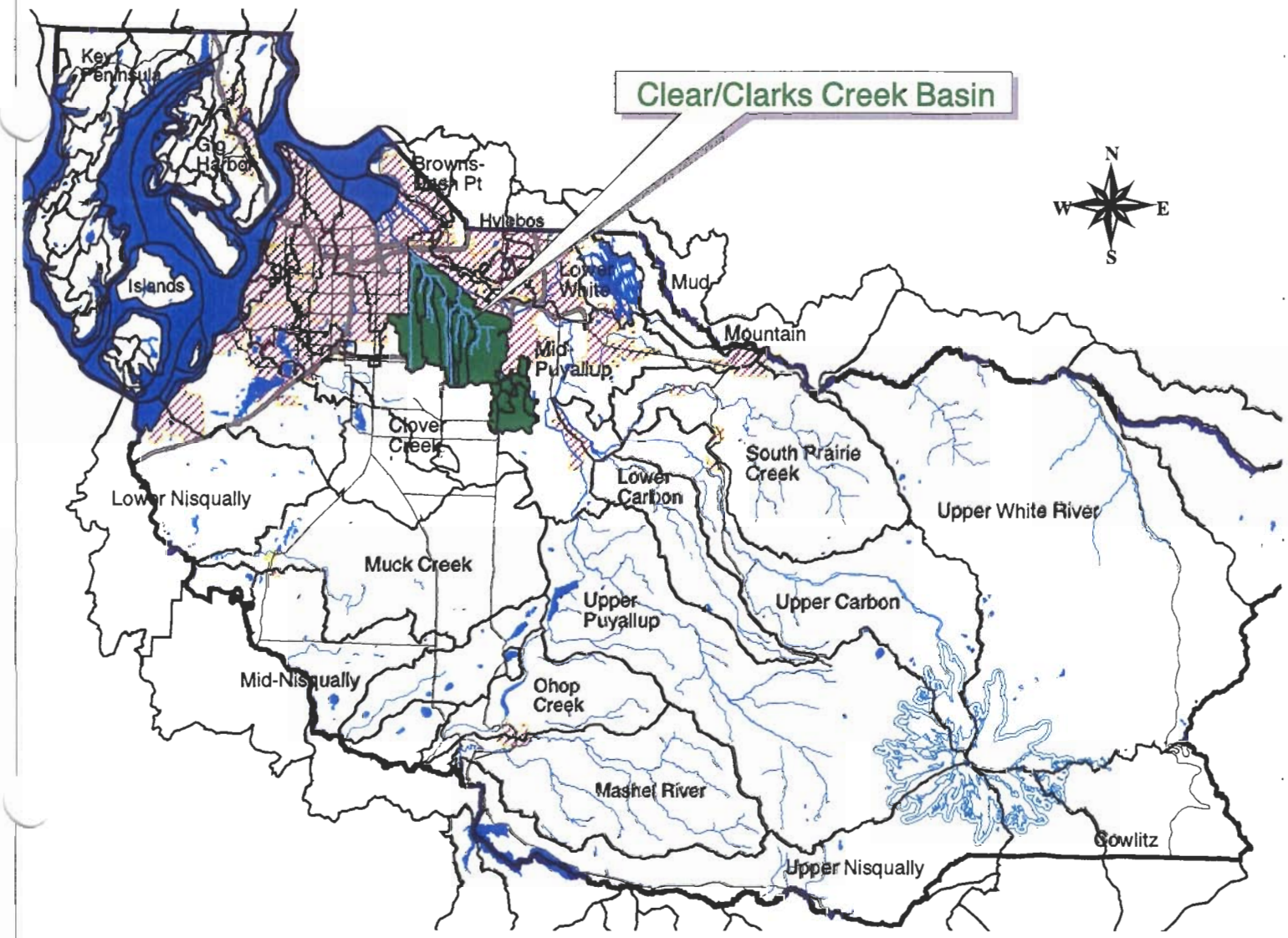
CHAPTER ONE
Introduction

Pierce County Public Works and Utilities - Water Programs Division (Water Programs), is responsible for surface water management in unincorporated Pierce County. In carrying out this responsibility, Water Programs plans, designs, secures permits for, builds and maintains storm drainage and surface water management facilities. Water Programs also identifies non-structural solutions to surface water problems such as monitoring needs, enforcement, regulatory changes, or services. As one agency of Pierce County government, Water Programs advises and works with other agencies, other jurisdictions, and with private interests to ensure that storm drainage and surface water issues are dealt with by appropriate parties as close as possible to the source of the problem. Related responsibilities include compliance with the stormwater quality requirements of the federal Clean Water Act, the County's Stormwater National Pollution Discharge Elimination System (NPDES) Permit, and the habitat protection requirements of the federal Endangered Species Act. Other related responsibilities consist of river levee maintenance, stream gauging, water quality monitoring, gathering of rainfall data, emergency response during floods, water supply planning and public information. Fees paid by property owners in unincorporated Pierce County and grant funds pay for these facilities and services.

1.1 Basin Planning Program

Water Programs is preparing a series of basin plans to identify and prioritize facilities improvements projects and other Water Program activities in individual drainage basins. Basin plans comprehensively tackle flooding, water quality and habitat aspects of surface water management in the major stream systems of the non-federal lands within the County. The basin plans will update the county-wide Pierce County Storm Drainage and Surface Water Management Plan (Montgomery Engineers Inc., 1991)(a.k.a., 1991 Update) by identifying and addressing the flooding, water quality and stream habitat problems in a particular drainage basin in more detail than was possible in 1991. They incorporate the requirements of major federal, State and Pierce County laws, regulations and policies enacted since the 1991 Plan, such as the State Growth Management Act, NPDES requirements of the federal Clean Water Act, and the fish listings under the federal Endangered Species Act (ESA). The basin plans will be implemented primarily through Water Programs activities. However, Water Programs will share information from basin plans to convey issues and needs that might most effectively be dealt with by other agencies and jurisdictions.

Figure 1-1 shows the location of the Clear/Clarks Creek Basin relative to the other 25 drainage basins in the County. The Clover Creek Basin, Mid-Puyallup Basin and Hylebos Basin lie adjacent to the Clear/Clarks Creek Basin. Of these basins, basins plans have been prepared for the Muck Creek Basin, Clover Creek Basin, Gig Harbor Basin and Mid-Puyallup Basin. Other basin plans will follow.



Legend

- Drainage Basin Boundaries
- Clear/Clarks Creek Basin
- Arterials*
  - Limited Access
  - Principle Road
- Streams in Clear/Clarks Creek Basin
- Water Features
- Cities in Pierce County*

Figure 1-1. Clear/Clarks Creek Basin & Vicinity

Pierce County
Public Works & Utilities
Water Programs · Geographic Information Services

Basin plans identify existing conditions that affect storm drainage and surface water, forecast future drainage conditions, identify potential solutions, and evaluate alternatives to the degree that they achieve objectives or create probable significant environmental impacts.

The basin plans concentrate on remedies for frequently flooded areas, water quality problems, fish and wildlife habitat protection, and other surface water management concerns in the unincorporated parts of Pierce County. Drainage facilities within cities and towns, national forests, parks, and military bases are not within the scope of basin plans unless they affect drainage conditions in unincorporated areas.

Basin plans are used to develop capital improvement, maintenance and repair, property acquisition, and program schedules and budgets. The planning process is divided into three phases:

Phase 1 is the basin characterization phase. It consists of inventorying and documenting existing conditions, such as flooding, water quality and habitat problems; existing storm drainage and surface water management facilities; regulatory environment; existing and future land use; stream flow characteristics; stream reaches and associated wetlands; other critical areas; the creek's ability to support various fish species; and the fish species present.

Phase 2 is the plan development and adoption phase. It builds on the findings of Phase 1 by correcting information, performing hydrologic and hydraulic analyses based on planned future conditions, filling information gaps, investigating problems, identifying solutions, and recommending solutions. This document is the culmination of Phase 2.

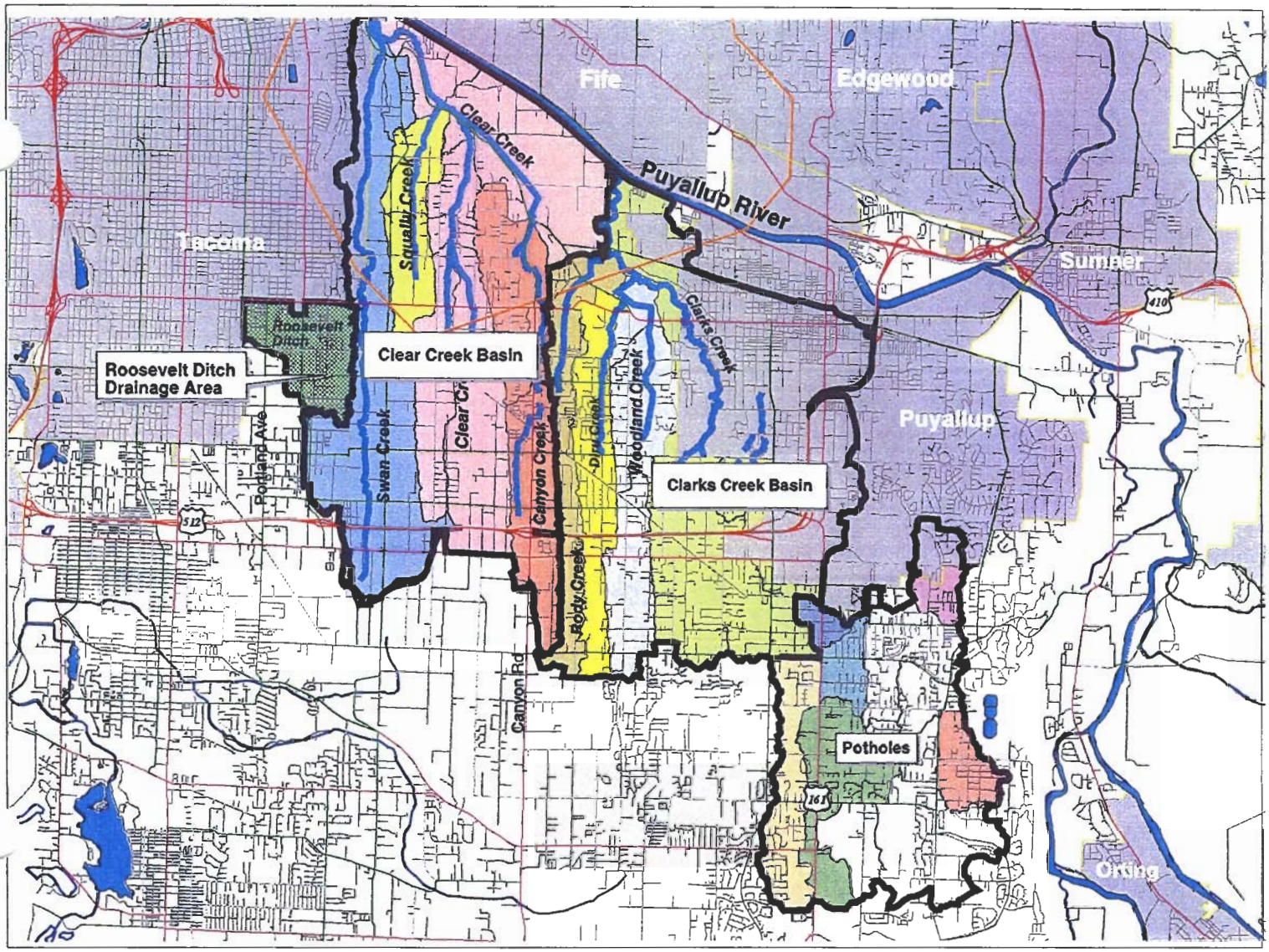
Phase 3 is the implementation, monitoring and plan update phase.

1.2 Clear/Clarks Creek Basin Plan

The Clear/Clarks Creek Basin Plan is the storm drainage and surface water management plan specific to the Clear/Clarks Creek Basin. It presents the results of the Clear/Clarks Creek Basin planning process. The Basin Plan includes an updated Characterization Report from Phase 1, as chapters one through five. Added are chapters six, seven, and eight, which document the analysis of problems, such as the results of hydrologic and hydraulic modeling used to estimate the amount of stormwater and stormwater volume peaks where flooding or other problems occur. Chapter Nine recommends capital improvement projects and programmatic solutions (non-structural measures, such as recommendations to amend certain regulations) to solve existing and projected future stormwater problems.

1.2.1 Study Area

The Clear/Clarks Creek Basin drains approximately 32.9 square miles (21,038 acres) of north-central Pierce County, of which 27.4 square miles (83 percent) exist within unincorporated Pierce County. The remaining 5.5 square miles (17 percent) lie in the cities of Tacoma and Puyallup.



LEGEND

- Clear/Clarks Creek Basin Boundary
- 117TH AVE POT HOLE
- 128TH ST POT HOLE
- 135TH ST POT HOLE
- 144TH ST POT HOLE
- ALDERWOOD POT HOLE
- CANDLEWOOD-MANORWOOD POT HOLE
- CANYON CREEK
- CAPITAL POT HOLE
- CLARKS CREEK
- CLEAR CREEK
- DIRU CREEK
- HEMLOCK
- RODY CREEK
- SQUALLY CREEK
- SWAN CREEK
- WOODLAND CREEK
- Streams
- Water Features

Arterials*
- Limited Access
- Principle Road
- Major Road
- Collector Road

- Puyallup Tribe 1863 Survey Area

Cities in Pierce County*

N
W E
S

Figure 1.2 Study Area

Clear/Clarks Creek Basin Plan

Pierce County
Public Works & Utilities
Water Programs

The Clear/Clarks Creek Basin is part of Washington State Water Resource Inventory Area (WRIA) 10, the Puyallup-White River Basin. The Basin is an amalgamation of four contiguous drainage basins, knit together for cost-efficiency and in consideration of interconnecting drainage improvements. The four basins are as follows:

- **Roosevelt Ditch Drainage Area**, areas draining to Roosevelt Ditch
- **Clear Creek Drainage Basin**, areas draining to Clear Creek
- **Clarks Creek Drainage Basin**, areas draining to Clarks Creek
- **Potholes Drainage Area,** areas draining to the potholes on South Hill

Clear and Clarks Creeks generally flow north before discharging into the Puyallup River at points east of the City of Tacoma. Clear Creek drains the western portion of the Basin. Clarks Creek drains the eastern portion of the Basin, including a portion of the City of Puyallup. The major tributaries to Clear Creek include Swan Creek, Squally Creek, and Canyon Creek. The major tributaries to Clarks Creek include Rody Creek, Meeker Ditch, Diru Creek, and Woodland Creek. The Clear/Clarks Creek Basin also includes the Pothole area, an 8.3-square-mile originally internally drained area on South Hill.

Roosevelt Ditch Drainage	
Clear Creek Basin	Swan Creek Squally Creek Clear Creek Canyon Creek
Clarks Creek Basin	Rody Creek Diru Creek Woodland Creek Clarks Creek
Potholes	• Afdem • Black Swamp • Capital • Heritage Glen • 128th Street • Meridian Street • 135th Street • 117th Street • Candlewood-Manorwood • Tip Top • Lower 144th Street • Alderwood • Upper 144th Street • Springfield • South Central • 110th Avenue

1.2.2 Description of Subbasins

Subbasins are the planning units of the basin plans. They are derived by dividing the stream basin into subbasins, then further dividing the subbasins into smaller and more manageable subbasins, generally on the basis of stream reaches. The division is one of the first steps in the basin planning process. Although for this study the "Basin" is referred to as the Clear/Clarks Creek Basin, for planning purposes it includes the two creek drainage basins, the potholes area of South Hill, and the Roosevelt Ditch drainage area. These drainages constitute the major subbasins of the planning area.

First, each basin in the Clear/Clarks Creek Basin was divided into subbasins:

- Clear Creek Basin was divided into four subbasins: Swan Creek, Squally Creek, Clear Creek, and Canyon Creek.
- Clarks Creek Basin was divided into four subbasins: Rody Creek (sometimes referred to as "unnamed tributary to Clarks Creek"), Diru Creek, Woodland Creek, and Clarks Creek.
- Pothole Basin was divided into 16 named subbasins; each one a separate "pothole" area.
- Next, each of the eight stream subbasins of Clear Creek and Clarks Creeks were divided into 31 smaller, more manageable, planning units based on stream reaches as described in Section 4.7, Aquatic and Riparian Habitat.

Some of the Pothole subbasin boundaries and names were based on information from the South Hill Drainage Improvements Report (Pierce County, 2001). The overall Clear/Clarks Creek Basin boundary (including the Pothole areas) delineation came from Pierce County and was not modified as part of this study.

1.2.3 Key Elements of the Basin Plan

Key elements addressed in the Clear/Clarks Creek Basin Plan are:

Existing Conditions

- Characterization of topography, soils, current and future flow volumes, water quality, habitat and land cover factors influencing surface water runoff

Problems

- Flooding due to surface water and/or groundwater
- Surface water quality impairment related to stormwater runoff
- Stream and riparian habitat degradation due to stormwater

Impacts

- Loss of beneficial uses (recreation, water supply, habitat, and drinking water, etc.)
- Negative effects of stormwater runoff on the ability to meet federal, State and local regulations
- Property damage from flooding, inadequate drainage or high groundwater
- Threats to public health and safety (road inundation, impaired surface water quality and drinking water quality, etc.)

Solutions

- Capital projects (e.g., flood control facilities, creek and watershed restoration, etc., related to storm drainage)
- Direct or indirect control of land use impacts (e.g., zoning, buffers, and stormwater facility design standards, etc.)
- Basin-specific development standards (e.g., discharge rates and volume control)
- Storm drainage system maintenance activities
- Additional research or on-going monitoring
- Others as appropriate

1.3 Statement of Purpose

The purpose of the Clear/Clarks Creek Basin Plan is to establish the actions Pierce County will take and what is needed to reduce flood hazards and other storm drainage problems, protect water quality, and to protect fish and wildlife habitat in the Clear/Clarks Creek drainage basin. Recommended actions reflect the physical characteristics of the Basin; the laws, policies and regulations that apply to surface water management in Pierce County; the preferences of citizens in the County and in the Clear/Clarks Creek Basin; and the character of existing land use and planned growth as set out in the Comprehensive Plan for Pierce County, Washington.

1.4 Goals and Objectives

Water Programs drew up general goals and objectives for basin plans as presented in *Table 1-1* to promote consistency between basin plans. The goals and objectives form the base evaluation criteria for selection of recommended facilities, policies, and surface water management program modifications from among the various alternatives. They also permit the facilities recommended by basin plans to be compared and ranked with one another.

TABLE 1-1
Goals of the Clear/Clarks Creek Basin Plan

Goal	Objectives
Reduce flood hazards	Incidents of property loss and repeat damage are reduced. Streams will not be adversely impacted by flood events. Pierce County standing under the Federal Emergency Management Agency Community Rating System is improved. New development is located outside of flood-prone area.
Improve fish & wildlife habitat	Number of stream miles available for wild, native fish populations is increased. Population numbers of species listed as endangered or threatened under the Federal Endangered Species Act (ESA) are maintained or increased. Quality and quantity of available wetland, riparian, and upland habitat is improved.
Improve water quality	State Surface Water Quality Standards (WAC 173-201a) are met or exceeded. Number of impaired (303d listed) waterbodies is reduced. Pierce County is in compliance with its NPDES permit for stormwater by meeting permit terms and conditions to the maximum extent practicable. Risk of groundwater contamination is reduced. Rates of erosion are reduced.
Demonstrate coordinated & responsible use of public resources	Cost of maintaining stormwater facilities is reduced. Project value is favorable when measured against costs and benefits. Polls demonstrate that public awareness of flooding, habitat, and water quality issues has increased. Monitoring and enforcement programs demonstrate an increase in services per dollar spent. Basin plan implementation also implements elements of other Pierce County plans. Other agencies and jurisdictions use basin plan findings in planning their activities.
Influence location & methods for new development	New development in flood-prone, riparian, or significant habitat areas is prohibited. Low Impact Development techniques are widely used. Effective BMPs are identified and widely used.

Sources: Guidance for Basin Planning, Pierce County Water Programs, June 2000., Pierce County Public Works & Utilities, Water Programs; Pierce County Storm Drainage and Surface Water Management Advisory Board, June 2005

CHAPTER TWO
Applicable Programs, Policies, and Regulations

Numerous federal, State of Washington and local regulations, laws, policies and programs affect how stormwater and surface water are managed in unincorporated Pierce County. This chapter describes those pertinent to the Clear/Clarks Creek Basin with an emphasis on coordination with other programs and consistency with adopted policies and plans. Chapter Two presents federal regulations and programs first followed by those of the State of Washington (State), Pierce County (County), and other agencies respectively.

2.1 Federal Regulations, Policies and Programs

2.1.1 Clean Water Act

National Pollutant Discharge Elimination System (NPDES)

In 1987, amendments to the Federal Clean Water Act (CWA) required the Environmental Protection Agency (EPA) to promulgate regulations for storm water discharges. EPA defined certain stormwater discharges as point source discharges subject to federal regulations under the National Pollutant Discharge Elimination System (NPDES) Permit Program. Two broad areas were created as follows:

1. "Stormwater Discharges Associated with Industrial Activity"
2. "Municipal Separate Storm Sewer Systems" in two phases. Phase I applies to municipalities with populations greater than 100,000 people. Phase II requirements, expected to be implemented by 2006, apply to municipalities with populations of 10,000 people or more and certain urban areas.

EPA delegated responsibility for implementation of the NPDES permit program to the Washington State Department of Ecology (Ecology).

Ecology issued the “Phase I” NPDES permit for the South Puget Sound Water Quality Management Area (which includes Pierce County) in July 1995. It was administratively extended in 2000 pending development of a “Phase II” permit.

The NPDES stormwater permit requires that permit holders control pollutants in stormwater to the maximum extent practicable, primarily by implementing a stormwater management program, a functional component of which is the basin plans. Ecology approved the Pierce County’s Stormwater Management Program in 1998. Required elements include:

- A program to control runoff from new development, redevelopment, and construction sites
- Treatment and source control measures for existing commercial and residential areas
- An operation and maintenance program for new and existing stormwater facilities
- Practices for maintaining public streets and highways to reduce stormwater runoff impacts

- A program to include water quality considerations in flood management projects
- A program to reduce pollutants from pesticide and fertilizer use
- A program to detect, remove, and prevent illicit discharges to the municipal separate storm sewer system
- A program to reduce stormwater pollution from industrial facilities that discharge into the separate storm sewer system. An educational program for residents, businesses, industries, construction contractors, government employees, and others
- A monitoring plan to determine the effectiveness of program activities
- Reporting requirements
- Coordination among jurisdictions sharing water bodies

Effect of the Current Stormwater NPDES Permit on the Clear/Clarks Creek Basin Plan

Recommendations of the basin plan must adhere to the County's Stormwater NPDES Permit requirements cited above and provisions of the Pierce County Stormwater Management Plan. For a description of inter-jurisdictional coordination, see Chapter Three. Chapter Four describes existing water quality conditions. Chapter Six analyzes water quality problems and presents alternative solutions. Chapter Nine contains the recommendations for addressing water quality problems most cost-effectively.

Section 303(d) List and Total Maximum Daily Loads (TMDLs)

Section 303(a, b, and c) of the Clean Water Act requires that states establish standards to protect the quality of the waters of the United States.

Ecology classified all major bodies of water in Washington based on their current or potential beneficial uses and established a set of water quality standards for each class. Section 303(d) of the CWA requires Ecology to prepare a list of waterbodies that are not meeting, or will not meet water quality standards, after application of the required technology-based effluent limits.

Ecology submitted its candidate Section 303(d) list for 1998 to EPA in June 1998. Clear Creek, Clarks Creek, Swan Creek, and Diru Creek were on the list as water bodies that do not meet the standards (for additional information, see Chapter Four, "Existing Conditions, Water Quality").

If a waterbody is not in compliance with standards for a particular pollutant, the CWA requires that a total maximum daily load (TMDL) of the pollutant be calculated. The TMDL is the maximum amount of the pollutant that can be discharged to the waterbody without violating the water quality standard for the pollutant.

Limits for all pollutant sources discharging to the water body are adjusted downward until the TMDL can be met.

Effect of 303(d) listings and TMDLs on the Clear/Clarks Creek Basin Plan

The timing of activities has implications for basin planning. Pierce County's NPDES stormwater permit requires that the stormwater management program be amended to take into account TMDLs within 4 months of their promulgation. If a basin contains a water body that is on the

Section 303(d) list but has not yet had a TMDL calculated, then the basin planning effort should anticipate the TMDL and focus on water quality control measures that address the listed pollutant(s).

A TMDL for fecal coliform bacteria is being developed by the City of Puyallup as part of their Clarks Creek Pollution Reduction project. As of November 2003, monitoring has been completed, but no TMDL has been calculated. Nevertheless, recommendations for the Clarks Creek Basin should contain various measures to minimize the likelihood of fecal coliform in stormwater runoff from County drainage areas.

Capital improvement projects and other control measures recommended for the drainage areas of streams identified in the 1998 303(d) list should be designed with the objective of removing the stream and listed parameter from the 303(d) list.

Section 404 Wetland Fill Permits

Section 404 of the CWA regulates placement of fill in waters of the United States. For the purposes of Section 404, waters of the United States are defined as wetlands adjacent to streams with flow greater than five (5) cubic feet per second and isolated wetlands greater than one acre that are hydraulically connected to regulated streams. Storm drainage projects that involve filling or work in small areas of wetlands may be permitted under one of several nationwide general permits. An individual permit, subject to a broader level of review, must be obtained for projects that that exceed the limits for nationwide permits.

Section 404 is administered by the U.S. Army Corps of Engineers (Corps); the Corps' Seattle District is responsible for issuing Section 404 permits in Pierce County. Because the goal of Section 404 is to avoid any net loss of wetlands, some of the projects identified in Pierce County's 1991 Plan have proven more costly to build than estimated. In general, capital projects that adversely effect wetlands should be avoided.

Effect of Section 404 Regulations on the Clear/Clarks Creek Basin Plan

Wetland protections argue for several basin plan approaches. First, wherever possible wetlands can be acquired to conserve the natural stormwater runoff and flood storage capacities they provide. Second, the cost estimates of future storm drainage facilities should include the costs of compensatory mitigation. Third, basin plans can identify new programs or program revisions designed to protect existing wetlands or create wetlands. Fourth, basin plan recommendations can be prioritized in part upon the extent to which wetland protection and enhancement can be achieved.

2.1.2 Endangered Species Act

The Endangered Species Act (ESA) directs the U.S. Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration (NOAA) Fisheries[1] to promulgate a list of endangered and threatened species and designate critical habitat for the listed species. Listed species with the greatest potential to affect surface water management in Pierce County are the chinook salmon (listed as threatened in March 1999) and the bull trout (listed as threatened in

[1] NOAA Fisheries was previously called the National Marine Fisheries Service (NMFS).

October 1999). NOAA Fisheries has indicated that additional salmonid species may be listed in the next few years. Chinook salmon are found in the Clear/Clarks Creek Basin (see *Section 4.7*).

Section 9 of the ESA prohibits "taking" of endangered species. To "take" means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct". The regulation explains that "harm" may include "significant habitat modification where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering".

If a proposed action is federally funded, or if it requires a permit from a federal agency, and if it could have an effect on a listed species, then Section 7 of the ESA requires the involved federal agency to consult with USFWS or NOAA Fisheries. After consultation, USFWS or NOAA Fisheries issues a biological opinion regarding the effects of the action. If USFWS or NOAA Fisheries finds that the action could jeopardize the continued existence of the species, the action cannot be permitted. If USFWS or NOAA Fisheries finds that the continued existence of the species is not jeopardized, then one of the agencies will issue an "Incidental Take Statement" and allow the action to proceed.

Section 4(d) of the ESA requires USFWS and NOAA Fisheries to adopt regulations as necessary to conserve the species listed as threatened. USFWS typically applies the Section 9 "take" prohibitions directly to threatened species. NOAA Fisheries typically promulgates "4(d) rules" that identify specific activities that can be conducted without constituting an unlawful take of the threatened species.

Pierce County has policies and programs that help to preserve and restore salmon habitat. The County is implementing early actions to preserve and restore salmonid habitat in coordination with King and Snohomish Counties. NOAA Fisheries has approved a set of transportation maintenance procedures that if followed protect transportation maintenance projects from liability under ESA. Other early actions include culvert replacements to improve fish passage and restoration and acquisition of key habitats.

Effect of ESA on the Clear/Clarks Creek Basin Plan

The salmonid listings have a broad effect on storm drainage and surface water management plans. Water quantity and water quality, as crucial features of fish habitat affected by the ways of solving flooding and storm drainage problems, must be addressed to protect listed species. Coordination with the varied agencies working on fish habitat initiatives should be reflected in recommended solutions to prevent overlap or duplication of effort.

2.1.3 National Flood Insurance Program

In 1968, the U.S. Congress initiated the National Flood Insurance Program (NFIP) (Chapter 44 CFR) under the National Flood Insurance Act to relieve the burden of disaster relief on the national treasury and state and local tax bases. The NFIP is administered by the Federal Insurance Administration (FIA), which is part of the Federal Emergency Management Agency (FEMA). The NFIP makes available affordable flood insurance to communities that adopt approved floodplain management regulations. Communities that do not participate in the NFIP do qualify for certain flood disaster relief. FEMA's Flood Insurance Rate Maps (FIRMs) form the basis for critical area zoning for flood hazards.

Pierce County participates in the NFIP. Flood hazard management regulations are codified in Title 17A.50 of the County Code and criteria and procedures are laid out in Chapter Nine of the Pierce County Stormwater Management and Site Development Manual. Federally subsidized flood insurance is available to local residents. To continue coverage, the County must remain in the NFIP and maintain minimum floodplain management regulations. FEMA requires a certification letter for any revisions to a FIRM. Certification activities include stream channel modifications, installation of culverts, and bridge construction.

Community Rating System (CRS)

As a reward for communities willing to do more than meet minimum NFIP requirements by taking actions to minimize flood losses and promote public awareness of flood hazards, FEMA created the Community Rating System (CRS). Community participation in the CRS is voluntary. The CRS offers reduced insurance rates based upon the class rating of a community. The CRS contains ten classes. "Class 1" gives the greatest insurance premium reduction. A "Class 10" community receives no premium reduction. Pierce County was the first county in the nation to earn a "Class 5" rating.

Effect of the NFIP and the CRS on the Clear/Clarks Creek Basin Plan

Basin plans serve as part of the flood hazard mitigation plan for Pierce County. To serve in meeting the prerequisites for a "Class 4" rating, the Clear/Clarks Creek Basin Plan has been developed to meet or exceed the following criteria:

Floodplain Management Planning Elements - CRS Planning Steps

- Organize – Use a steering committee of department staff
- Involve the public – Engage people living and working in floodplains to identify problems, community goals and alternatives that will solve problems
- Coordinate with other local governments in the planning area, state and federal agencies, Indian tribes, and other Pierce County departments and programs
- Assess the hazard(s)
- Assess the problem(s)
- Set goals
- Review possible activities
- Draft an action plan
- Adopt the plan
- Implement the plan, evaluate it periodically, and revise it as needed to keep it current and effective

TABLE 2-1
Federal and State Laws and Regulations and Clear/Clarks Creek Basin Plan

Law or Regulation	Application to the Clear/Clarks Creek Basin
Federal Laws	
Clean Water Act. Section 402 National Pollutant Discharge Elimination System (NPDES)	Pierce County Stormwater NPDES Permit, consistency with coordination requirement,
Clean Water Act. Section 303(d) Total Maximum Daily Load (TMDL) Listing	Must consider ways of reducing stormwater contributions to pollutant loads
Clean Water Act. Section 404 Permit Requirements for Wetland Filling	Pierce County provides direction for basin plans to avoid recommendations that would have negative impacts on wetlands
Endangered Species Act	Consistency between the basin plan & Tri-County Endangered Species Act Response
	Implementation of the Puyallup WRIA Conservation Plan
National Flood Insurance Program	Acknowledgement of the programs initiated with the Consistency with NFIP objectives and CRS standard Pierce County Flood Hazard Management Code
State Laws, Plans & Regulations	
Water Quality Standards	Analyze water quality and develop projects & programs toward maintaining water quality standards and anti-degradation rule
Puget Sound Water Quality Management Plan	Drainage development standards; Stormwater Management Manual; Stormwater Pollution Control Manual
Growth Management Act	Critical areas regulations, consistency between comprehensive plans and capital improvement plans required
State Environmental Policy Act	Environmental review for basin plan and individual projects
Shoreline Management Act	Pierce County Shoreline Master Program (adopted as WAC)
State Hydraulic Code	Hydraulic Project approvals required for in-stream work
Watershed Management Act	N/A
The Non-Point Rule	Lower Puyallup WRIA Watershed Action Plan

Source: Pierce County Water Programs

2.1.4 Settlement Agreement with the Puyallup Tribe

In 1989, the U.S. Congress passed the "Agreement between the Puyallup Tribe of Indians, Local Governments in Pierce County, the State of Washington, the United States of America, and certain private property owners" (Settlement Agreement). Pierce County signed the Settlement Agreement in 1988. In the Settlement Agreement, the County agreed that, "The Tribe's treaty

fishery must be managed to achieve increased salmon and steelhead production, including protection of necessary habitat, while providing for residential, commercial, industrial and other development, natural resource use, and protection of lives and property from flooding."

The County promised to consult with the Tribe when amending land use and resource plans lying within the 1873 Survey Area (See *Figure 1.2, Study Area*). Consultation consists of notifying the Tribe of the proposal, giving an opportunity for consultation and discussion, and making good faith efforts to accommodate the concerns of the Tribe in rendering its decision.

Effect of the Settlement Agreement on the Clear/Clarks Creek Basin Plan

The Settlement Agreement underscores the basin plan objective of protecting and enhancing fish habitat through stormwater management activities. It imposes an obligation for the parties to consult with one another as set out in Document 7 of the Settlement Agreement.

2.2 State Regulations, Plans and Permits

2.2.1 State Water Quality Standards

Washington Administrative Code (WAC) 173-201A and 173-200 affect the discharge of stormwater to surface water and groundwater, respectively, by establishing water quality standards for each of the different classes of water and articulating the federal anti-degradation policy. WAC 173-200 also calls for designation of special groundwater protection areas based on unique characteristics (e.g., aquifer recharge areas, wellhead protection areas, or sole source aquifers). Chapter Four describes the water quality standards and how well the Mid-Puyallup Basin streams achieve the standards.

In July 2003, Washington adopted a new set of water quality standards. The new standards cannot be used until they are approved by EPA, which is expected in 2004. Updated rules establish standards for temperature to protect temperature-sensitive fish, such as bull trout and Dolly Varden. A new indicator (enterococci) will be used to measure the amount of bacteria in marine waters that are not used for shellfish harvesting. New values for ammonia in waters without salmon species have been added.

Ecology will classify fresh waters by actual use (such as fish habitat, swimming and water supply), rather than by class (AA, A, B, C and Lake classes), to make the standards less complicated to interpret and provide future flexibility as the uses of a waterbody evolve.

Effect of Water Quality Standards on the Clear/Clarks Creek Basin Plan

Storm drainage planning considers ground and surface water quality standards along with other factors when developing specific capital improvement alternatives, such as a large regional infiltration basin. This is largely because the standards are the foundation for other water quality programs such as NPDES permits, water clean-up plans (also known as TMDLs), and 401 Water Quality Certifications. Water quality standards are also used as benchmarks for developing recommendations for non-structural solutions.

2.2.2 Aquifer and Wellhead Protection

The Safe Drinking Water Act of 1974 (SDWA) transferred responsibility for regulation of drinking water to the EPA and called on the EPA to take a number of steps to protect the quality of the nation's drinking water supplies. EPA has set maximum contaminant levels (MCL) in drinking water for more than 100 substances. Section 1424(e) of the SDWA established a Sole Source Aquifer Program. EPA was authorized to identify aquifers that are the only or principal source of drinking water for an area. The program also calls for EPA to review all federally funded projects planned for the area. Based on the review, the EPA administrator may withhold federal financial assistance for projects determined to be potential threats to a designated aquifer. The Clear/Clarks Creek Basin lies in a designated sole source aquifer.

In 1986, a new provision of the SDWA (Section 1428) required every state to develop a wellhead protection program to guard the quality of groundwater bodies used for water supply so that water arrives at a well uncontaminated. The Tacoma-Pierce County Health Department administers the wellhead protection program in Pierce County.

Effect of Aquifer and Wellhead Protection Regulations on the Clear/Clarks Creek Basin Plan

Basin plans take into account the locations of wells and wellhead protection requirements in siting new storm drainage facilities or recommending improvements to existing facilities. Stormwater infiltration facilities must be designed to meet groundwater quality standards or be sited to avoid areas where groundwater intersects aquifers providing potable water supplies.

2.2.3 The Growth Management Act and the Comprehensive Plan for Pierce County Washington

The Growth Management Act (GMA) directed local governments of fast-growing counties, cities, and towns to prepare and adopt comprehensive plans and implementing regulations for managing their growth. Pierce County was required to prepare a comprehensive plan that meets the GMA precepts. The Comprehensive Plan for Pierce County Washington (County Comprehensive Plan) became effective in December 1994. Development regulations to implement the comprehensive plan were adopted in 1995.

Three GMA planning goals directly apply to storm drainage planning. They are as follows:

> "*Urban growth. Encourage development in urban areas where adequate public facilities and services exist or can be provided in an efficient manner.*"
>
> *"Environment. Protect the environment and enhance the state's high quality of life, including air and water quality, and the availability of water."*
>
> *"Public facilities and services. Ensure that those public facilities and services necessary to support development shall be adequate to serve the development at the time it is available for occupancy and use without decreasing service levels below locally established minimum standards."*

The GMA influences the provision of storm drainage and surface water management services and facilities by requiring that: 1) frequently flooded areas (flood hazard areas) be identified and protected; 2) urban facilities be constructed in urban areas only; 3) a level of service standard be

established for storm drainage facilities; and 4) capital improvements be identified to meet the adopted level of service given planned land use.

Effect of the GMA on the Clear/Clarks Creek Basin Plan

The GMA mandates that comprehensive plans be internally consistent (RCW 36.70A.070) and that counties perform their activities and make capital budget decisions in conformity with their comprehensive plans. (RCW 36.70A.120) Because basin plans recommend capital improvement projects and form the basis of the annual capital budget for the County Storm Drainage and Surface Water Management Utility, basin plan recommendations are required to be consistent with the County Comprehensive Plan. Basin plans are also used to formulate the longer-term (six-year) capital improvement plan, also known as the "Capital Facilities Element" of the County Comprehensive Plan (The Supplemental Environmental Impact Statement in Chapter Ten examines the consistency of this plan's recommendations with the County Comprehensive Plan).

Land use decisions drive stormwater management infrastructure needs. Adopted land use/zoning and current development regulations are used in this Basin plan to model future hydrologic conditions and determine the type, size and location of facilities that will be needed to support planned growth. Critical areas designations are used to indicate potential sites for stormwater facilities, such as infiltration ponds (aquifer recharge areas) or natural stormwater detention sites (wetlands and riparian corridors). Conversely, surface water management recommendations can influence land use density and intensity choices, for instance if a basin plan identifies stream reaches that must be protected from the adverse hydrologic effects of new development. Existing and planned land use is described in Chapter Four, "Existing Conditions".

2.2.4 Shoreline Management Act

The Shoreline Management Act (SMA) establishes a broad policy for how Shorelines of the State can be used, giving preference to uses that:

- Protect the quality of water and the natural environment
- Depend on proximity to the shoreline (water-dependent uses)
- Preserve and enhance public access or increase recreational opportunities for the public along shorelines

Shorelines of the State include all marine waters, streams with a mean annual flow greater than 20 cubic feet per second; lakes 20 acres or larger; upland areas 200 feet landward from mean high water; biological wetlands; river deltas; and some or all of the 100-year floodplain, including all wetlands within the entire floodplain, when they are associated with one of the other listed waters.

The SMA divides authority for compliance between local and State governments. Cities and counties are the primary regulators. Each city and county adopts a shoreline master program and use regulations that are based on State guidelines but tailored to the needs of the community.

Pierce County adopted its Shoreline Master Program in 1974 and the Use Regulations in 1975 (amended in 1992). Shoreline use regulations set out a permit system for administering the program.

Effect of the Shoreline Master Program and Use Regulations on the Clear/Clarks Creek Basin Plan

Many of the proposed projects contained in this basin plan are likely to be located within a regulated shoreland and subject to permit requirements. The conditions that might be imposed on recommended projects are considered in Chapter Ten, Supplemental Environmental Impact Statement, Land and Shoreline Use section.

2.2.5 State Hydraulic Code

The Washington State Hydraulic Code (RCW 75.20.100-140) regulates any activity affecting the state's fresh waters and salt waters, in order to preserve fish and wildlife habitats. The Hydraulic Code is administered by the Washington State Department of Fish and Wildlife (WDFW). The WDFW requires any person, organization, or government agency whose construction project lies within the ordinary high water line of marine waters and fresh waters of the state to obtain a Hydraulic Project Approval (HPA) Permit. The HPA Permit typically specifies how construction projects are designed, managed, sequenced, and conducted to minimize adverse effects on fish and shellfish.

Effect of the State Hydraulic Code on the Clear/Clarks Creek Basin Plan

Certain alternatives could lie within or near state waters. Conceptual design and cost estimates for these facilities should take into consideration the conditions likely to be imposed on the project via the HPA Permit.

2.2.6 The Nonpoint Rule

WAC Chapter 400-12 establishes criteria and procedures for ranking watersheds in Washington State and for developing and implementing action plans for watersheds that need corrective and/or preventive actions. The purpose of WAC 400-12 is to reduce pollutant loading from nonpoint sources, prevent new sources from being created, enhance water quality, and protect beneficial uses. The planning process encourages collaborative problem solving among local, state, tribal, and federal interests. It relies on voluntary actions, local ordinances, and state and federal laws, regulations, and programs for implementation.

Each lead entity (usually a county) convenes a committee to review and/or re-rank the watersheds wholly or partly within the county boundaries, using criteria specified by the State. Local watershed management committees are then formed to develop action plans for the ranked watersheds. Pierce County has prepared action plans for the Lower Puyallup River, which includes the Clear/Clarks Creek Basin.

Effect of the Nonpoint Rule on the Clear/Clarks Creek Basin Plan

As with the WRIA planning process, the nonpoint action planning process and any completed plans should be considered when developing the basin planning strategy, basin-specific objectives and when evaluating projects.

2.3 Pierce County Regulations, Policies and Programs

2.3.1 Pierce County Storm Drainage and Surface Water Management Master Plan (Volumes I and 2), James M. Montgomery, 1991 (1991 Plan)

The 1991 Plan is the original capital improvement program (CIP) and program plan for the Pierce County Storm Drainage and Surface Water Management Utility. It documents basin characteristics as of 1991, development of the CIP and refinement of alternatives. The Clear/Clarks Creek Basin was one of the basins studied. The 1991 Plan describes physical attributes of the drainage basin (including the Roosevelt Ditch area), the drainage system existing at the time; the hydrologic modeling performed and model results. It identifies alternatives and recommends a CIP specific to the Clear/Clarks Creek Basin.

Over the course of the fourteen years since adoption of the 1991 Plan, significant changes have occurred in the regulatory environment, program policies of federal and State funding agencies and Pierce County policy affecting stormwater management. In 1995, the Storm Drainage and Surface Water Management Plan became part of the Pierce County Comprehensive Plan. Several stormwater studies and plans have been added to the 1991 Plan, such as the Clover Creek Basin and 144th Street East Drainage Plans (informally). In 1995, Pierce County secured a stormwater NPDES permit. These factors coupled with continuing land development and other changes in field conditions, have frequently ruled out projects originally recommended and have required that other alternatives be identified and implemented. Appendix B presents the projects recommended in the 1991 Plan for the Clear/Clarks Creek Basin and reports how the recommendations have been implemented. Projects shown as completed represent most of the existing regional drainage facilities covered in Chapter Four.

2.3.2 Army Corps of Engineers General Investigation New Starts Program

The Army Corps of Engineers General Investigation New Start Program funds large complex projects where there is a federal interest and when co-sponsored by a local government, agency or non-profit with local matching funds. Congressional approval is required to initiate a new start. Projects are managed by the Corps of Engineers. A New Start begins with research and study, a feasibility study, preliminary design and engineering. After the preliminary work is completed, but before construction of the identified projects, Congress must reauthorize the project and allocate funds.

Congress authorized a General Investigation (GI) New Start for the Puyallup/White watershed area. The initial work for the GI New Start relies on work done by a group of scientists representing agencies and governments such as the Puyallup Tribe of Indians, Washington State departments of Fish and Wildlife and Natural Resources, the Port of Tacoma, the cities of Tacoma, Federal Way and Puyallup, the Pierce County Conservation District, and Pierce and King Counties. With the Puyallup/White River watershed area in mind, they identified a number of potential projects that could help in restoring water quality and fish habitat in the watershed.

Several of the projects lay in the Clear-Clarks Creek Basin as follows:

Swan Creek Stream Restoration (in progress)
Project identified by City of Tacoma
Estuarine aquatic habitat restoration by the City of Tacoma on City of Tacoma-owned land. Excavate approximately two acres of filled wetland, replant with native vegetation within and adjacent to the wetlands, including nearby slopes. Eliminate fish passage impediments.

Clear Creek Floodgate Removal (partially completed through a Port of Tacoma project)
Local co-sponsor: Pierce County Water Programs
Salmonid recovery. Restore natural connectivity between Clear Creek and the Puyallup River by removing the two floodgates at the Clear Creek discharge point, buy out potentially flood prone property, and/or build a setback levee to protect homes. The Port of Tacoma replaced one floodgate with an electronic gate to allow river water to wax and wane into Clear & Swan Creeks with tidal raises in river level. Drainage District #10 maintains the second floodgate.)

Clear Creek Off-Channel Habitat
Local co-sponsor: Port of Tacoma
Restoration of off-channel habitat. Purchase land and conduct restoration actions by excavating/recreating wetlands adjacent to Swan and Clear Creeks, re-establishing riparian vegetation, and connection of wetlands to the streams.

Puyallup-Lower Sub-Basin Barrier Removals
Local co-sponsor: Pierce County Conservation District
Remove and replace culverts that are barriers to fish passage and restore habitat.

Clarks Creek & Meeker Ditch Confluence Improvement
Local co-sponsor: City of Puyallup
Habitat restoration, water quality improvement and flood reduction. Construct off-channel rearing & wetland areas at the confluence of the two streams. Regrade confluence area to create off-channel habitats, provide additional flood storage, and construct a forested wetland complex.

Effect of the GI New Starts Program on the Clear/Clarks Creek Basin Plan

Each of the projects in the GI New Start program is acknowledged in the flooding, habitat and water quality analyses. The Pierce Conservation District identified barriers to fish passage augmented the field investigations performed by the consultant, CH2M HILL. Coordination with each of the local co-sponsors is included in basin planning outreach efforts.

2.3.3 Studies and Reports

- Surface-Water Hydrology and Runoff Simulations for Three Basins in Pierce County, Washington, United States Geological Survey (USGS), 1994. This report documents a hydrologic analysis of the Clover, Clear, and Clarks Creek Basins. The report describes the basin characteristics (e.g., soils, topography, groundwater influences) and the conceptual model of the rainfall-runoff process, and simulates the process using the Hydrologic

Simulation Program-FORTRAN (HSPF) mathematical model. Actual stream discharge measurements and precipitation information were also used to calibrate and validate the simulation model.

- Lower Puyallup Watershed Phase I Report, Lower Puyallup Watershed Management Committee (LPWMC), March 1992. This report is the first phase of the Lower Puyallup Watershed Action Plan, which is an effort to solve the problems of nonpoint source pollution in the watershed. Phase I of the Action Plan provides a characterization of the basin, assesses water quality, defines the nonpoint water pollution problems, and describes the goals and objectives. The report includes a detailed description of the Clear/Clarks Creek Basin, which is one of the sub-watersheds within the Lower Puyallup watershed.
- Ground-Water Hydrology of the Tacoma-Puyallup Area, Pierce County, Washington, United States Geological Survey, 1999. This report describes and quantifies the groundwater movement system, recharge, water use, water level fluctuations, and general groundwater chemistry within the geological landforms of the Tacoma-Puyallup area.
- Water Quality of the Lower Puyallup River Valley and Adjacent Uplands, Pierce County, Washington, United States Geological Survey, Water Resources Investigation Report 86-4154, 1989. This report documents the water quality conditions within the Lower Puyallup watershed. Surface water and groundwater samples were collected and analyzed for a variety of pollutants. Eight sites within the Clear/Clarks Creek Basin were monitored by the USGS.

In addition to these studies, Pierce County completed a drainage inventory of the County-owned structures, pipes, and channels, and the data have been entered into the County's geographic information system (GIS) database. Data from this drainage inventory, as well as other GIS features available from the County, have been incorporated into this Plan.

CHAPTER THREE
Stakeholder Involvement

Chapter Three identifies the main stakeholders and their interests in the Clear/Clarks Creek Basin Plan. Stakeholders are people, agencies, or groups of people with an interest in the outcome of the plan. The chapter also describes efforts to involve the public and other stakeholders in the planning process.

3.1 Stakeholders and Relationship to Basin Plan

The Clear/Clarks Creek Basin Plan (Basin Plan) relies on the involvement of: citizens, the Storm Drainage and Surface Water Management Advisory Board (SWAB), federal, State of Washington, and local agencies; other Pierce County departments and programs potentially affected by implementation of recommended capital improvements projects and programmatic actions of this plan.

Citizens and landowners in the Clear/Clarks Creek Basin planning area are the primary stakeholders. Other stakeholders of this basin plan include: SWAB; City of Puyallup; City of Tacoma; Pierce County Planning and Land Services Department (PALS); Pierce County Public Works and Utilities, Transportation Division; Washington State Department of Fish and Wildlife (WDFW); Washington State Department of Ecology (Ecology); Pierce Conservation District; Puyallup Tribe of Indians; Federal Emergency Management Agency (FEMA); Army Corp of Engineers; drainage districts; and the Puyallup River Watershed Council.

Water Programs incorporated considerable public information and public involvement in the development of the Clear/Clarks Creek Basin Plan to respond better to the varied interests of people living and working in the Basin. The following activities illustrate the core efforts undertaken:

- Water Programs staff identified people, groups and agencies with an interest in the outcome of the Basin Plan. An introduction to the basin plan and planning process was sent to the people identified.
- Stakeholders assisted in identifying issues and important values to consider in the Clear/Clarks Creek Basin Plan at public meetings, through completed questionnaires and one-on-one meetings.
- The County's Storm Drainage and Surface Water Management Advisory Board (SWAB), was briefed and has received the preliminary plan for consistency with County stormwater policies and has recommended its adoption to the County.
- Stakeholders provided data and information for use in the draft basin characterization, and assisted in identifying alternatives.

- Briefings of the Puyallup River Watershed Council occurred during preparation of the Basin Plan.
- County staff and consultants conferred with agencies with expertise and jurisdiction within the Basin.
- Water Programs notified the public and other stakeholders of the availability of the Draft Basin Plan and Draft Supplemental Environmental Impact Statement (DSEIS) and invited comment on the Draft Basin Plan and DSEIS. Interested people reviewed and commented on the Draft Basin Plan and DSEIS.
- Both the Pierce County Council and the Pierce County Planning Commission (Planning Commission) conduct formal public hearings on the proposed Basin Plan and DSEIS. Comment recorded becomes part of the official public record of the Basin Plan.

3.1.1 Pierce County Planning and Land Services (PALS)

Within unincorporated areas of Pierce County, the County's Department of Planning and Land Services (PALS) provides the following public services:

- Administer environmental review regulations
- Enforce compliance with land use zoning and development codes
- Issue development permits and authorizations
- Conduct long-range land use planning for unincorporated County areas

PALS staff whose project areas extend into the Clear/Clarks Creek Basin planning area provided information as follows:

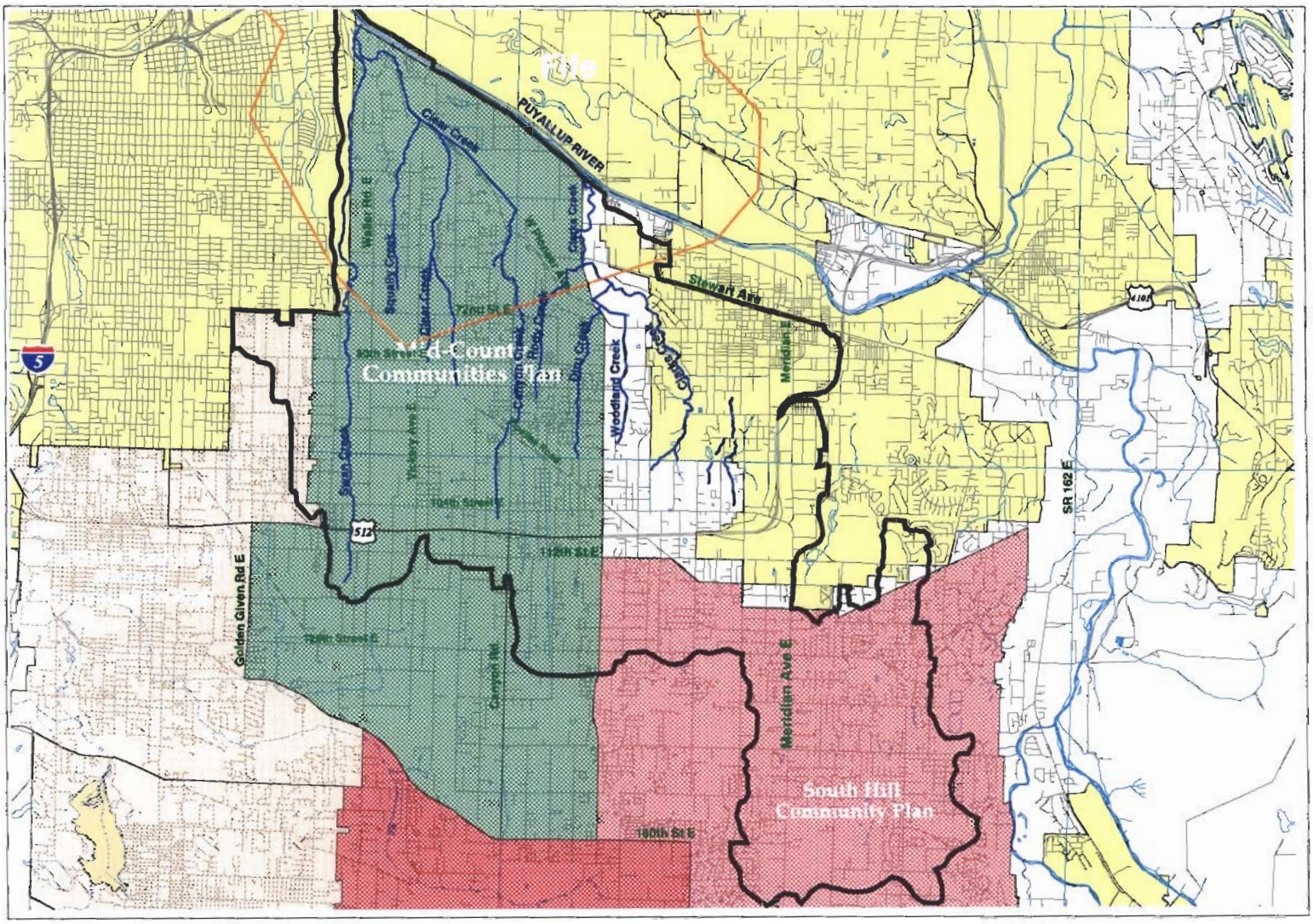
- Effect of storm drainage and surface water management activities on existing and planned land uses
- Growth management policies regarding land use and public facilities (See also *Chapter Two*, Comprehensive Plan for Pierce County, Washington)
- Planned land uses, density, and current development regulations

South Hill Community Plan. The Advance Planning section of PALS helped the South Hill Community to articulate a community plan that was adopted in April 2003.

Figure 3-1, "Relationship of Clear/Clarks Creek Basin to Community Planning Areas," illustrates the South Hill Community Plan area in relation to the Clear/Clarks Creek Basin.

Citizens of South Hill expressed the following desires regarding stormwater management:

- Design stormwater management facilities and retrofit existing facilities so they are visually part of the community's open space network.
- Design stormwater facilities in a way that protects people from safety concerns, but integrates functionality as part of the walkway and park and recreation system.
- Continue to reduce the severity and number of flood events.
- Provide information to PALS about the effects of development practices on the ability to manage stormwater effectively.



LEGEND

- Clear/Clarks Creek Basin Boundary
- 1873 Puyallup Tribal Survey Area
- Streams of Basin
- River & Other Streams

Community Planning Areas

- Mid-County Communities Plan
- Parkland Spanaway Midland
- South Hill Community Plan

- Roads - All*
- Cities in Pierce County*

1 0 1 Miles

N W E S

Figure 3.1 Basin Relationship to Community Planning Areas

Clear/Clarks Creek Basin Plan

Pierce County
Public Works & Utilities
Water Programs

Basin planning staff attended meetings of the South Hill Community Plan Advisory Board to listen to citizens as they identified the vision and needs of the community. Stakeholder questionnaires were given to interested citizens to document problems and community perspectives. Several citizens who reside within the Clear/Clarks Creek Basin commented on stormwater related problems.

County Water Programs staff also coordinated with the South Hill Community Planning Board by providing facts about local hydrology, storm drainage problems, stormwater requirements for new development, current policies and law regarding surface water management, and anticipated changes to policy and law regarding stormwater, surface water, and local stormwater facilities.

Mid-County Communities Plan. The Mid-County Communities Plan area extends across 47% of the Clear/Clarks Creek Basin. This includes all of the Clear Creek drainage basin, the eastern part of the Roosevelt Ditch drainage area, and the westerly half of the Clarks Creek drainage basin (Rody Creek and Diru Creek drainages). *Figure 3-1* shows the location of the Clear/Clarks Creek Basin in relation to the Mid-County Communities planning area.

PALS forecasts release of the Draft Mid-County Communities Plan in 2005. Coordination efforts have consisted of providing descriptions of drainage conditions to the Mid-County Communities Planning Board, and including planning board members on the mailing list for the Draft Basin Plan and DSEIS so members have an opportunity to review and comment on the Draft Basin Plan as the Mid-County Communities Plan takes form. Citizens' concerns expressed during development of the community plan have been integrated into the problem descriptions. Recommended actions in this Basin Plan respond to the concerns.

Parkland-Spanaway-Midlands Communities Plan. Adopted in 2002, the Parkland-Spanaway-Midlands Communities Plan occupies the western half of the Roosevelt Ditch drainage area. Although specific recommendations were not adopted for the Roosevelt drainage area, the community plan calls for the integration of public regional stormwater ponds into the natural environment and the community through multiple-use design.

3.1.2 Washington State Department of Ecology (Ecology)

Ecology is the permitting authority for NPDES permits. Pierce County Water Programs has a "Phase I" Stormwater NPDES Permit. Actions implemented from basin plans must comply with permit terms.

Ecology also is responsible for many aspects of watershed protection grants and activities, administration of the State Environmental Policy Act (SEPA), and enforcement of sediment, groundwater, and surface water standards.

Ecology is also the state agency charged with identifying water bodies with compromised water quality or that are not expected to improve within the next two years. Ecology submits a program to the federal Environmental Protection Agency (EPA) for restoring water quality in the listed water bodies. Water segments with management plans likely to result in improvement of water quality sufficient to meet standards need not be listed. EPA requires states to clean up

threatened waters and establish "Total Maximum Daily Load" (TMDL) limits for each listed water quality parameter. NPDES permits are written and revised based on these listings. Operating specifications for the NPDES permit can mandate that storm water runoff not contribute additional pollutant loads to the listed water bodies.

3.1.3 Washington State Department of Fish & Wildlife (WDFW)

The Washington State Department of Fish and Wildlife (WDFW), along with the Puyallup Tribe, helped identify gauging locations and conducted additional "Benthic Invertebrate Biological Index" (BIBI) sampling in the Clear/Clarks Creek Basin; the results of which are included in Chapter Four. WDFW is the State agency responsible for issuing hydraulic permits for work in State waters. Primary interests in the Clear/Clarks Creek Basin are:

- Salmon recovery
- Protection of other fish and wildlife species

WDFW operates the Puyallup Hatchery on Clarks Creek. The hatchery has been identified as a source of nutrients to Clarks Creek (KCM 1993, 1996). The hatchery is located just below Maplewood Springs in the City of Puyallup. The hatchery site includes a constructed intake pond that provides the hatchery with water. The pond is full of fine sediment; a problem addressed in Chapter Seven, "Water Quality Analysis" for Clarks Creek. The hatchery currently rears brown trout, rainbow trout and kokanee, which are transported for release in other stream and lake systems. They also rear steelhead, which are transported to the Voights Creek Hatchery for release. Any surplus beyond the number assigned to go to Voights Creek are released into Clarks Creek.

The Clear/Clarks Creek Basin Plan coordinated with WDFW by considering the Integrated Streambank Protection Guidelines in the conceptual design of storm drainage facilities. WDFW staff provided ideas for how to solve Clarks Creek water quality problems. Additional coordination took place in preparation of the Supplemental Environment Impact Statement.

3.1.4 Puyallup Tribe of Indians

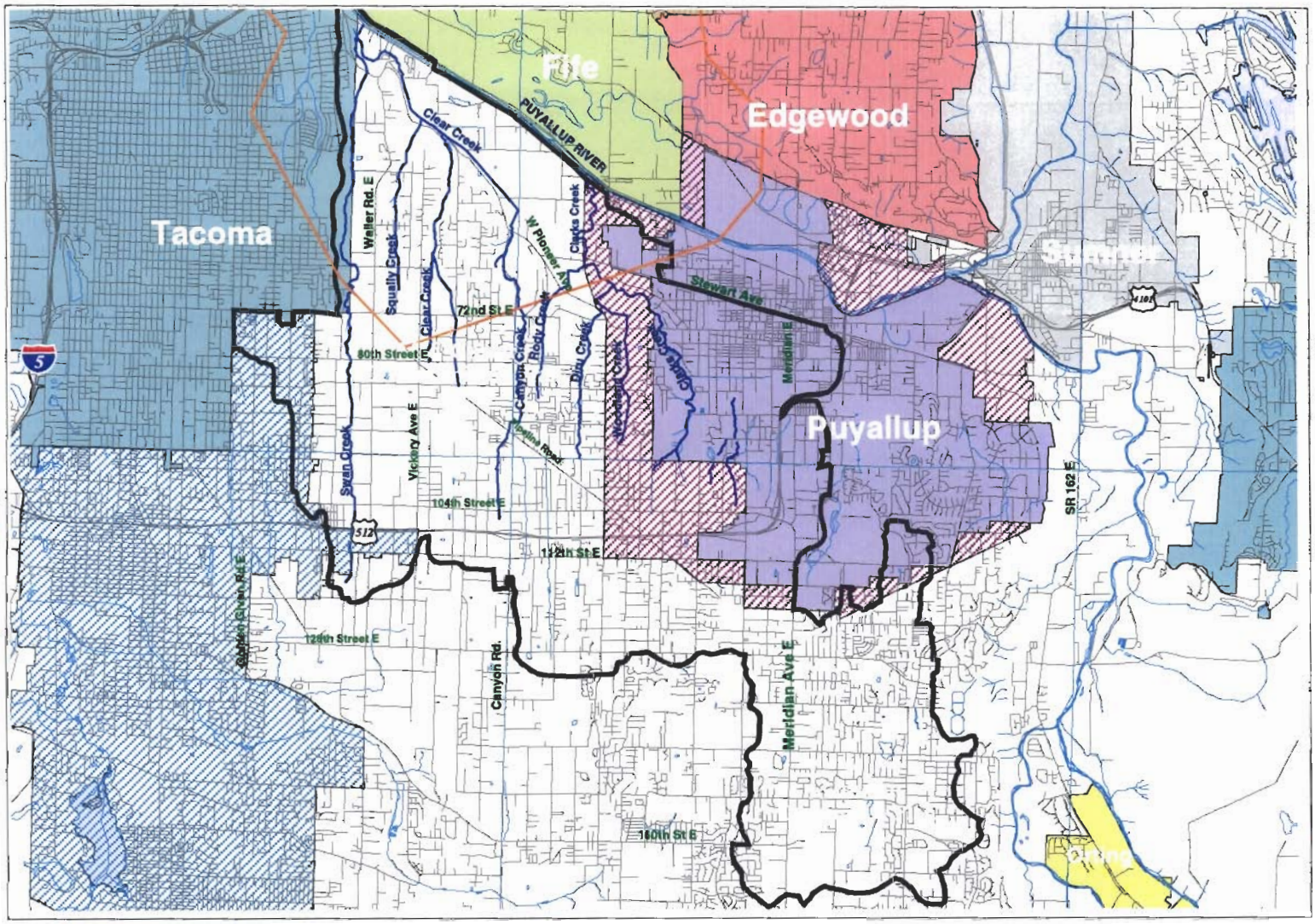
The Puyallup Tribe of Indians (Puyallup Tribe) has actively worked on storm and surface water issues in the Puyallup River Watershed. The Tribe conducted water quality sampling at several locations in the Clear/Clarks Creek Basin and they assisted in characterizing conditions by sharing data. Sampling results are presented in the Water Quality section of Chapter Four. The Tribe participates in the City of Puyallup's Clark Creek Pollution Reduction Project, assisting with collection of water quality information and data assessments. Staff for the Puyallup Tribe reviewed and provided comment on the Draft Clear/Clarks Creek Basin Characterization Report. The comment is contained in *Appendix "C,"* Basin Plan Public Involvement & Agency Coordination Correspondence.

The Puyallup Tribe maintains one fish hatchery on Diru Creek (at approximately 72nd Street East and Pioneer Way East). The Tribe is constructing a new hatchery on Clarks Creek between River Road and Pioneer Way East, which will serve as a rearing facility for Chinook salmon hatched at the Diru Creek hatchery

Parts of the Clear Creek and Clarks Creek drainage basins fall within the 1873 Survey Area of the Puyallup Tribe, depicted in *Figure 3-2*. Plans for the use of land and development plans are subject to the 1989 Settlement Agreement between the Puyallup Tribe, the U.S. Government, the State of Washington, and local governments. Chapter Two describes the provisions of the agreement applicable to the Clear/Clarks Creek Basin Plan.

Representatives for the Puyallup Tribe cited the following issues or desires:

- Participation of Pierce County Water Programs in projects to restore oxbows along the lower reaches of the Puyallup River.
- Protection of stormwater water quality by using "Best Management Practices" for stormwater treatment, including retrofitting existing facilities.
- Removal of barriers to fish passage in creeks tributary to the Puyallup River.
- Concern with the amount of growth & development in the basin without: (1) requiring and enforcing use of "Best Management Practices" for stormwater; and (2) encouraging low-impact development.



LEGEND

- Clear/Clarks Creek Basin Boundary
- Streams
- Roads - All*
- Bonney Lake
- Edgewood
- Fife
- Orting
- Puyallup
- PUYALLUP UGA
- Sumner
- Tacoma
- TACOMA UGA
- 1873 Puyallup Tribal Survey Area

0.9 0 0.9 Miles

N W E S

Figure 3.2 Basin Relationship to Local Governments

Clear/Clarks Creek Basin Plan

Pierce County
Public Works & Utilities
Water Programs

3.1.5 Cities and Towns

Unincorporated Pierce County occupies over 93% of the Clear/Clarks Creek Basin; 17% of the Basin lies within two cities, Tacoma and Puyallup. (See *Figure 3-2*, Local Governments in the Clear/Clarks Creek Basin, and *Table 3-1*, Areas of Local Governments in the Clear/Clarks Creek Basin)

Table 3-1
Areas of Local Governments in the Clear/Clarks Creek Basin

Local Governments	Acres of Jurisdiction in Basin	Total Acres of City	Percent (%) of City in Clear/Clarks Creek Basin	Percent (%) of Clear/Clarks Creek Basin in Jurisdictions
Pierce County	19,567	---	---	93%
Puyallup	3,131	7,920	39%	15%
Tacoma	340	32,163	1%	2%
Cities Total	*1,471*	---	---	---
Total	**21,038**	**---**	**---**	**100%**

Source: Pierce County Geographic Information System 11,2003

Although the Basin Plan focuses on unincorporated areas, surface water follows topography without regard for political boundaries. Stormwater runoff within cities frequently passes into unincorporated areas and vice versa. Drainage conditions and decisions in cities have potential to improve or worsen flooding, water quality and habitat conditions in unincorporated areas. Conversely, stormwater management decisions for County governed areas can affect the surface water volume and quality in the cities.

With these relationships in mind, city staff in Tacoma and Puyallup were periodically briefed on the on the findings and direction of the Clear/Clarks Creek Basin Plan. They were asked about flooding problems in subbasins shared with the County and other drainage issues of concern to the City. All stated an interest in sharing data and information and in collaborating to solve shared drainage concerns.

City of Puyallup

The City of Puyallup is working on a pollution reduction project for the Clarks Creek Watershed, about half of which flows through unincorporated Pierce County. The pollution reduction project is intended to recommend “Total Maximum Daily Loads” (TMDLs) for pollutants (primarily pollution indicated by fecal coliform bacteria) degrading Clarks Creek. Both Clarks Creek and its tributary, Meeker Ditch (Meeker Ditch lies wholly within the City of Puyallup),

have exceeded water quality standards for fecal coliform bacteria and pH[2]. In addition to the bacteria problems, high levels of nitrogen, phosphorus and sediment have been recorded. These pollutants contribute to the excessive growth of aquatic plants in Clarks Creek.

Pierce County Water Programs is a participant in the City of Puyallup's TMDL study as a member of the technical advisory committee for the project. Study recommendations probably will not be published until after completion of the Clear/Clarks Creek Basin Plan. However, this Basin Plan acknowledges the water quality issues and recommends actions for the unincorporated Pierce County portion of the Clarks Creek drainage area to minimize the County's contribution to the problem. If the TMDL study identifies other measures for Pierce County action, they can be considered for amendment to the Basin Plan.

City of Tacoma

The westerly edge of the Swan Creek drainage area lies within City of Tacoma boundaries. Largely undeveloped, the City boundaries encompass the majority of Swan Creek through its canyon section. The headwaters of Swan Creek and the valley floor fall within unincorporated Pierce County. Because of the proximity of lower Swan Creek to the industrial area of the Commencement Bay tideflats and the importance of the wetland function in and around Commencement Bay, the City of Tacoma chose lower Swan Creek to become a Natural Resource Damage Assessment (NRDA) restoration site. The City acquired approximately 11 acres of land, removed physical structures, constructed a new channel reconnecting Swan Creek to the Haire Wetland, and planted native vegetation in order to create, enhance, and protect salmon habitat. City staff stated concerns about sedimentation from the intense scouring that occurs in upstream Swan Creek.

Tacoma receives stormwater flow from the County's Roosevelt Ditch drainage area. Roosevelt Ditch flows to Tacoma's T-Street Gulch storm drainage facilities. The T-Street Gulch discharges to the Puyallup River shortly before it empties into Commencement Bay. The City's concerns in the Roosevelt Ditch drainage range from increasing peak stormwater volumes with more development and the effects on Tacoma facilities downstream to protecting water quality.

3.1.6 Other Agencies or Groups

Pierce Conservation District

The Pierce Conservation District (Conservation District) is a special purpose district authorized by State statute RCW 89.09 to help citizens manage natural resources wisely. Statute authorizes conservation districts to conduct surveys and research, conduct educational and demonstration projects with the consent of landowners, design improvements, and recommend actions of individuals and governments to conserve natural resources. They cannot regulate or require adherence to their programs or recommendations. The Conservation District administers a Dairy Waste Management program, a Farm Assistance program, Salmon Recovery programs, and a Stream Team program. At the heart of these programs are water quality, soil conservation, habitat protection and habitat restoration.

[2] pH is a measure of the degree of acidity or alkalinity in a substance

The Clear/Clarks Creek Basin Plan uses an inventory of culverts that bar fish passage prepared by the Conservation District to point out problem culverts in the stormwater drainage system. In 1997, the Conservation District funded a water quality assessment of Clarks Creek, Meeker Ditch, and the City of Puyallup Drainage System. The description of water quality conditions in Clarks Creek in Chapter Four uses the Conservation District's assessment as a source document.

Puyallup River Watershed Council

The Puyallup River Watershed Council is a collaborative group of leaders within the Puyallup River Watershed. It serves as a forum for solving problems within the Watershed, promotes its sustainable resources, and pursues the preservation and restoration of the Watershed for future generations. The Council is active in public education about non-point pollution. Over time, they have expanded their interests to include the review and ranking of salmon recovery projects within the Watershed. Membership includes representatives of State agencies, the Puyallup and Muckleshoot tribes, Pierce County, environmental groups, public utilities, cities and town, businesses, farmers and other citizens.

The Water Committee of the Watershed Council expressed the following interests and concerns:

- Improvement of stormwater quality that enters the Puyallup River and its tributary streams
- Continuing dialogue with the Water Committee as the Basin Plan progresses

Coordination between the various programs within the County that either contribute stormwater to the Clear/Clarks Creek Basin, work on salmon recovery, or administer and prepare regulations concerning land clearing, grading, open space and land development

Port of Tacoma

The Port of Tacoma has constructed a series of off-channel wetlands between Clear Creek and Swan Creek known as the Clear Creek Habitat Area. The 8.5-acre projects provide off-site mitigation for Port improvements in the Tacoma tideflats. To ensure sufficient water to inundate the wetlands and to maintain fish access from the Puyallup River into the wetland system, the Port replaced one of the flap gates at the mouth of Clear Creek with a tide gate that remains open, allowing tidally influenced water in the river to enter Clear Creek and the wetlands. This allows salmonids unobstructed passage to spawning areas. It also serves as the transport medium for juvenile salmonids migrating to Puget Sound from wetland rearing areas. The tide gate acts as a floodgate when water levels reach a certain elevation in the Puyallup River, closing until water elevations decrease enough to enable Clear Creek to drain into the river without river induced backwater flooding.

The Port owns an additional 31 acres (two parcels) in the Clarks Creek floodplain upstream from the existing constructed wetlands. These properties may be sites for future off-site wetland/fish habitat mitigation projects.

Interests of the Port of Tacoma lie in protecting the water quality of Swan Creek and Clarks Creek and in continuing to allow tidally influenced river water to replenish the wetlands.

METRO Parks Tacoma

Metropolitan Park District owns and manages the 250-acre Swan Creek Park at East 59th Street and Roosevelt Avenue East. Although the park is currently undeveloped, a primitive dirt trail extends along the creek. A canyon containing Swan Creek stretches the length of the park. Several community and student groups are dedicated to improving habitat along the creek for fish and plants.

Ameliorating Swan Creek's channel down-cutting and associated loss of habitat and slope stability are significant issues for METRO Parks and users of the park.

Clarks Creek Greenway Project

With project design funded by the National Park Service, the concept of a Clarks Creek Greenway is the brainchild of a group of Puyallup School District educators, residents on the creek and the Puyallup River Watershed Council. Its goals are to provide resident and visitor access and educational opportunities at appropriate locations along Clarks Creek and to create a non-motorized transportation link from the greenway to South Hill. The project also entails habitat restoration and habitat maintenance along the creek.

Ongoing communication with the Clarks Creek Greenway group about maintenance and capital improvement projects along creek at the project concept (pre-design) phase are key interests.

3.1.7 Property Owners, Residents, and Businesses within the Clear/Clarks Creek Basin

Pierce County Water Programs invited citizens to participate in basin planning at several points in the basin plan's development as follows:

Start of Planning

Information & Questionnaire Mailing

Water Programs sent approximately 350 informational packets to property owners adjacent to streams, creeks, rivers, floodplains, and wetlands in the Basin. Information described the basin planning process and included a questionnaire soliciting information about the basin and the preferences and perceptions of people responding. A large percentage of respondents expressed concern about water quality and habitat as opposed to flooding problems. The planning team conducted follow-up conversations with several respondents to obtain more information for use in the problem identification task. Project staff added respondents to the mailing list for future meetings and mailings.

Public Meeting

On May 22, 2001, project team members met in the Pierce County Library Administration Office (112th Street East & Waller Road) to converse with citizens in the Basin about surface water problems and the basin plan.

Website Launched

Water Programs launched an interactive and continuously maintained project website in 2001 to keep citizens, property owners, and other stakeholders informed of the basin plan's progress.

Basin Characterization

Briefing

Water Programs staff briefed the South Hill Community Planning Board. Subjects included the basin planning process and existing drainage conditions in the Clear/Clarks Creek Basin.

Public Meeting

The project team presented the findings of the Draft Clear/Clarks Creek Basin Characterization Report to citizens on the evening of June 5, 2002, at the County Library Administration Office. Citizens shared their concerns, perceptions, and ideas for solving problems. Several people asked about reduced flow in Clark's Creek, repetitive losses in the lower Clear Creek floodplain, and the volume of sediment being transported to the valley floor. Other issues included flooding on Canyon Road and 90th Street East, flooding in the 135th Street East pothole, garbage in several of the creeks, the new tide gate at the outlet of Clear Creek, the Woodland Avenue East (Woodland Creek) detention project, City of Puyallup storm drainage plans and projects and Puyallup Fair activities.

Draft Basin Plan

Public Meeting

Water Programs will sponsor an open house style public meeting on the Draft Supplemental Environmental Impact Statement and the Draft Plan shortly after issuing the Draft Basin Plan. Public comment recorded at the meeting will be addressed in the Final Supplemental Environmental Impact Statement for the Draft Clear/Clarks Creek Basin Plan.

Appendix "C" contains copies of the questionnaire form, public meeting notices and related public information.

Implementation of Basin Plan

Water Programs will provide periodic status reports to property owners, residents, and businesses describing projects scheduled for construction, noting projects completed, reporting on progress of programmatic activities, and inviting comment on what has been working and what can be improved.

3.2 Roles and Responsibilities

Pierce County Department of Public Works and Utilities holds that in order for basin plans to achieve their objectives a partnership must be forged with people. Keys to agreement are:

- Effective communication between staff, consultants and stakeholders and
- Consideration of each person's or group's viewpoints at practical points in the planning process.

3.2.1 Responsibility for Decision-Making

Water Programs selects the set of recommendations (projects, proposed policies, other suggestions in the Draft Basin and DSEIS) presented to the public, the Storm Drainage and Surface Water Management Advisory Board (SWM Advisory Board). The SWM Advisory Board recommends the Basin Plan to the Pierce County Planning Commission, County Executive, and County Council.

Water Programs transmits a proposed Basin Plan and Final Supplemental Environmental Impact Statement to the Pierce County Executive, who then refers it to the County Council. Basin plans are approved and adopted by ordinance.

3.2.2 Communication

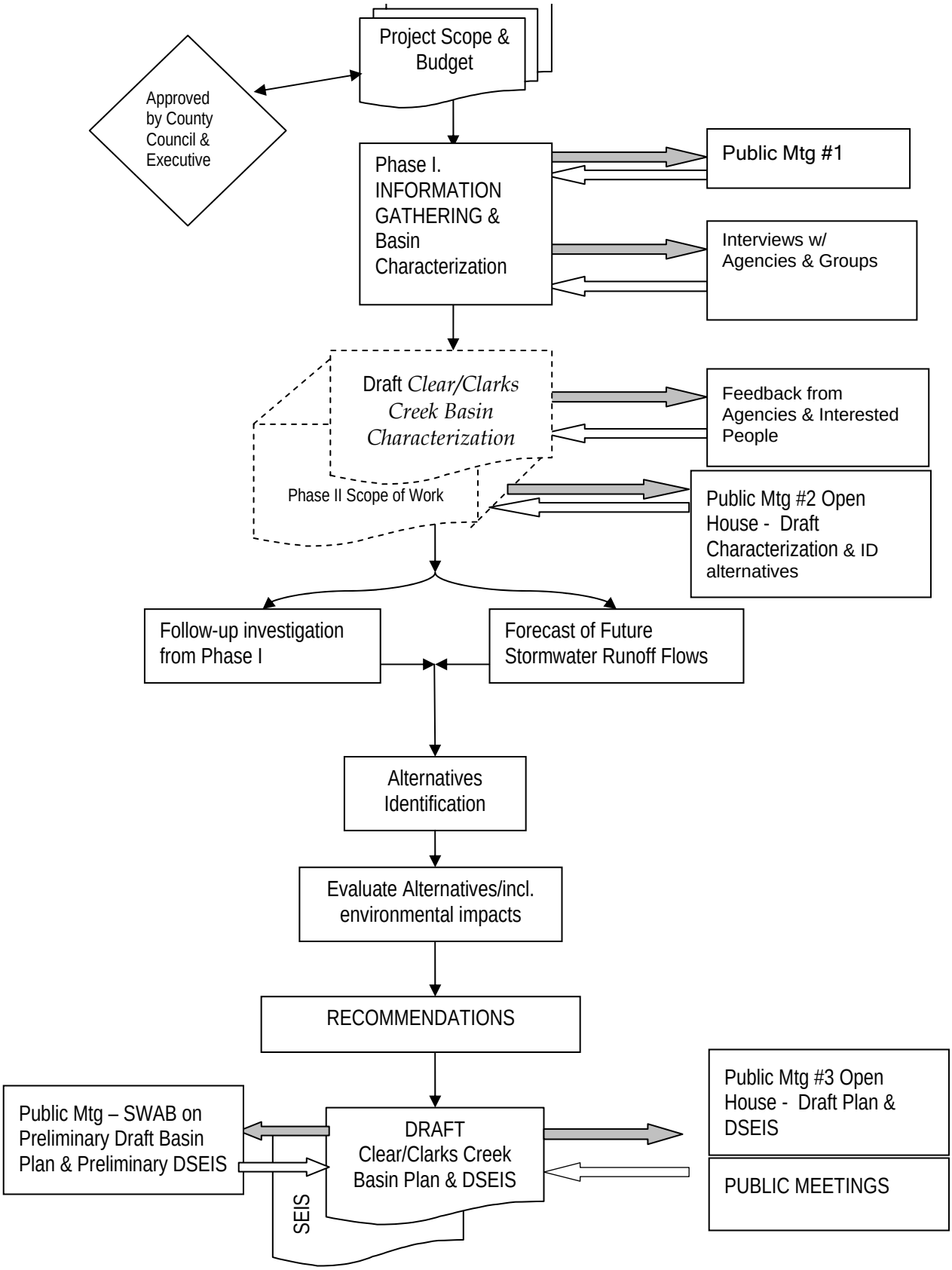
Effective communication entailed dialogue between the planning team and stakeholders, sharing data and history, what has been working, what has not been working, what people would like to see, and their perceptions about problems and the best ways to solve them, etc.

Successful communication usually takes a mix of outreach efforts to reach enough people or accommodate their busy schedules. Accordingly, communication with the public for this basin plan employed such media as individual and public meetings, open houses, study sessions, public access television, newsletters, newspaper articles, public notices, and formal requests for comment through public hearings.

3.2.3 Public Involvement at Key Points

Figure 3.3 illustrates the stages in the planning process when public information and opportunities for involvement occurred.

Figure 3.3 Communications with Public & Other Agencies



CHAPTER FOUR
Current Conditions

Chapter 4 describes characteristics of the Clear/Clarks Creek Basin existing and known at the time of writing that are pertinent to an understanding of storm drainage facilities, flood hazards and surface water conditions in the basin. The chapter begins with descriptions of natural features, such as topography, soils, climate, and flood hazard areas that influence surface water patterns and historical problems. The chapter then describes the natural and constructed drainage systems, followed by water quality and the aquatic, riparian, and wetland habitats relevant to managing storm water runoff within the regulatory environment described in Chapter 2. Presentation of current conditions wraps up with land use and population data and the record of flood losses within the basin over time. Subsequent chapters of the basin plan rely on the information presented here, e.g., an accurate characterization of problems identified during the planning period (see Chapter 5) draws from the facts set out here in analyzing problems (Chapter 6) and identifying and evaluating alternatives (Chapters 6, 7, and 8).

4.1 Topography, Soils, and Rainfall

The Clear/Clarks Creek Basin is located in north-central Pierce County in Water Resource Inventory Area (WRIA) 10. It encompasses both the Clear Creek and Clarks Creek drainage basins, along with an adjacent area of potholes and the unincorporated part of the Roosevelt Ditch drainage. The Clear/Clarks Creek Basin drainage area is approximately 32 square miles in size. Both Clear Creek and Clarks Creek flow into the Puyallup River shortly before the river empties into Commencement Bay. Clear Creek drains the western portion of the basin. Clarks Creek drains the eastern portion of the basin, including a large portion of the City of Puyallup. The potholes extend into the City of Puyallup and drain internally except during extreme storm events.

4.1.1 Topography

The varied topographical landforms in the Clear/Clarks Creek Basin are the product of volcanic activity, tectonic uplifting, glacial advances and retreats, and erosion by rivers and streams. Intermittent volcanic activity and uplift of the volcanic range, eventually resulted in the creation of the Cascade Mountain Range. Deposits of sandstone, shale, and coal compressed, folded, uplifted, and eroded into the foothills of Mount Rainier and the Cascade Range. Over the past one (1) million years, glaciation modified the landscape of what is now the Puget Sound lowlands, as repeated advances and retreats of the Puget Sound lobe of the Cordilleran ice sheet scoured elongated hills and valleys oriented in a north-south direction (LPWMC, 1992). Ice from the most recent episode of glaciation, known as the Vashon Stage, retreated about 12,500 years ago.

Glacial deposits resulting from the Vashon glaciation include advance outwash, glacial till and recessional outwash. Advance outwash (rock carried forward as a glacier advances) and glacial till were formed of deposits of silt, sand, clay, gravel and boulders compacted by the weight of

overlying ice. They usually drain poorly. Meltwater from receding glaciers deposited recessional outwash, deposits of sand with traces of silt and gravel that drain well. The pothole area is characteristic of topography that resulted from the recessional outwash underlain by glacial till (LPWMC, 1992). Rivers and streams have eroded the glacial deposits into alluvial valleys and the steep slopes lining them. The Puyallup River valley resulted from a combination of mudflows and alluvial action of the Puyallup River. *Figure 4-1* depicts the topographic features of the Clear/Clarks Creek Basin. Soil characteristics of the Clear/Clarks Creek Basin resulting from these geological processes are described in Section 4.1.2.

Creek Drainage Basins

The lower portion of the Clear Creek and Clarks Creek drainages is composed of the nearly level flatlands of the Puyallup River valley. South of Pioneer Way, elevation rises quickly from the floodplain to steep valley walls and the upper basin. Transitions along the streams are characterized by steeply sloped canyons that result from the streams cutting into the valley walls (Montgomery, 1991). Upper portions of the basin, including the potholes area are terrace and rolling hills with numerous small ponds and wetlands. Elevations range from a high of 500 feet near the headwaters of Diru Creek to 20-30 feet at the northern edge of the basin where the creeks drain into the Puyallup River valley along Pioneer Way (USGS, 1994).

Swan Creek, Squally Creek, and Canyon Creek discharge into Clear Creek in the Puyallup River valley before Clear Creek enters the Puyallup River. These streams are very flat in the upland areas, and then drain through narrow and relatively steep channels down the hillside into the flat floodplain area of the Puyallup River. The basin is considerably urbanized and contains many fabricated stormwater conveyance channels that carry water from roads and developed areas to natural stream waters (USGS, 1994). Swan Creek drains a small section of the City of Tacoma on the western edge of the basin. The communities of Midlands and Summit are also located with the Clear Creek Basin (see *Figure 1-2*). Along the lower reaches, Clear Creek drains some of the flat agricultural areas in the floodplain south of the Puyallup River and north of Pioneer Way. Much of this floodplain area falls within designated flood hazard areas and has experienced repetitive losses of property due to floods (Tetra Tech/KCM, 2001).

Clarks Creek, located immediately east of the Clear Creek Basin, receives Rody Creek, Meeker Ditch, Diru Creek, and Woodland Creek and drainage from a large portion of the City of Puyallup. Rody Creek, Diru Creek, and some of Woodland Creek have topographic characteristics similar to the streams in the Clear Creek Basin. They also exhibit narrow steep channels, which cut into the hillside as they flow from the uplands terrain toward the Puyallup River valley and the Clarks Creek mainstem. Clarks Creek becomes a meandering stream north of Pioneer Way after it flows down the hillside.

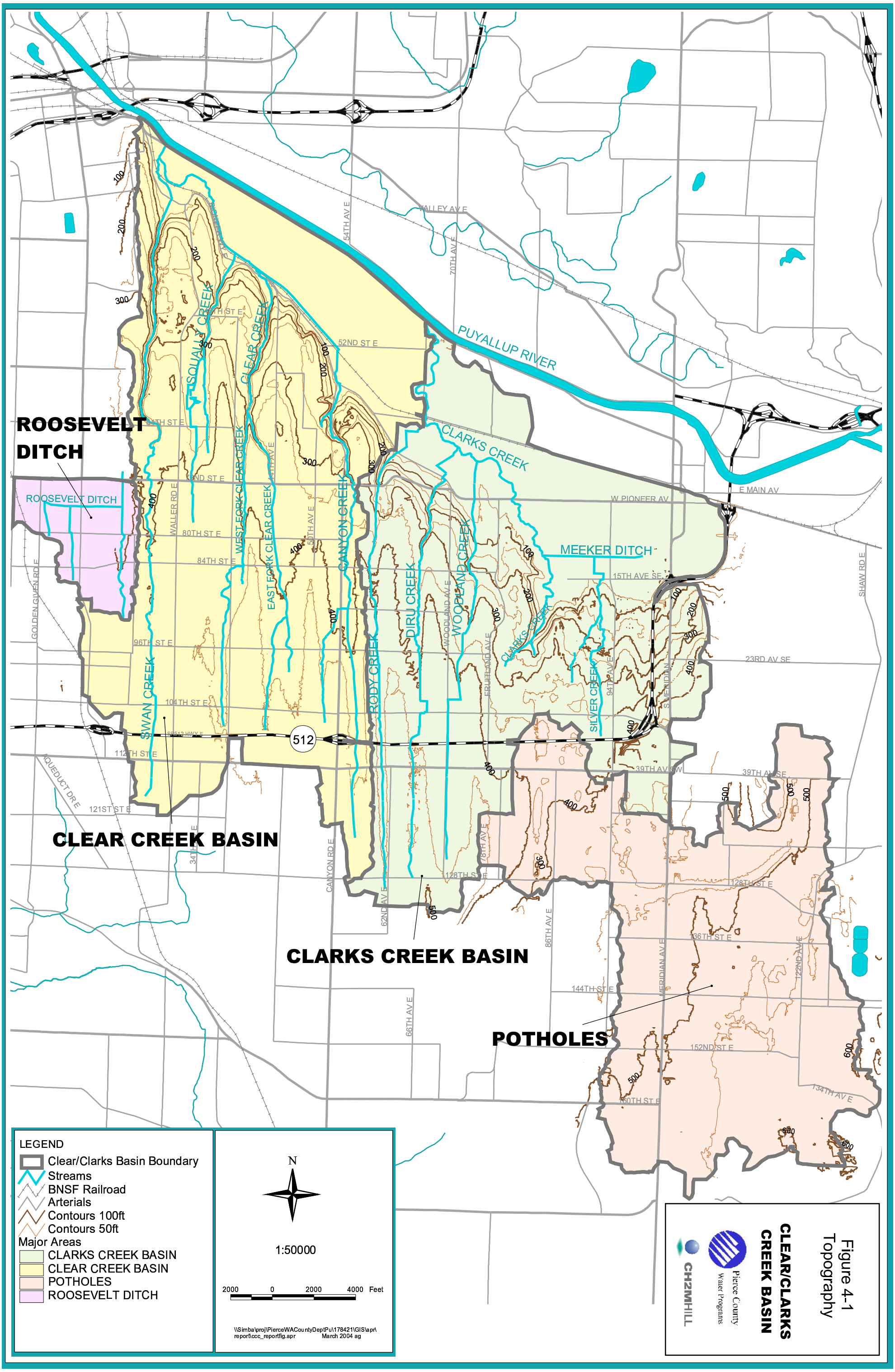


Figure 4-1
Topography

Roosevelt Ditch Area

Roosevelt Ditch is located to the west of Swan Creek and drains to the City of Tacoma's T-Street drainage system. This area has topographic features similar to the upland area of Swan Creek with a relatively flat upland area and a moderately sloped channel. Manmade conveyance systems from commercial and residential areas adjacent to Portland Ave East connect runoff from the basin to Roosevelt Ditch. A small portion of the Roosevelt Ditch, west of 12th Avenue East, drains to the north toward the drainage system on 72nd Street East.

Potholes Area

Sixteen potholes exist to the south and southeast of the Clarks Creek drainage basin. Potholes are small basins where surface water drains to a system of closed depressions or ponds with no outlets. There are no stream channels draining the potholes. During large storm events, stormwater fills the depressions to flood level and then overflows to adjacent basins (URS, 1999).

Topography of the area resembles the uplands of the Clear Creek drainages, mostly rolling hills with gentle slopes. The elevations in the Pothole basin range from a low of about 400 feet in the northwest to a high of about 600 feet in the southeast.

4.1.2 Soils

Soil associations in the basin, shown in *Figure 4-2*, consist of three types: Alderwood-Everett, Kapowsin, and Puyallup-Sultan. The Natural Resource Conservation Service (NRCS) classifies soils into four hydrologic soil types (A, B, C and D) based on the soil's runoff potential. Type A soils typically have a very high infiltrative capacity and generate the least amount of runoff relative to the other soil groups. Conversely, type D soils have the lowest infiltrative capacity and generate the highest amount of runoff. Type D soils are typically associated with saturated soil conditions. *Figure 4-2* illustrates the general distribution of the soil groups across the basin. This figure shows that the Clear/Clarks Creek basin contains all four soil groups.

Lowlands near the Puyallup River

The soils in the lowlands area near the Puyallup River are of the Puyallup-Sultan association. They are generally located in the area bounded by the Puyallup River to the north, Pioneer Way to the south, and the City of Puyallup to the east. Puyallup-Sultan soils are nearly level, well-drained soils that formed in alluvium, deposited on the floodplains by the floodwaters of the White and Puyallup Rivers. The upper 20 to 30 feet of alluvium consists primarily of silt, muck, and fine sand and some gravel deposits. According to the Soil Survey of Pierce County (SCS, 1979), the Sultan soils are moderately well drained, and the Puyallup soils are well drained. Puyallup soils, fine sandy loam soils, underlie most of the City of Puyallup, whereas the remainder of the lowlands area is intermixed with both Sultan and Puyallup soils. Puyallup and Sultan soils are classified as hydrologic soil type A and C, respectively.

Western Uplands

The soils in the western half of the upland portion of the Clear/Clarks Creek Basin are of the Kapowsin association, generally west of 86th Avenue East and south of Pioneer Way. Kapowsin soils are classified as hydrologic soil type D. Perched groundwater and areas of standing water form are characteristic of Kapowsin soils during the wetter months. Stormwater infiltration

systems are not appropriate for areas with these soil characteristics. The gravelly loamy soils formed in glacial till and are typically moderately well drained soils on undulating to rolling uplands. There are two types of glacial tills associated with the Kapowsin soils. Lodgment till consists of up to 200 feet of glacial deposits that were compacted by the weight of the overlying glaciers. Because of the compact and dense nature of lodgment till, it is often referred to as hardpan, and has very low permeability. Lodgment till restricts the infiltration of water and can create extremely saturated surface soil during the wet seasons. The second type of glacial till in the basin is ablation till, which was formed as glaciers melted and left sediment that had been carried by the ice. In contrast to the lodgment till, ablation till consists of loose well-drained sands and gravels. Ablation till is found on the top of lodgment till and tends to vary in thickness from zero to several feet (USGS, 1994).

Eastern Uplands & Potholes

Alderwood-Everett association soils are located south of the City of Puyallup in the eastern half of the basin and within the majority of the pothole area. These soils are moderate to excessively well-drained formed in glacial till and recessional outwash on the uplands. The Alderwood series consists of moderately well-drained soils that formed in glacial till, with a hardpan layer just below the surface that reduces infiltration and results in standing water, wetlands, and high seasonal groundwater table (KCM, 2000). Alderwood soils are classified as hydrologic soil type C. The Everett series soils are generally excessively well-drained because they were formed in loose, gravelly glacial outwash deposits. Everett soils are classified as hydrologic soil type A.

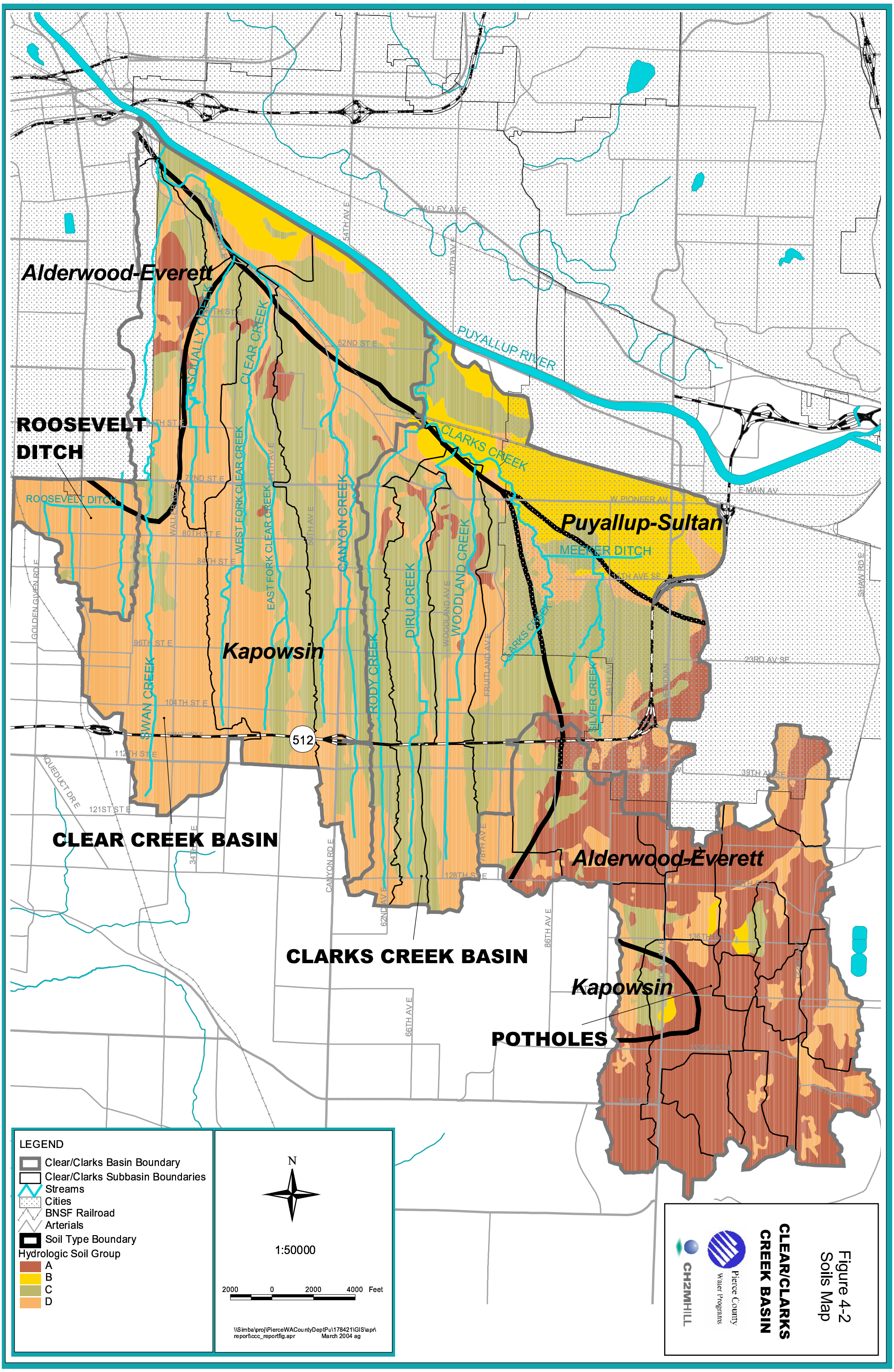
Salmon Springs Aquitard

Along the deep canyons near the mouths of Swan Creek, Clear Creek, Canyon Creek, Rody Creek, and Diru Creek, are areas where erosion and down cutting has exposed a geological deposit known as the Salmon Springs Drift, a land form older than the Vashon Drift (see Section 4.1). The Salmon Springs Drift is extremely impermeable and restricts the downward movement of water (USGS 1994). Many springs are present where the overlying, highly permeable Vashon advance gravel deposits meet the layer of Salmon Springs Drift. The springs were noted during the field surveys as part of this study (see also Section 4.7).

Alderwood and Kapowsin soils in the uplands portion of the Clear/Clarks Creek Basin provide less than optimal conditions for on-site sewer systems and stormwater infiltration systems. Both Alderwood and Kapowsin soils are underlain by glacial till, with seasonal high or perched groundwater tables, and can cause hydraulic overloads of poorly designed on-site sewer systems. Stormwater infiltration systems are not appropriate for the areas with these soil characteristics. On the other hand, the excessively draining Everett soils provide for rapid drainage from on-site sewer systems and stormwater infiltration systems, but may not provide for adequate treatment of pollutants, and can potentially cause groundwater pollution (KCM, 2000) if pretreatment is not provided.

4.1.3 Rainfall

Meteorological variables such snow pack, temperature, precipitation distribution and the intensity and orientation of the jet stream affect storm drainage and flooding. The Clear/Clarks Creek Basin is characteristic of the coastal to upland areas of Puget Sound,


Alderwood-Everett
ROOSEVELT DITCH
ROOSEVELT DITCH
PUYALLUP RIVER
CLARKS CREEK
SQUALLY CREEK
CLEAR CREEK
WEST FORK CLEAR CREEK
EAST FORK CLEAR CREEK
CANYON CREEK
RODY CREEK
DIRU CREEK
WOODLAND CREEK
SILVER CREEK
SWAN CREEK
Puyallup-Sultan
MEEKER DITCH
Kapowsin
512
CLEAR CREEK BASIN
CLARKS CREEK BASIN
Alderwood-Everett
Kapowsin
POTHOLES
LEGEND
Clear/Clarks Basin Boundary
Clear/Clarks Subbasin Boundaries
Streams
Cities
BNSF Railroad
Arterials
Soil Type Boundary
Hydrologic Soil Group
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CH2MHILL
Pierce County Water Programs
CLEAR/CLARKS CREEK BASIN
Figure 4-2
Soils Map

with warm, dry summers and cool, wet winters. The Pacific Ocean and the Cascade Mountains moderates the climate, resulting in mild winters, with most of the precipitation in the basin falling as rain. The Cascade Mountains tend to shield the area from colder, arctic air masses, while also increasing the tendency for rainfall. Approximately 78 % of the precipitation in the area falls between October and April (see *Figure 4-3*). Mean annual precipitation is 40.7 inches per year (USGS,1999). Typical rain storms of the region arrive from the west or southwest as large frontal storms and are generally low in intensity and long in duration (LPWMC, 1992). Average annual snowfall is approximately 8.7 inches per year (WRCC, 2003). *Figure 4-4* shows the long-term rainfall for the precipitation gauge at the McMillan Reservoir in the potholes area.

In most parts of western Washington, floods generally occur in late fall and in winter as a result of prolonged rainstorms. These floods may be augmented by water from snowmelt if rain falls on snow. The rain-on-snow floods are usually of short duration. In basins at higher elevations, floods may occur in the spring as a result of rapid snowmelt. These floods are usually of longer duration than the winter floods (USGS, 1998).

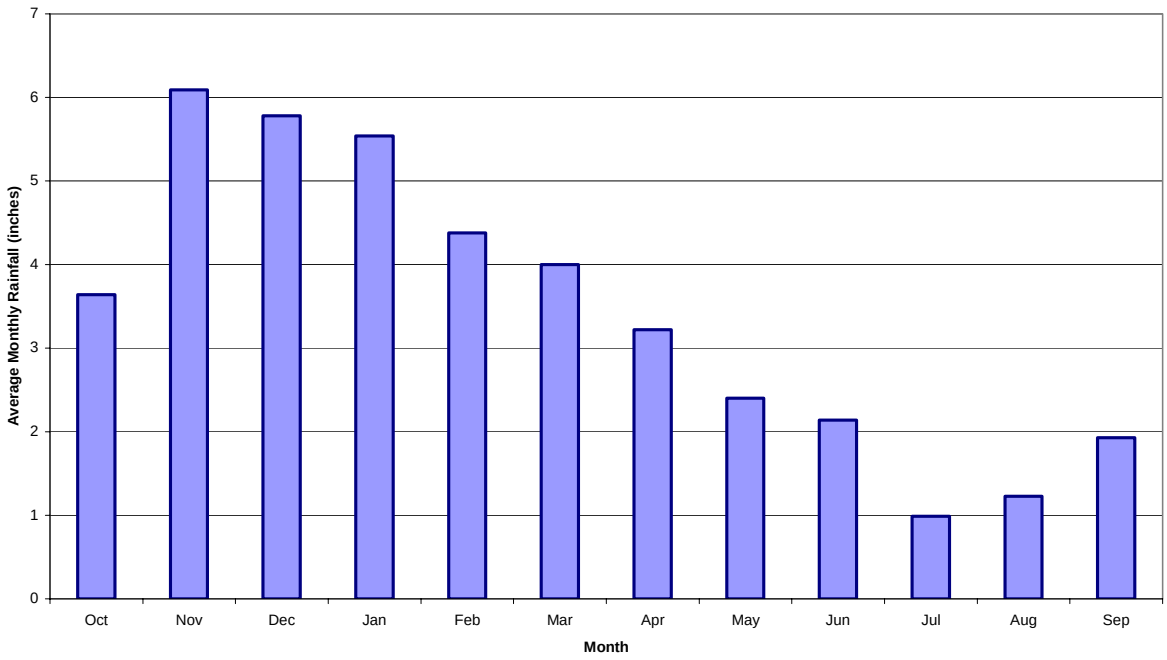


Figure 4-3
Average Monthly Rainfall at McMillan Reservoir
Source: Western Regional Climate Center

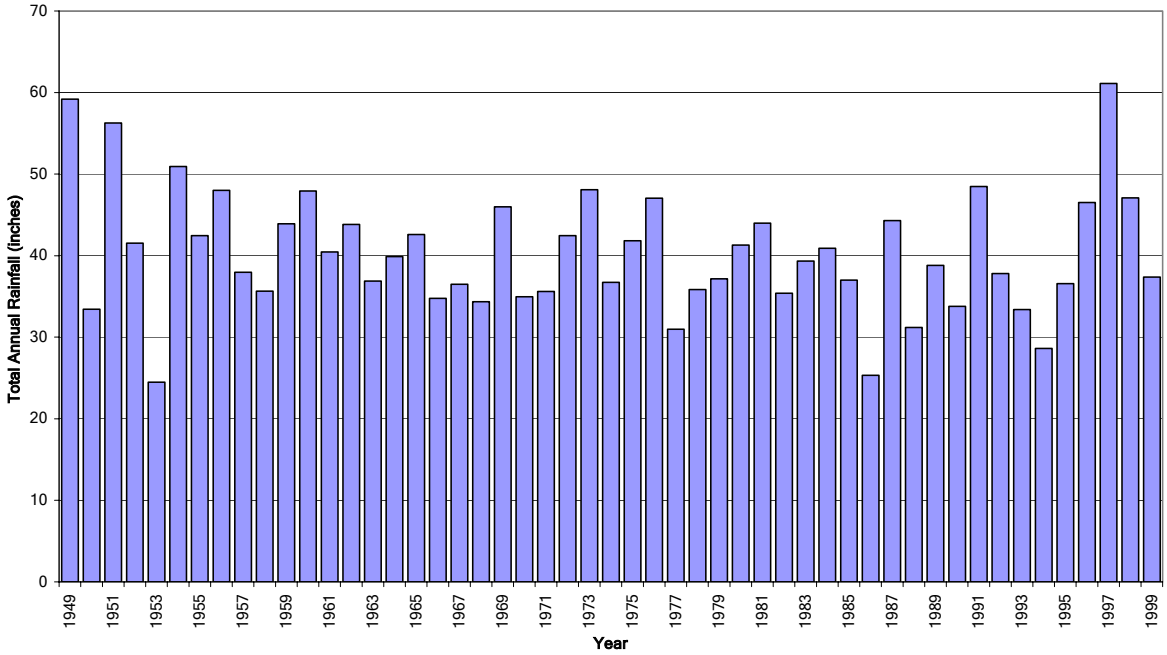


Figure 4-4
Historic Annual Precipitation at McMillan Reservoir

4.2 Land Use and Population

4.2.1 Land Use

To assess the hydrologic characteristics of a basin and to determine the potential for water quality problems requires an accurate understanding of a basin's existing and proposed land uses. Various land uses have different effects on the water quality and the hydrologic components of a watershed. Undeveloped forested land allows for maximum infiltration of rainwater and has the least potential for causing water pollution. Highly developed areas (characterized by large areas of impervious surfaces) whether residential, commercial, or industrial land uses increase the surface runoff of stormwater, carrying pollutants picked up from the manmade surfaces into the streams and waterways. Increased stormwater discharges frequently erode drainage ditches and stream channels, increase turbidity of stream water, deposit sediment in habitats important to fish and aquatic life, and fill downstream flood storage areas. Poor agricultural practices, such as improperly applied irrigation methods and feeding or watering livestock too close to a stream, can also contribute to water quality problems when the practices increase erosion and disturb soils adjacent to streams. These areas can be significant sources of sediment, fecal coliform bacteria, and nutrients such as nitrate and phosphate. Excess nutrients in water reduce the dissolved oxygen content that fish and other aquatic organisms require.

Existing Land Use

Typical land cover in the Clear/Clarks Creek Basin is a patchwork of grass pastures and lawns associated with a mostly rural/residential landscape. Approximately 45 % of the basin consists of low-density residential areas of houses, with densities generally less than or equal to one dwelling unit per acre (USGS, 1994). Small hobby farms are scattered throughout the basin. Vacant lands and open spaces comprise approximately 22 % of land use. Roadways and highways occupy approximately 12 % of the land. The basin includes the southwestern half of the City of Puyallup, a small portion of the City of Tacoma, and the neighborhoods of Summit and Midland (see *Figure 1-2*). Much of the City of Puyallup is nearing its ultimate development density (i.e., build out), so future development will likely occur as infill of vacant parcels. Commercial land uses are concentrated primarily along the major transportation corridors within the basin (such as along Meridian Avenue and the SR-512 Interchange near the South Hill Mall). In general, the rural-residential landscape becomes more urbanized closer to the Cities of Puyallup and Tacoma, to the South Hill Mall, and along Meridian Avenue and River Road.

Development Patterns

General land use patterns within the Clear/Clarks Creek Basin are shown in *Figure 4-5*. A considerable portion of the City of Puyallup (the City limits are shown as a dashed outline in *Figure 4-5*) lies within the northeastern corner of the Clear/Clarks Creek Basin. Medium-density residential developments, schools, and commercial land uses dominate this area. Commercial businesses are located primarily along Meridian Avenue (SR 161), Stewart Avenue, and at the interchange of Pioneer Way with SR 161. These areas have been central focus points for development. Other significant commercial developments within the basin include the South Hill Mall and the Summit County Center, located at SR 512/31st Avenue SW and Canyon Road/SR 512, respectively.

Public open space facilities and parks include the Western Washington Fairgrounds, Clarks Creek Park (both located within the City of Puyallup), Orangegate Park, DeCoursey Park in Puyallup, and Swan Creek Park (undeveloped). Thun Field, also known as the Pierce County Airport, lies partly within the southernmost portion of the Clear/Clarks Creek Basin, in the Pothole area. The heaviest concentrations of agricultural activities within the basin, mainly small farms, are located primarily between Pioneer Way East and River Road (SR 167), in the northern portion of the Clear/Clarks Creek Basin. However, there are numerous small hobby farms located within the flatter, uplands areas of the Clear and Clarks Creeks tributaries (Swan, Rody, Diru, Woodland, and Canyon Creeks).

As described previously, most of the streams within the Clear/Clarks Creek Basin flow through steep canyons as they drain from the upland areas to the south, and then flow north toward the Puyallup River valley and the low-lying floodplains. Due to the steep topography of the canyons, most of the canyon areas have remained in large lots with buildings setback away from canyon rims. The exceptions include two large quarry areas, one along Canyon Creek and one along Rody Creek.

The southeastern portion of the Clear/Clarks Creek Basin (South Hill) is experiencing rapid development, as are many other areas in Pierce County and the Puget Sound region. This portion of the basin contains some of last few large undeveloped parcels of land that are zoned for Moderate Density Single Family Residential use in the basin. The Meridian (SR-161) and SR-

512 highway corridors have both contributed to recent development in this portion of the watershed.

Future Land Use

The *Comprehensive Plan for Pierce County, Washington* (County Comprehensive Plan) (Pierce County, March 1999) was developed and adopted in 1994 in response to the requirements of the Washington State Growth Management Act (GMA), as described in Section 2.1. The County Comprehensive Plan seeks to obtain and balance 13 different planning goals. These goals include reducing sprawl while still encouraging development, providing public facilities and services to support development, protecting the environment while protecting property owners' rights, promoting economic development, preserving archeological and historical sites, artifacts and structures, and processing permits in a timely manner, while at the same time encouraging citizen participation in the planning process (Pierce County, March 1999). The County Comprehensive Plan, codified as Title 19A of the Pierce County Code, divides the Clear/Clarks Creek Basin into rural areas and urban growth areas.

The Land Use Element of the *Pierce County Comprehensive Plan* includes a growth and development strategy on how and where development will occur in the future. It is important to consider the proximity of existing surface water within the basin to future designated Employment Centers, Commercial Centers, Mixed-Use Districts, Moderate Density and High-Density Residential Districts, and Rural Activity Centers. The future land use designations that lie within the Clear/Clarks Creek Basin are described in the following sections. *Figure 4-6* shows their geographic locations.

As shown in *Figure 4-6*, most of the basin is currently zoned for agricultural or rural residential development and moderate-density single-family development. The entire northwestern portion of the basin is designated as Rural Separator or Agricultural lands. Most of the creeks run through lands that are zoned for such lower intensity land uses.

There are large parcels of land throughout the basin that have been platted for development but have remained undeveloped for several years. As land is developed, the off-site stormwater drainage system, built and natural, will be affected. The subdivision developments would increase population and the number of automobiles in the basin; require construction of new roads; and add large amounts of new impervious surfaces. These impacts will cumulatively increase sources of nonpoint water pollution, duration of erosive stream flow velocity, peak stormwater runoff rates, and the volume of stormwater runoff. Commercial and industrial land uses will have similar effects. In response to the changes, Chapter Six of this plan forecasts the volume of stormwater we can expect given planned land uses, and the ability of the drainage system to accommodate the projected

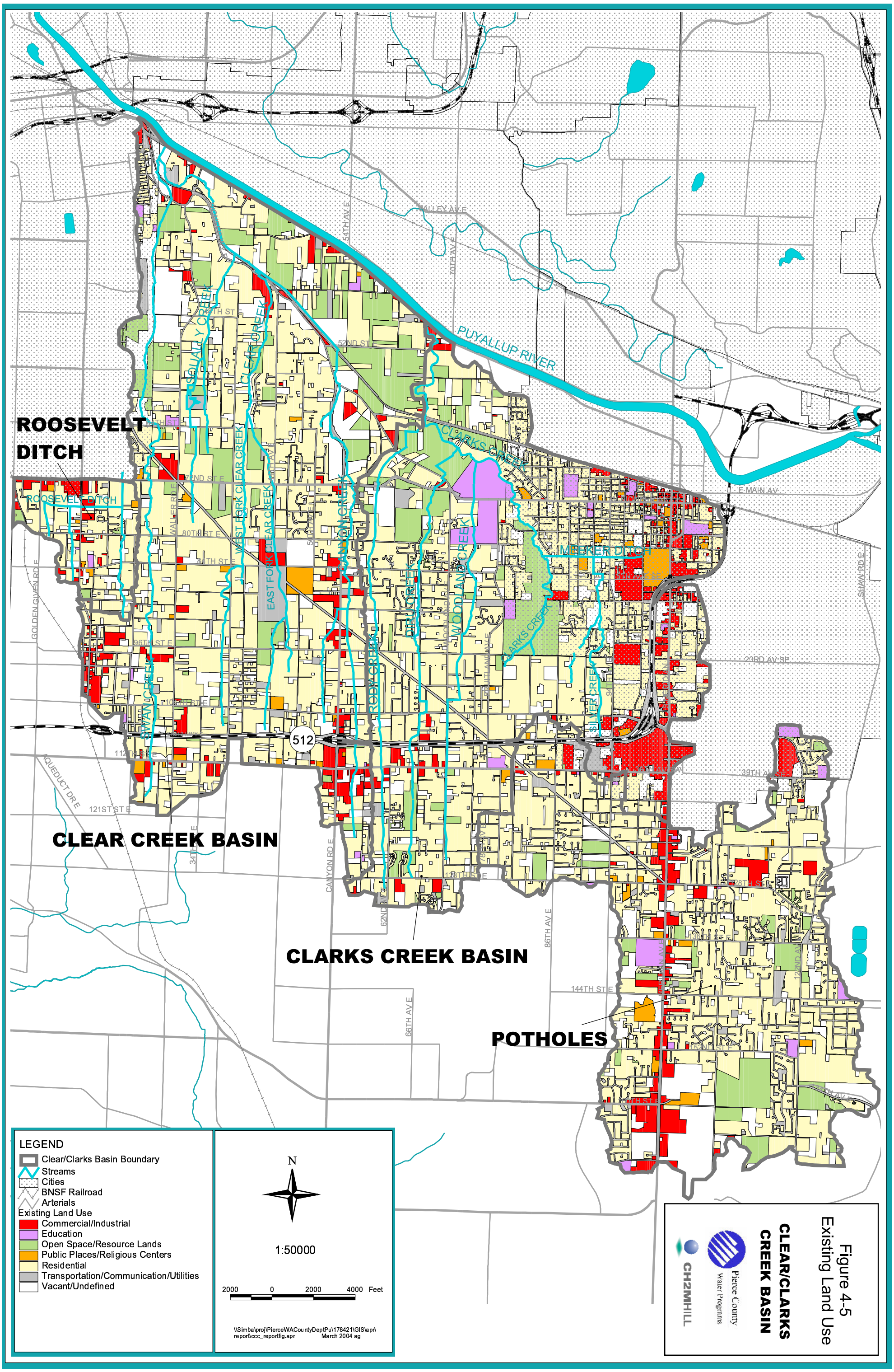
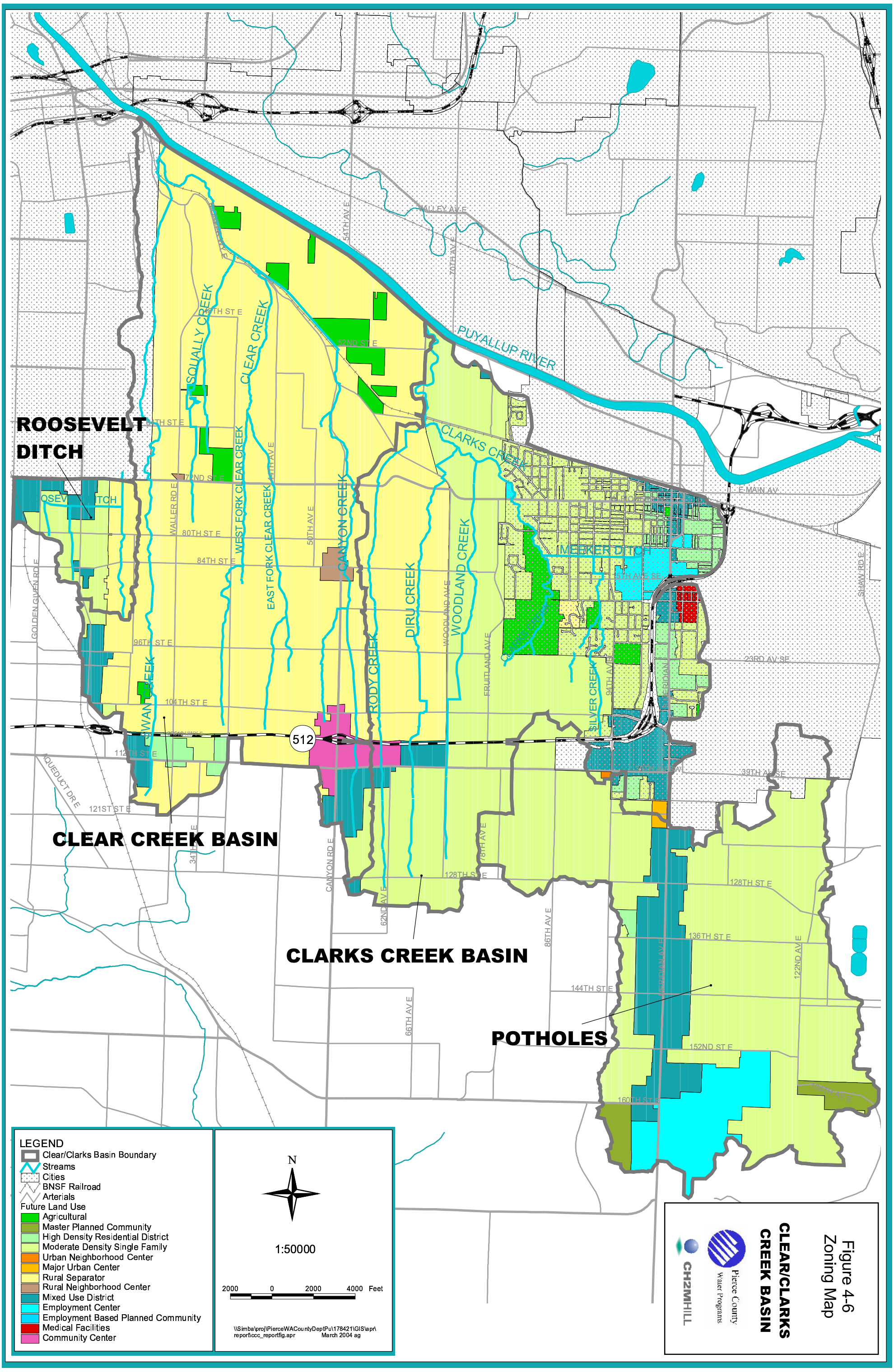


Figure 4-5
Existing Land Use
CLEAR/CLARKS CREEK BASIN


ROOSEVELT DITCH
CLEAR CREEK BASIN
CLARKS CREEK BASIN
POTHOLES
PUYALLUP RIVER
SQUALLY CREEK
CLEAR CREEK
WEST FORK CLEAR CREEK
EAST FORK CLEAR CREEK
CANYON CREEK
RODY CREEK
DIRU CREEK
WOODLAND CREEK
CLARKS CREEK
IMEBKER DITCH
SILVER CREEK
SWAN CREEK
54TH AV E
70TH AV E
HALLEY AV E
48TH ST E
52ND ST E
72ND ST E
80TH ST E
84TH ST E
96TH ST E
104TH ST E
112TH ST E
121ST ST E
128TH ST E
136TH ST E
144TH ST E
152ND ST E
160TH ST E
WALLER RD E
50TH AV E
GOLDEN GIVEN RD E
AQUEDUCT DR E
CANYON RD E
62ND AV E
66TH AV E
86TH AV E
78TH AV E
122ND AV E
MERIDIAN AV E
FRUITLAND AV E
94TH AV E
E MAIN AV
23RD AV SE
39TH AV SE
SHAW RD E
512
LEGEND
Clear/Clarks Basin Boundary
Streams
Cities
BNSF Railroad
Arterials
Future Land Use
Agricultural
Master Planned Community
High Density Residential District
Moderate Density Single Family
Urban Neighborhood Center
Major Urban Center
Rural Separator
Rural Neighborhood Center
Mixed Use District
Employment Center
Employment Based Planned Community
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Pierce County Water Programs
CLEAR/CLARKS CREEK BASIN
Figure 4-6
Zoning Map

stormwater runoff. It recommends various facilities and projects to manage the stormwater without significant flooding and loss of property. Chapter Seven analyzes water quality and recommends projects and programs to keep stormwater, either discharged into the natural drainage system or infiltrating into the ground, within the State water quality standards and the terms of Pierce County's stormwater NPDES permit. Chapter Eight examines projected stormwater flows and current habitat problems due to drainage facilities or stormwater for their effects on fish habitat. Then projects are recommended to correct existing problems and problems that can be anticipated as the basin develops.

The following land uses are planned for the Clear/Clarks Creek Basin.

Employment Centers

An employment center is a concentration of office parks, manufacturing, other industrial development, or a combination of activities. These areas are likely to be developed to their maximum allowable densities. Any vacant and undeveloped land will probably be absorbed. Eventually these areas will have to expand or new centers will be designated. Employment centers within the Clear/Clarks Creek Basin include:

- Sunrise Parkway East, between 122nd Avenue and 134th Avenue
- Thun Field (Pierce County Airport) and adjacent areas

Community Centers

A community center has as its focus a significant commercial traffic generator around which develops a concentration of commercial and some high-density multi-family developments. One community center has been designated within the basin:

- Canyon Road: Canyon Road East at 112th Street

Rural Centers

Rural centers are concentrations of shopping, services, and employment in rural areas. Pierce County recognizes three different types of rural centers: rural activity centers, rural neighborhood centers, and rural gateway communities. Rural neighborhood centers are the only type designated within the Clear/Clarks Creek Basin. The two rural neighborhood centers within the Clear/Clarks Creek Basin are as follows:

- Canyon Road East and 84th Street East
- Waller Road East and 72nd Street East

Urban Neighborhood Centers

An urban neighborhood center is a concentrated mix of small-scale retail and service commercial and office development that serves the daily needs of residents within the immediate neighborhood. Residential development at various densities may occur within the center. One urban neighborhood center lies within the Clear/Clark Creek Basin:

- Southwest corner of intersection of 39th Avenue SW and 94th Avenue East

Mixed-Use Districts

Mixed-use districts are concentrations of commercial, office, and multi-family developments located along major arterials, state highways, highways, and major transit routes. These areas cater to a customer base beyond the surrounding neighborhoods or community because of their placement near major transportation routes. Several mixed-use districts are designated within the basin:

- Meridian East (SR 161) between 120th Street East and 160th Street East
- 112th Street East between Canyon Road and Woodland Avenue
- 112th Street East between Portland Avenue and Swan Creek
- Portland Avenue between SR 512 and 93rd Street
- 76th Avenue East between River Road and 56th Street
- Portland Avenue E at 85th Street E
- South of 72nd Street from 18th Avenue E to 9th Avenue E

High-Density Residential Districts

High-density residential districts are composed of multi-family and high-density single-family housing, located within walking distance of a major roadway. Only two small high-density residential districts are designated within the Clear/Clarks Creek Basin:

- Between SR 512 and 112th Street East from Swan Creek to Vickery Avenue
- Northwest corner of Meridian East (SR 161) and 136th Street

Moderate-Density Single-Family Residential

More than one-third of the Clear/Clarks Creek Basin is designated moderate-density single-family residential. Geographic areas that fall outside of a designated center or district, as described above, are designated moderate-density single-family residential. This designation provides for single-family and two-family dwelling units:

- From Woodland Avenue to the eastern edge of the basin, excluding the City of Puyallup and the above-mentioned areas
- From 20th Avenue E to the western edge of basin

Rural Separator

Almost half of the Clear/Clarks Creek Basin is designated Rural Separator. It includes rural lands planned to buffer or separate between urban growth areas. In this case, areas designated Rural Separator within the Clear/Clarks Creek Basin act as a buffer between the Cities of Tacoma and Puyallup. Within these areas, low to moderate residential densities and rural activities, such as agriculture, are encouraged. Rural areas are to contain diverse housing opportunities, through a mix of large lots and clustering of housing:

- West of Woodland Avenue E to the Roosevelt Ditch drainage, from the Puyallup River on the north to the southern end of the basin excluding the SR-512 corridor and the specific areas mentioned above

Community Planning Efforts

Three community plan areas lie within the boundaries of the Clear/Clarks Creek Basin: the Mid-County Communities Plan area, the South Hill Community Plan area, and a small portion of the Parkland-Spanaway-Midland Communities Plan area. The community planning process uses the Pierce County Comprehensive Plan as a foundation and allows citizens to make specific recommendations regarding such things as special areas to protect, infrastructure and transportation design features, commercial and large-scale housing design, and certain land use patterns; things that can directly affect surface water and groundwater resources. See Chapter Two for detail about the community plans in the basin.

Impervious Surface Analysis

The basin characterization estimates the total impervious surface area of the watershed. This enables conceptual computer modeling activities to accurately simulate the rainfall-runoff relationships within a watershed. A conceptual hydrologic model requires accurate quantification of the amount of impervious surfaces within each basin and subbasin to predict existing and future flow patterns within a watershed (USGS, 1994). One of the primary physical attributes used for a watershed is the calculated effective impervious area (EIA). As described in *Appendix " D "* of Pierce County's *Guidance for Basin Planning* (Pierce County Water Programs, 2000), the EIA considers the fact that some impervious areas are hydraulically connected to others, allowing for a quicker response to rainfall events (PCWP, 2000).

The basic hydrologic principles of the runoff cycle include surface retention at the land surface, flow from hillsides to the stream channels, flow in the stream channels to the mouth, and interaction of surface water with groundwater. As a basin becomes developed, hydrologic characteristics are altered due to construction of impervious surfaces and structures, compaction of soils, and stream channel modifications. Trees and grasslands are removed, and soils become compacted for paving and by grading for roads and buildings. Also, natural drainage features are also often replaced with man-made pipes and channels. Therefore, when rain falls on the land surface, the amount of natural infiltration and storage is reduced, increasing the volume of surface runoff into stream channels. Flows are transmitted at higher rates and more quickly to the natural stream channels. When rainfall exceeds the infiltrative capacity of the soil, a process called Horton overland flow occurs. This results in an increase in the peak flow rates in the streams and channels, which in turn increases the potential for erosion and flooding.

For the Clear/Clarks Creek Basin, the existing percent EIA for the 48 subbasins was computed assuming land use as shown in *Figure 4-5* and future percent EIA values were computed assuming that the zoning as shown in *Figure 4-6* would be fully realized. The impervious surface analysis is described in *Appendix "D." Table 4-1* shows the existing and future land-use condition EIA for each subbasin.

The data show that under the existing conditions, the EIA is estimated to be 19 % for the Clear Creek basin, 25 % for the Clarks Creek Basin, 27 % for the Pothole Basin, and 31 % for the Roosevelt Ditch area. The Clarks Creek Basin includes much of the City of Puyallup and the South Hill Mall commercial area. The Pothole Basin also contains a significant amount of commercial area along Meridian Avenue, and a significant amount of medium-density residential development. The overall EIA for the Clear/Clarks Creek Basin is approximately 23 %.

TABLE 4-1 Existing and Future Land-Use Conditions EIA			
Subbasin Name	Existing % EIA	Future % EIA	Difference in % EIA
Roosevelt Ditch	31	46	15
Swan Creek	21	26	5
Squally Creek	11	14	3
Canyon Creek	21	25	4
Clear Creek	17	19	2
Overall Clear Creek Basin	19	23	4
Rody Creek	22	31	9
Diru Creek	19	28	9
Woodland Creek	17	35	18
Clarks Creek	29	37	8
Overall Clarks Creek Basin	25	35	10
110th Avenue Pothole	38	58	20
117th Street Pothole	28	43	15
128th Street Pothole	32	50	18
135th Street Pothole	35	53	18
Lower 144th Street Pothole	19	37	18
Upper 144th Street Pothole	18	34	16
Afdem Pothole	19	39	20
Alderwood Pothole	20	40	20
Black Swamp Pothole	22	42	20
Candlewood-Manorwood Pothole	21	30	9
Capital Pothole	47	66	19
Heritage Glen Pothole	19	41	22
Meridian Pothole	41	63	22
Springfield Pothole	24	39	15
South Central Pothole	5	18	13
Tip Top Pothole	14	22	8
Overall Potholes Basin	27	45	18
Overall Total Clear/Clarks Creek Basin	23	33	10

Under future land-use conditions, the area of built-out basin is expected to be approximately 25 % for the Clear Creek basin, 35 % for the Clarks Creek basin, 45 % for the Pothole Area, and 46 % for the Roosevelt Ditch area. The EIA for the overall Clear/Clarks Creek Basin is estimated to be 33 %. *Table 4-1* shows that there will be more impervious surface area in the basin than under

current conditions. T his may lead to more flooding and water quality problems unless appropriate stormwater controls are used as the areas develop. The majority of the increases occur in the Pothole Basin and Clarks Creek Basin.

4.2.2 Population

Current Population

Population estimates in the Clear/Clarks Creek Basin for 1990 were prepared by CH2M HILL using 1990 census block group data from the U.S. Census Bureau website (U.S. Census Bureau, 2002). The 1990 population figures were estimated from the 22 individual census block groups located within the Clear/Clarks Creek Basin, and the 38 census block groups partially located within the Clear/Clarks Creek Basin boundaries. Populations of block groups that were partially located within the basin were estimated using aerial photographs or by multiplying the total block group population by the percentage of the block group located within the basin. Using the process described above, population within the basin was estimated to be 44,466 and 61,704 in 1990 and 2000 respectively. *Figure 4-7* shows the current population estimate for Pierce County and the Clear/Clarks Creek basin. According to the U.S. Census Bureau, population in the Clear/Clarks Creek basin increased by 39% between 1990 and 2000, an annual compounded increase of 3.33 %.

Future Population

Pierce County has experienced substantial growth in previous years and is expected to support more growth over the next 30 years. From a 1990 population of 586,203, Pierce County grew by 20 % to 700,820 in 2000 (U.S. Census, 1990 and 2000). According to the Puget Sound Regional Council's (PSRC) long-range population forecasts for the Forecast Analysis Zones (FAZs) within Pierce County, the County is expected increase 16 % to 812,859, by the year 2010 (PSRC, 2002). According to the *2001 Population and Employment Forecasts* report for the Central Puget Sound Region, Pierce County is expected to reach the following populations in the years 2010, 2020, and 2030 (PSRC, October 2001):

2010: 812,859
2020: 892,314
2030: 951,747

Future population projections for Pierce County can help to predict future populations within the Clear/Clarks Creek Basin. The estimated 1990 population in the Clear/Clarks Creek Basin was 44,466, which represented about 7.6 % of the total county population of 586,203 in 1990. In 2000, the estimated population in the Clear/Clarks Creek Basin was 61,704, which represented about 8.8 % of the total county population of 700,820 in 2000. Assuming that the Clear/Clarks Creek Basin will continue to capture at least 8 % of the county's growth, it is predicted that in 2010, the population residing in Clear/Clarks Creek Basin will be approximately 65,000 and 71,000 people in 2020. *Figure 4-7* shows the future population estimate for Pierce County and the Clear/Clarks Creek Basin.

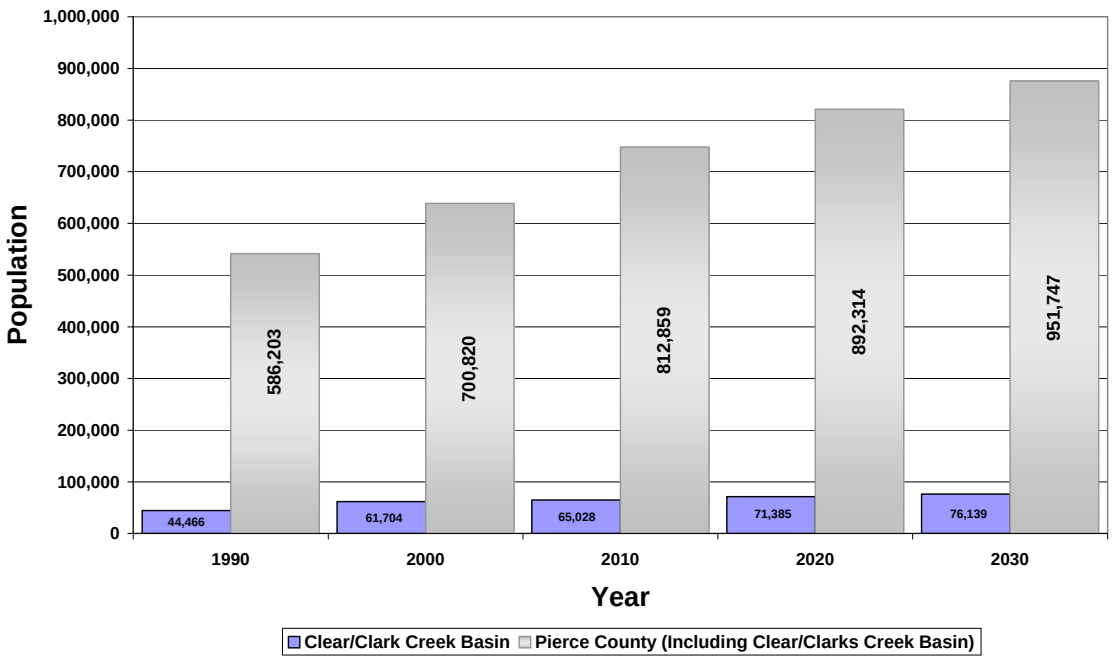


Figure 4-7
Population Trends in Clear/Clarks Creek Basin

4.3 Natural and Constructed Drainage

This section presents an overview of the Clear/Clarks Creek Basin drainage system and describes the natural and constructed drainage characteristics and features within each subbasin. It also presents brief discussions of historical and current stream flow monitoring and the influences of groundwater on the stream systems.

4.3.1 Drainage Overview

The Clear/Clarks Creek Basin drains approximately 32.7 square miles, including the 8.3-square-mile Pothole area and 1.0-square-mile Roosevelt Ditch drainage area. The natural stream channels of the Clear/Clarks Creek Basin system include approximately 33 miles of streams, according to Pierce County's 2002 GIS hydro coverage. The Clear/Clarks Creek Basin streams drain part of the Lower Puyallup sub-watershed (in Water Resources Inventory Area No.10 – Puyallup-White). Both Clear Creek and Clarks Creek flow from the northern slope of the hillside between east Tacoma and southwest Puyallup. The two drainage basins converge with the Puyallup River within three miles of salt water. Tidal fluctuations in the river cause regular backwater flows at the mouths of these streams.

The Clear Creek drainage contains four subbasins as follows:

1. Swan Creek
2. Squally Creek
3. Canyon Creek, and
4. East and West Forks of Clear Creek

Clear Creek also drains some of the flat agricultural area south of the Puyallup River.

The Clarks Creek basin also has four subbasins in unincorporated County:

1. Rody Creek
2. Diru Creek
3. Woodland Creek
4. Clarks Creek

Each of these creeks flows north and joins Clarks Creek near the toe of the slope encasing the Puyallup River valley. Clarks Creek flows generally northwest from Maplewood Springs located in the City of Puyallup and continues north after reaching the Puyallup River floodplain, joining the river at river mile (RM) 5.8.

Another tributary, Meeker Ditch, lies entirely within the City of Puyallup. Meeker Ditch drains area surrounding and including the Puyallup fair grounds and the Silver Creek drainage area of South Hill. Meeker Ditch then flows west to where it joins Clarks Creek just above the developed portion of the City's DeCoursey Park.

Figure 4-8 shows the boundaries and locations of the drainage subbasins. Streams generally flow from south to north in relatively parallel alignments. Clear Creek and Clarks Creek streams can be separated into upper, middle, and lower sections. The headwaters of the streams typically lie within rolling moderately sloped upland areas south of SR-512. Flowing north, the creeks enter deeply entrenched canyons with actively down-cutting channels, and emerge onto the flat Puyallup River valley. The lower sections, in the floodplain of the Puyallup River, are low in gradient and flow though ditch-like channels.

Groundwater contributes to perennial stream flow as discharge from seeps and springs where the densely compacted till layer intersects with stream channels. Groundwater provides perennial flows in the creeks. Upstream from these points, flow frequently disappears during late summer. Groundwater characteristics are discussed in Section 4.3.6.

Numerous wetlands in the basin help to control the volume of peak stormwater runoff by storing stormwater that otherwise would runoff; this can mitigate down-cutting of stream channels and the sedimentation of streams so damaging to fish and other aquatic species habitat. Floodwater storage is especially relevant in the eight potholes in the Clear/Clarks Creek Basin where there are no surface water drainage outlets. Wetlands also have sociocultural value in offering educational and recreational opportunities and aesthetic value to public and private landowners. The distribution and habitat benefits of wetlands in the Clear/Clarks Creek Basin are discussed in detail in Section 4.5.1.

The Potholes Basin consists of 16 individual basins. Each drains to a central depression where runoff infiltrates to ground water. Runoff often collects within the areas of lowest elevation until the stormwater can percolate into the ground. During extreme storm events, collected stormwater can overflow into an adjacent pothole.

The Roosevelt Ditch drainage area is an extension of the City of Tacoma's T-Street Gulch drainage basin. Roosevelt Ditch is a man-made channel that carries urban runoff to the T-Street

Gulch drainage system. The T-Street Gulch flows to the Lower Puyallup River west of Clear Creek.

4.3.2 Natural Drainage System

This section describes the natural drainage system of the Clear/Clarks Creek drainages. This section also includes a general discussion on land use to provide a context in describing the natural system as it exists today.

Clear Creek Basin

The Clear Creek subbasin has the largest tributary area of the drainage subbasins in the Clear/Clarks Creek Basin, draining 5.8 square miles of primarily rural residential land, with large plots of open resource and agricultural land (see *Figure 4-5*), most of which are in the lower floodplain areas and flanking hillsides. There are several large plots of open space designated as parks and a power line right-of-way in the middle section of the subbasin along Pipeline Road.

The upper reach of Clear Creek begins at the headwaters south of SR-512 in the vicinity of a wetland area between 40th Avenue East and 50th Avenue East and ends at Pioneer Way East. From the headwaters, Clear Creek flows north through rolling hills and uplands areas. There are an East Fork and a West Fork of Clear Creek. The forks flow through small channels south of 84th Street. The West Fork passes under the large substation between Pipeline Road and 80th Street East via a 52-inch culvert. Between 84th Street East and where the East Fork and the West Fork combine near 61st Street East, the stream channels become increasingly defined with steep side slopes. South of 72nd Street East, the streams begin flowing through deep canyons before discharging into the lower reach near Pioneer Way and 46th Avenue East. The Trout Lodge Fish Hatchery is located near the confluence with Canyon Creek just upstream of the culvert under Pioneer Way.

The lower Clear Creek mainstem extends west along the toe of the hill slope parallel to the Puyallup River, collecting drainage from Canyon, Squally, and Swan Creeks before joining the Puyallup River near I-5 at river mile (RM) 2.6. The lower reach begins where Canyon Creek enters Clear Creek, at Pioneer Way and Canyon Road East, and continues to the mouth of Clear Creek at the Puyallup River. Clear Creek parallels Pioneer Way as it flows northwest and is joined by Squally Creek. Most of the lower section of the stream has been channelized through the farmlands alongside the Burlington Northern Santa Fe railroad right-of-way. Lower Clear Creek also drains much of the low-lying farmlands north of Pioneer Way and south of the Puyallup River. This primarily agricultural area contains numerous constructed ditches and channels that convey water to Clear Creek.

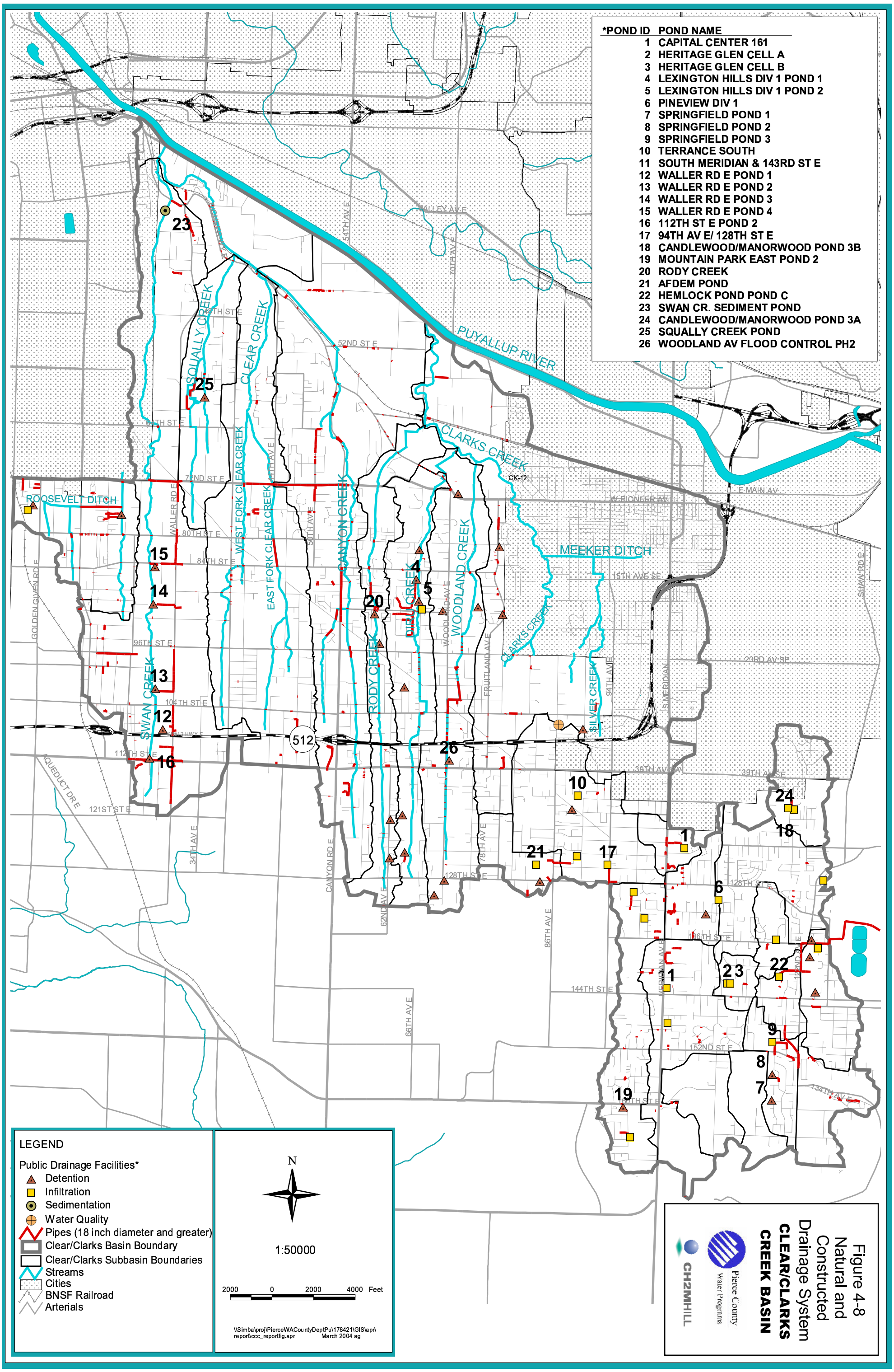


Figure 4-8
Natural and Constructed Drainage System
CLEAR/CLARKS CREEK BASIN

The area is also in the Clear Creek floodplain and is considered a flood hazard area (TT/KCM, 2001). The stream flows through these floodplain areas and some localized ponding areas with standing water, as it joins with Swan Creek and then discharges into the Puyallup River.

The Puyallup River is tidally influenced upstream of the mouth of Clear Creek. Daily tidal fluctuations and flow conditions in the Puyallup River affect the water level within the creek. Before floodgates were installed at the mouth of the Clear Creek, high tides and flooding in the Puyallup River would back water up into the Clear Creek channel. This backwater condition prevented Clear Creek from discharging to the river and resulted in extensive flooding in the Clear Creek.

Canyon Creek is the eastern-most tributary to Clear Creek, and drains an area of 2.2 square miles. The basin is substantially developed, with a string of commercial areas located along Canyon Road East and a concentration of commercial and light manufacturing in the vicinity of Canyon Road East and 112th Street East. There are two large gravel quarries along the lower section of Canyon Creek south of 72nd Street East. The headwaters of Canyon Creek are in low-lying wetland areas north of 128th Street East. The creek flows though the rolling hills of the upper reaches in moderately confined channel and through a series of culverts as it crosses under SR-512 and other arterial roads. The mainstem of Canyon Creek parallels Canyon Road East and connects with the west fork of the creek near the 90th Street crossing. The west fork originates north of 112th Street East and parallels 52nd Avenue East. From the 90th Street East confluence, Canyon Creek flows through various pipes and confined channels, and then enters the steep canyon just upstream of 72nd Street East. Flows continue north, crossing Canyon Road twice near the gravel quarries downstream of 72nd Street East. Canyon Creek then crosses under Pioneer Way East and the Burlington Northern Santa Fe Railroad. From this point, the creek flows northwest through a channelized ditch for approximately 6,000 feet where it discharges to Clear Creeks.

Squally Creek is the smallest of the subbasins, with a tributary area 0.9 square miles. This is a moderately developed subbasin, mostly rural residential. The headwaters lie just south of 72nd Street East. The upper section contains a few wetlands and areas of ponding water along the relatively small stream channel in this area. The stream parallels Waller Road East to the west and 36th Street East to the east, and then enters the steep canyon just south of 48th Street East. Squally Creek joins Clear Creek at Pioneer Way. There have been some historical bridge erosion/scour problems with the 48th Street East bridge due to high creek flows and the narrow, confined channel within the canyon area.

Swan Creek is the most westerly subbasin within the Clear Creek System. It drains an area of 3.8 square miles. The predominant land use is mostly rural residential neighborhoods, with some small hobby farms scattered throughout middle and upper sections of the subbasin. The headwaters of the stream are located south of 112th Street East near Waller Road (see *Figure 4-8*). Most of the south end of the basin is becoming increasingly developed with residential communities and commercial areas. The well-defined stream channel begins near 112th and parallels Waller Road as Swan Creek flows across the rolling hills of the uplands, passing under the arterial roads in a series of large culverts. The stream meanders through the uplands until 72nd Street East where it drops into the steep canyon Swan Creek joins Clear Creek north of Pioneer Way. The lower section of the basin through the canyon area is mostly undeveloped

with parklands. Swan Creek Park is one of the larger parks in the basin, located in the canyon. Approximately 60 acres of the valley drainage area has been redeveloped by the City of Tacoma and Port of Tacoma by converting selected parcels from commercial and residential land uses to a natural resource area due to the construction wetlands for off-channel rearing areas for fish.

Clarks Creek Basin

The Clarks Creek Basin is the largest of the basins addressed in this plan. It drains approximately 6.5 square miles; 39% of the Clarks Creek Basin lies within the City of Puyallup. Clarks Creek flows generally northwest from South Hill and continues north after reaching the Puyallup River valley, joining the river at RM 5.8.

The Clarks Creek watershed includes Diru, Rody, and Woodland Creeks in unincorporated Pierce County, as well as Meeker Ditch in the City of Puyallup. Diru, Woodland, and Rody Creeks flow generally north to their confluence with Clarks Creek near the toe of the hill overlooking the valley. Meeker Ditch drains the area around and east of the Puyallup fair grounds and then flows west to where it joins Clarks Creek just above Puyallup's DeCoursey Park.

Clarks Creek originates in wetlands south of 96th Street East and east of Fruitland Avenue East in unincorporated Pierce County. It is primarily fed by Maplewood Springs (See *Figure 4-8*). The creek flows through the protected Maplewood Springs watershed, a large tract of forested land set aside to protect the City of Puyallup's water supply. The City of Puyallup has an intake at the spring that provides part of the City's water supply. After leaving the Maplewood Springs watershed, the creek descends through a steep canyon to the Puyallup River valley where it passes through the WDFW fish hatchery. The hatchery channels creek water into the facility and discharges to the creek. From the hatchery, Clarks Creek turns to the northwest passing numerous residences and DeCoursey Park. The lower section of the stream north of Pioneer Way meanders through the farmlands in a fairly wide and deep channel that has been modified by adjacent landowners. There are developed lots and small hobby farms adjacent to the stream all the way to the mouth at the Puyallup River.

The eastern portion of the Clarks Creek subbasin drains the City of Puyallup and the South Hill Mall area. The area around the headwaters is heavily developed with commercial establishments surrounding the mall area. Much of the drainage in the eastern portion of the basin flows through man made conveyance channels and pipes and enters the lower section of Clarks Creek and Meeker Ditch at various points. A storm drain diversion at 15th Avenue SW and S Meridian transfers stormwater from the Clarks Creek Basin to the Mid-Puyallup River Basin. Meeker Ditch drains a substantial portion the City of Puyallup. It has a series of historical water quality problems associated with the fairgrounds and the urban nature of the watershed (Ecology, 1990). Section 4.6 further discusses water quality.

Woodland Creek is the second largest subbasin in the Clarks Creek Basin, draining about 1.8 square miles. Basin characteristics are similar to most of the subbasins in the Clear Creek basin. Characteristics include a relatively narrow drainage basin originating in rolling uplands area near SR-512, flow north towards the Puyallup River valley, cutting through the hillside in a narrow, steep canyon as the stream approaches Pioneer Way. The Woodland Creek subbasin is moderately developed, mostly rural residential with large lots and hobby farms, and relatively

few commercial areas. A large part of the lower area consists of land owned by Washington State University and is used for various agricultural and horticultural programs.

The headwaters of Woodland Creek begin near the intersection of 128th Street East and Woodland Avenue East. Much of the upper channel is a roadside drainage ditch along Woodland Avenue East, crossing under SR-512 where Pierce County maintains an active flow gage. From SR-512, the stream is conveyed via a series of confined man-made channels and pipes. A 24-inch pipe conveys flows from just south of 104th Street and Woodland Avenue, to 100th Street. Downstream of 100th Street, the creek again flows through a series of channels and culverts, and then enters the upper edge of its canyon area north of 96th Street. From here, the stream is located between Woodland Avenue to the west, and Fruitland Avenue to the east. The stream leaves the hillside through the Washington State University property, north of Pioneer Way. South of Pioneer Way, the stream becomes channelized and is piped through the agricultural lands owned the university. Woodland Creek joins with the Clarks Creek near DeCoursey Park and the Puyallup Tribe reservation boundary.

Diru Creek joins with Clarks Creek north of Pioneer Way at Woodland Avenue East extended. Diru Creek has a drainage area of 1.3 square miles, and like Woodland Creek, is a characteristically narrow drainage basin with steep-sloped canyons between the uplands and the lower section in the Puyallup River valley. Land use throughout this subbasin varies. The lower sections of the subbasin, from the mouth to 80th Street, contains a number of large plots of open space, designated as forested and agricultural land according to the County GIS database. The Puyallup Tribe maintains a fish hatchery at the mouth of Diru Creek, between 72nd Street East and Pioneer Way (see *Figure 1-2*). From 80th Street East to SR-512, the basin becomes substantially developed with numerous housing developments on small lots. The area from SR-512 to the headwaters near 128th Street East is mostly rural residential and small hobby farms. However there are a few new developments occurring in the extreme south end of the basin (near 128th Street East) where large vacant lots are being developed with new moderate density housing subdivisions.

The headwaters begin in a large wetlands area near 128th Street East. Diru Creek flows from 128th Street East to SR-512 in a natural channel. A 36-inch-diamter culvert conveys streamflow under SR-512. The stream enters an extended reach where it flows through small channels, roadside ditches, storm drain and pipes until it reaches 96th Street East. Below 96th Street East, the creek enters a natural open channel system passing under several arterial streets via large culverts from 96th Street East to 84th Street East, and then enters the steeply sloped canyon area downstream from 84th Street East. North of the canyon area, Diru Creek flows past the hatchery, and then flows through a channelized reach from Pioneer Way East to the confluence with Clarks Creek.

Rody Creek is the westernmost subbasin in the Clarks Creek Basin. Several reports refer to this tributary as an “unnamed tributary” to Clarks Creek (USGS, 1983). Rody Creek’s drainage area is approximately 1.2 square miles and consists primarily of rural residential land uses and a few large resource lands, one of which is a large quarry just upstream of 72nd Street East. There are a few areas of new developments occurring in the middle of the basin between 96th Street East and 84th Street East, and some in the headwaters area 128th Street East. The stream channel between the headwaters and SR-512 is not well defined. Downstream of SR-512, stream flows

are conveyed by a small but well-defined natural channel through residential developments. From 96th Street East through 80th Street East, the channel deepens and Rody Creek flows through the canyon area, passing under busy arterial streets through a series of large culverts. Rody Creek's canyon is extremely deep and narrow. The stream leaves the canyon area at Pioneer Way, flows through the flat agricultural lands until it joins with the main branch of Clarks Creek just upstream of the Burlington Northern Santa Fe Railroad bridge.

Potholes Basin

The Potholes Basin consists of sixteen (16) separate closed depression areas where stormwater flows to a series of ponds or depressions. Generally, stormwater that reaches the depression collects in a pond and infiltrates into the groundwater or evaporates. However, during large storm events, some of the potholes can overflow to neighboring potholes. For example, South Central Pothole overflows to Springfield Pothole. During an extremely large storm event, the Afdem Pond would overflow to Clarks Creek.

Within this terrain of undulating hills, the boundary lines between potholes can be drawn in many ways. Depressions in a pothole that overflow during major storms can be combined with the area to which it overflows or left separate. The 16 potholes identified and illustrated in this basin plan represent the division of potholes existing during the basin characterization phase of this plan's preparation, a snapshot in time. As development occurs and depressions are filled, natural drainage patterns are altered. Therefore, the delineation of potholes probably will change over time.

Land within the potholes is becoming increasingly urbanized, with commercial areas along Meridian Avenue and residential subdivisions throughout the basin. The drainage system has been extensively modified with pipes and channels, and a number of regional ponds and infiltration facilities replacing natural drainage courses that have been graded or filled. The constructed drainage system is discussed in the next section. A list of the potholes, their size, overflow paths, and similar characteristics follows:

110th Avenue Pothole receives runoff from 268 acres along 110th Avenue East, between 152nd Street East and 169th Street East. Direction of runoff flow is generally west to a depression located near Meridian Avenue East at approximately 156th Street East.

117th Avenue Pothole is a horseshoe shaped pothole draining 529 acres, extending from 110th Avenue East to immediately east of Military Road East and from approximately 116th Street East on the north to 136th Street East on the south. Direction of runoff flow is generally to the north to a wetland that receives and stores floodwater during storm events.

128th Street Pothole is located to the east of Meridian Avenue East, from approximately 122nd Street East to 136th Street East. 249 acres drain to a nine-acre depression at the intersection of Meridian and 128th Street East. The photograph to the right shows the flooded intersection during the winter of 1996 when the pond flowed over Meridian Avenue.

135th Street Pothole is a north-south bearing basin approximately 612 acres located just west of Meridian Avenue E. It borders 94th Avenue East on the west and stretches between 128th Street East and 160th Street East. The area has several interconnected wetland/pothole areas historically connected by ephemeral streams whose floodplains have been filled for building and landscaping purposes.

Lower 144th Street Pothole contains 150 acres. It extends from approximately 137th Street East on the north to approximately 150th Street East on the South, from 115th Street East on the west to 123rd Street East on the east. Nearly 25 acres of wetlands provides floodwater storage, a portion of which has standing water year-round. Hemlock Pond is the central depression to which stormwater flows in this pothole.

Upper 144th Street Pothole is one of the few potholes with year-round standing water. It drains 313 acres, located between approximately 151st Street East and 168 Street East, east of 122nd Avenue East. Seventeen % of the pothole area (53 acres) is wetlands. Runoff flows to a large wetland just north of Sunrise Parkway.

Afdem Pothole consists of 199 acres north of 128th Street East at approximately 80th Avenue East that were significantly modified by years of gravel mining. Since 1999, the gravel mine has been reclaimed and reconfigured for use as a regional stormwater infiltration facility. Little water could have flowed out of this basin given its highly permeable soil. But if it had, the overflow path would have been towards Clarks Creek. Substantially the same configuration exists today.

Alderwood Pothole contains several ponds and wetlands including Ates Pond (named for the last property owner) known for standing water year-round with seasonal flooding. The pothole has a drainage area of 307 acres, which are rapidly developing into moderate density residences.

Black Swamp Pothole is the largest of the potholes, encompassing 834 acres and several wetlands and depressions that historically stored stormwater. Black Swamp itself, pictured to the right, typically held water all year and extended into adjacent wetlands during storms. It receives overflow from a depression to the east and surface runoff from surrounding

area during storms. The pothole area starts near SR-512 and extends south to 128th Street East, stretching between Afdem Pothole on the west and the ridge to the west of Meridian Avenue on the east.

Candlewood-Manorwood Pothole contains 306 acres, the northern part extending into the City of Puyallup. It extends from 33rd Avenue in the City on the north to 122nd Street East. The area drains to the south-central toward a wetlands and a depression running in a north-south direction to where 122nd Street East exists now. The depression was regularly inundated during storms.

Capital Pothole is 120 acres extending across Meridian Avenue East from approximately 120th Street East on the north to 127th Street East on the south. Although records indicate no major flooding in recent years, 1997 and 1998 brought reports of over the road flooding on 123rd Street Court East and private property flooding at 120th Street East to the east of Meridian.

Heritage Glen Pothole at 102 acres is the smallest of the potholes. It is located in the center of the potholes drainage, south of 136th Street East to approximately 147th Street East, and from 110th Avenue East on the west to 116th Avenue East. More than six and one-half acres is floodwater storage where stormwater runoff collects and infiltrates.

Meridian Street Pothole at 721 acres and shaped like a bean, extends from the ridge just west of Meridian Avenue to as far east as 115th Avenue East, from 136 Street East on the north to 176th Street East. Runoff drains to a depression at Meridian Avenue East and 144th Street East that previously flooded across Meridian.

South Central Pothole consists of 210 acres the majority of which is forest and farmland. Normally, stormwater is contained in the pothole, where it infiltrates to groundwater. However, during severe storm events, stormwater exceeds the soil's ability to infiltrate water fast enough and flooding occurs. In the winters of 1996 and 1997, flood water spilled into the neighboring Springfield Pothole.

Springfield Pothole is a 223-acre basin. Stormwater in this basin flows to a series of depressions. No natural surface water outlets are present so the only means of exit is evaporation and infiltration. The majority of the basin is medium and high-density residential development. In the winter of 1996/1997, pothole water surface levels reached flood stage, damaging several residences and streets.

Tip Top Pothole contains 152 acres that straddle 136th Street East near Military Road East. The depression that provides stormwater storage extends across 26 acres.

Roosevelt Ditch

The Roosevelt Ditch drainage is located to the west of Swan Creek subbasin with 72nd Street East as its northern border and 91st Street East as its southern border. The subbasin is predominantly comprised of single family density residential homes and small hobby farms. Commercial lots are located along Portland Avenue East. The headwaters of Roosevelt Ditch

begin just south of 91st Street East with a natural drainage channel running south to north. The channel crosses culverts at 91st Street East, 90th Street East, 88th Street East, 84th Street East, and 80th Street East. From 80th Street East to 72nd Street East, a project completed in 1991 converted Roosevelt Ditch from a natural drainage channel to a straightened ditch with increased capacity. It discharges to City of Tacoma facilities at 72nd Street East, which conveys runoff to the Puyallup River.

An unnamed tributary carrying runoff from the west side of the subbasin discharges into Roosevelt Ditch about 1,200 feet south of 72nd Street East. The headwaters for this tributary are located just south of 85th Street East and west of Portland Avenue East. At about the 7600 block of Portland Avenue East, this south-to-north running channel turns east into a 24-inch diameter storm drain. The storm drain extends for approximately 2,000 feet before discharging to Roosevelt Ditch.

A second unnamed tributary carries runoff along the west side of 12th Avenue East. It extends south to north before turning east and discharging into the tributary described in the previous paragraph.

4.3.3 Constructed Drainage System

The drainage system of the Clear/Clarks Creek Basin has been extensively modified with stormwater pipes, ditches, detention pipes, stormwater ponds and infiltration facilities. Numerous culverts and bridges have also been constructed throughout the basin at driveway, road and highway crossings. Pierce County recently performed an inventory of all the drainage facilities within the County. Facility locations were determined using a Global Positioning System (GPS) and entered in the County's Geographical Information System (GIS). As part of the inventory, the County identified all drainage facilities within the unincorporated portion Clear/Clarks Creek Basin, including most of the pothole area. The drainage network in the City of Puyallup portion of the Clarks Creek basin is not included in the GIS database. *Tables 4-2 and 4-3* summarize the drainage facilities within the Clear/Clarks Creek Basin. The major constructed drainage systems and capital improvement projects (CIP) under construction or in design are described by subbasin in the sections that follow.

TABLE 4-2
Drainage Inventory of

Pipe or Culvert Diameter[a] (inches)	Length of Pipe (feet)	Number of Culverts	Length of Detention Pipes (feet)
≤ 12	77,000	391	-
12	338,000	2,677	400
18	55,000	167	30
24	25,000	67	1280
36	22,000	24	2670
48	8,000	34	680
Total	526,000	3,360	5,000

[a] Includes all pipes up to next nominal pipe size
[b] Pipes oversized to serve a detention purpose, also referred to as vaults.

TABLE 4-3
Drainage Facilities in Clear/Clarks Creek Basin

Facility Type	Number of Facilities
Detention Ponds	36
Infiltration Basins	22
Water Quality Treatment Ponds	1
Sedimentation Basin[a]	1
Bioswales[b]	15

[a] A pond whose primary function is to provide a quiescent environment that enables suspended particulates to precipitate out of the storm water.

[b] A treatment component of a drainage facility that uses a broad open channel with a gentle slope lined with vegetation to filter pollutants out of stormwater.

Clear Creek Basin – Drainage Facilities

Within the Clear Creek Basin, there are about 13 large storm drainage systems with pipe sizes 24 inches in diameter or greater, and many smaller pipes and channels/ditches conveying stormwater from roadways and developments to stream channels. Of these 13 large systems, six are located within the Swan Creek Basin, one is in the Squally Creek basin, two are in the Clear Creek subbasin, and four are in the Canyon Creek subbasin. Two of these storm drainage systems discharge into large subsurface detention pipes. There are also six large detention ponds and one sedimentation pond in the Clear Creek basin. The larger detention and conveyance systems are described below (see *Figure 4-8* for locations).

- Four large storm drain systems, ranging from 24 to 48 inches in diameter, collect and convey stormwater along Waller Road and adjoining areas, between SR-512 and 80th Street East, and route stormwater to four detention ponds (one for each system). They discharge the stormwater to Swan Creek.

- A large storm drain along 72nd Street East (24 to 30 inches in diameter) collects runoff from 72nd Street East and adjacent areas and conveys it to a 72-inch-diameter detention pipe that discharges to Swan Creek.

- An off-channel sedimentation pond was constructed in 1990 just upstream of Pioneer Way at Swan Creek to remove the sediment and gravel that was conveyed down the canyon and formerly blocked culverts.

- A 52-inch-diameter storm drain conveys the East Fork of Clear Creek under a large substation between 84th Street East and 80th Street East.

- At the intersection of Canyon Road and Pipeline Road, Canyon Creek flows into the 24-inch storm drain that runs along Canyon Road to 84th Street East. The combined flows from Canyon Creek and the roadway runoff reenter the natural creek channel at 84th Street East. Over the road flooding at 90th Street East has necessitated an existing CIP project to raise 90th Street East and improve conveyance with compensating storage at 84th Street East (Canyon Creek Bypass Project No. D138-003, Pierce County, 2001).

- Squally Creek Detention Pond at 58th Street East and Waller Road East was constructed in 1995, D306, to control flooding and scour of the creek channel.

There are two flood gates at the mouth of Clear Creek at the Puyallup River. One is allowed to remain open to permit tidally influenced waters to extend into Clear Creek and Swan Creek and into constructed off-channel wetland areas. The tide gate closes at elevated river stages (TT/KCM, 2001). The other flood gate is a flap gate that permits Clear Creek to discharge into the river, but prevents river flood water from flooding behind the river levee by entering Clear Creek. When the river elevation becomes higher than the Clear Creek water level, the tide gate and flap gate close. Clear Creek has no discharge so flows back up and flood the areas between Pioneer Way and River Road. This area is has experienced considerable and repetitive losses. The flooding problems are discussed further in chapters five and six.

Drainage District 14 is located within the Clear Creek basin between 80th Street East and 121st Street East and between Vickery Avenue East and Portland Avenue East. The primary conveyance for this drainage district is Swan Creek (see *Figure 4-8*).

Clarks Creek Basin

Within the Clarks Creek Basin, about six large stormwater piping systems with diameters of 24 inches or greater exist, as well as numerous smaller pipes and channels that convey stormwater from roadways and developments to stream channels. Three of these six large systems are located in the Rody Creek subbasin, two in the Woodland Creek drainage area, and one in the lower reach of Clark Creek near the mouth. Three of these large piping systems are oversized detention pipes. There are also 17 large detention ponds and one infiltration basin in the Clarks Creek Basin. Descriptions the larger detention (see *Figure 4-8*) and conveyance systems follow:

- A 24-inch-diameter storm drain was constructed along Woodland Avenue in the upper reaches from just south of Pipeline Road and 104th Street East to SR-512. This storm drain conveys stormwater to a 36-inch-diameter detention tank and then to Woodland Creek at 100th Street East.

- A two-phase project is proposed along 112th Street East and Woodland Avenue East in the Woodland Creek subbasin to alleviate flooding and channel erosion. The first phase has been constructed. The second phase is pending property acquisition.

- A 24-inch to 30-inch storm drain collects and conveys stormwater from a residential neighborhood along 66th Avenue East to Diru Creek at 90th Street East.

- A 24-inch storm drain collects and conveys stormwater runoff from a residential neighborhood between 90th Street East and 84th Street East and routes the water to a detention pond in the subdivision before discharging into Diru Creek at 84th Street East.

- The Rody Creek Detention Facility, is located adjacent to Rody Creek at 90th Street East and 59th Avenue East. This facility functions as a stormwater infiltration basin for 660 acres.

Potholes Basin

In each pothole there is either a combination of independent stormwater systems or systems that transfers stormwater either out of the pothole to a facility in an adjacent pothole or transfers stormwater in a fairly complex manner. Such stormwater systems or facilities found in each of the 16 pothole subbasins may include a series of pipes, detention/retention ponds, floodplains or wetlands. However, there are unique stormwater facilities present; for example, bordering the 135th Street and 128th Street Pothole there is a large 72-inch diameter detention tank near the 132nd Street East and Meridian Avenue East intersection. Although the majority of stormwater pipes found in each pothole are 21-inch diameter or less, there is another larger storm drain trunk line which is situated along 122nd Avenue East near the intersection with 152nd Street East in the north section of the Springfield Pothole. This 24-inch diameter storm drain collects and conveys stormwater to a detention pond called Springfield Pond 3.

Over the past decade, State and County regulations have required the installation of stormwater management systems for new development. In the pothole areas, where there is no defined outlet for stormwater, the County has required that new developments retain all excess stormwater volumes on-site. As a result, new developments must infiltrate the additional stormwater runoff volumes created by new impervious areas. This poses a challenge if soils in a particular pothole are not conductive to infiltration.

In the potholes basin, infiltration ponds outnumber detention ponds. Detention ponds found in the basin were probably constructed before pothole regulations went into effect. See *Figure 4-8* for publicly owned ponds associated with each pothole.

The constructed drainage system within the Potholes Basin is largely an interdependent system. Development of a constructed drainage system has resulted in the conveyance of stormwater from internal potholes and depressions to a central location in each pothole. Each of the potholes stormwater conveyance networks are described below.

> 110th Avenue Pothole. No regional facilities have been constructed in the area. No flooding problems have been reported.
>
> 117th Avenue Pothole. No regional facilities have been constructed in the area. No flooding problems have been reported
>
> 128th Street Pothole. During significant rainfall events, a low-lying area on 128th Street East, east of Meridian Avenue East experiences flooding and frequent roadway overtopping. The road has been closed several times due to the inadequacy of an existing infiltration trench and numerous drywell systems in the basin.
>
> 135th Street Pothole. This basin lies west of Meridian and borders 94th Avenue East between 160th Street East and 128th Street East. The drainage area is composed of several interconnected wetlands/pothole areas. Stormwater generally overflows from filled depressions in a northerly direction to a small public infiltration pond near 128th Street East. During large rainfall events the system gets overwhelmed to the point where several roadways, private driveways, residential structures and septic systems begin to flood.

Upper 144th Street Pothole. Contributes to the South Hill pumping station. See South Hill Drainage Improvement section.

Lower 144th Street Pothole. Contributes to the South Hill pumping station. See South Hill Drainage Improvement section.

Afdem Pothole. Afdem Regional Stormwater Infiltration Facility, D325, is a reclaimed gravel pit that consists of a pretreatment pond followed by an infiltration pond. It is situated at the southern end of the Clarks Creek subbasin on the north side of 128th Street East at 86th Avenue East. Although the pond overflow during extreme storm events is to the Clarks Creek headwaters area, the Afdem facility currently serves approximately 1,200 acres of the Clover Creek Basin in addition to approximately 500 acres within the Clarks Creek drainage.

Alderwood Pothole. Stormwater from the Alderwood Pothole is channeled to Hemlock Pond and the South Hill Pump Station.

Black Swamp Pothole. The Black Swamp basin is approximately 339 acres in area. The terrain would best be described as rolling to undulating. Several low areas (depression storage areas) exist. The highest elevation achieved in the basin is about 440 feet while the lowest elevation is about 340 feet found in the pothole (1929 NGVD). The average slope of the land is approximately 2%,

The 1991 comprehensive stormwater management plan identified this area as a potential flood hazard area which held true during the 1996 and 1997 storm events. Several houses in the pothole experienced either flood damage or access problems. Through the scoping process it was determined the best way to deal with the flooding was to purchase homes that had significant flood damage. In 2002 (D133) two duplexes were purchased awaiting their removal for minor grading and fencing work yet to be completed.

Candlewood-Manorwood Pothole. The lowest elevations occur within the Candlewood residential area. To protect property, 21-inch storm drains convey stormwater to two infiltration ponds that were constructed by Pierce County in 1990.

Capital Pothole. No regional facilities have been constructed in the area. No flooding problems have been reported

Heritage Glen Pothole. A regional retention pond was constructed in 1995 in response to repetitive flooding in and around the Heritage Glen residential development.

Meridian Street Pothole. A Pierce County owned regional retention pond located near the northeast corner of the 144th Street East and Meridian intersection. The regional pond was built in 1990 in response to repetitive flooding on Meridian causing road closures and delays to traffic. The pond was designed for a 25-year event which at that time was the standard for Pierce County. In winter of 1997, the pond was overwhelmed and overtopped onto adjacent properties and caused another road closure on Meridian. Since the pond did not meet the current standard in 1997 of 100-year design it was put on the

Capital Facilities Plan (D147-003) for expansion. In 2000, the pond was expanded to accommodate the existing 100-year level of service.

South Central Pothole. Future connection to South Hill pumping station. See South Hill Drainage Improvement section.

Springfield Pothole. Future connection to South Hill pumping station. See South Hill Drainage Improvement section.

Tip Top Pothole. Before the South Hill pumping station project was built this pothole was receiving overflow from the Ates pond in the Alderwood pothole inundating a large portion of the pothole producing structural flooding. Since the pumping station has been built all of the overflows from Ates have been re-routed towards the pumping station which relieves the Tiptop pothole from previous flooding problems.

South Hill Drainage Improvements. The South Hill drainage improvement design report (URS, 2001) described several pothole subbasins within the South Hill Drainage Improvement Area—Upper 144th Street Pothole, Alderwood Pothole, South Central Pothole, Hemlock Pothole, and Springfield pothole. The design report recommended solutions to connect basins and relieve flooding that occurred during the winters of 1995/1996 and 1996/1997. The recommended solution, which has since been implemented, routes excess stormwater by gravity to Hemlock Ponds (A, B, and C) and then pumps via a new pumping station through a force main to an existing overflow pipeline from the City of Tacoma's McMillan Reservoir directly to the Puyallup River (URS, 2001).

Currently, the south hill pumping station receives stormwater from the Upper 144th Street Pothole, Alderwood Pothole and the Hemlock Pothole. The pumping station was designed to accommodate runoff from the South Central Pothole and Springfield Pothole but those basins are not presently connected. The Springfield Pothole project (D136-003) is currently on the Capital Facilities Plan as a pipeline project that would connect into the Hemlock ponds with construction in 2007. The South Central Pothole presently flows to the Springfield ponds but would need minor conveyance upgrades identified under the Springfield project.

Additional detailed descriptions of past improvements and/or future improvements can be found in the South Hill Drainage Improvement Design Report (URS 2001).

Roosevelt Ditch Drainage Area

In the Roosevelt Ditch subbasin, ditch and culvert systems are primarily used to capture and convey runoff from residential areas. These systems drain to natural channels within Roosevelt Ditch or to enclosed storm drain pipe systems on Portland Avenue and 72nd Street East. A 24-inch diameter storm drain conveys runoff west of Portland Avenue to Roosevelt Ditch to the east (see *Figure 4-8*). At 72nd Street East within the City of Tacoma, Roosevelt Ditch drains to a 48-inch diameter concrete pipe that conveys water through the City of Tacoma T-Street Gulch drainage facilities to the Puyallup River.

4.3.4 Stream Flow Characteristics

The geography, hydrology, and geology of the three basins significantly affect stream flow characteristics. In the glacial till headwaters of Clear and Clarks Creeks, stream channels have gentle slopes and adjacent wetlands and low areas provide water storage (USGS, 1994). Most stream channels in the upper reaches have little or no surface flow from late May through September. Streams have been channelized and are best characterized as grassy ditches. Some of this upland area has potential for groundwater recharge, as evidenced by the gaining nature of the floodplain reaches of the streams (habitat field survey) and information from previous studies (USGS, 1994).A gaining stream is a stream in which flow is increasing due to groundwater inflow.

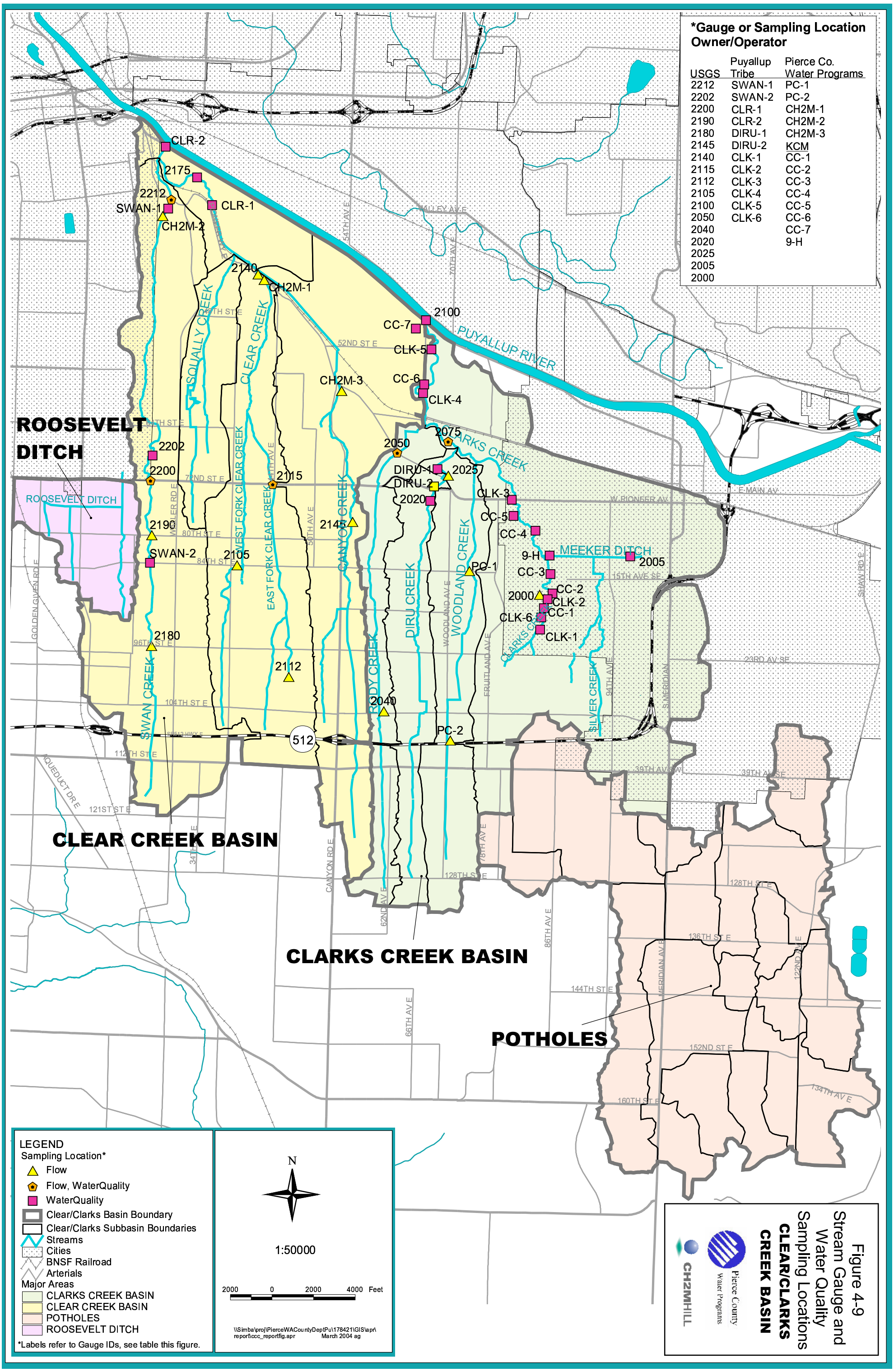
In the middle sections, streams enter deeply entrenched ravines with actively down-cutting channels. During a study of the basins in the early 1990s, USGS observed that the steep slopes provide little storage capacity, resulting in increased stream flow velocities and quick responses to rainstorms (USGS, 1994). USGS also noted that as the streambeds cut through the till hardpan layers and expose the permeable substratum, stream flows are lost throughout the channel bed, which helps recharge the groundwater aquifer (USGS, 1994).

Stream flows reappears in the floodplain reaches of the streams from springs or seeps in the sides of the channels. Clarks Creek is an extreme example; flows observed during the habitat field survey in May 2001 increased from one cubic foot per second (cfs) to about 30 cfs within several hundred yards of Maplewood Springs**.**

In-stream flow is important to water quality because the natural continuous flow of the stream provides habitat to riparian life. Streambeds shaped by the meandering flow of the water are better equipped to handle high flows without extreme erosion. Channelized streams that do not experience regular flow have increased occurrences of scouring and erosion increasing the turbidity of the water.

Stream Flow Monitoring

Stream flow monitoring provides the most accurate means of characterizing hydrologic and water quality conditions in the streams. Stream flow measurements can be used to validate hydrologic models, compute long-term streamflow statistics, and analyze trends in water quality. For this reason, Pierce County Water Programs has established a measurement and water quality monitoring programs to supplement ongoing and past measurement efforts by the USGS and others. *Table 4-4* lists the stations where stream flow is measured, including the station identification code, the period of record for the historical and active USGS flow gauges, the two active Pierce County flow gauges, and the three active flow gauges installed by CH2M HILL as part of this study. The table also lists some USGS water quality sampling stations. *Figure 4-9* depicts the locations of all these stations. A description of the flow data follows.


*Gauge or Sampling Location Owner/Operator
USGS | Puyallup Tribe | Pierce Co. Water Programs
2212 SWAN-1 PC-1
2202 SWAN-2 PC-2
2200 CLR-1 CH2M-1
2190 CLR-2 CH2M-2
2180 DIRU-1 CH2M-3
2145 DIRU-2 KCM
2140 CLK-1 CC-1
2115 CLK-2 CC-2
2112 CLK-3 CC-3
2105 CLK-4 CC-4
2100 CLK-5 CC-5
2050 CLK-6 CC-6
2040 CC-7
2020 9-H
2025
2005
2000
ROOSEVELT DITCH
CLEAR CREEK BASIN
CLARKS CREEK BASIN
POTHOLES
PUYALLUP RIVER
MEEKER DITCH
SQUALLY CREEK
CLEAR CREEK
CLARKS CREEK
CANYON CREEK
DIRU CREEK
WOODLAND CREEK
SWAN CREEK
SILVER CREEK
LEGEND
Sampling Location*
Flow
Flow, WaterQuality
WaterQuality
Clear/Clarks Basin Boundary
Clear/Clarks Subbasin Boundaries
Streams
Cities
BNSF Railroad
Arterials
Major Areas
CLARKS CREEK BASIN
CLEAR CREEK BASIN
POTHOLES
ROOSEVELT DITCH
*Labels refer to Gauge IDs, see table this figure.
N
1:50000
2000 0 2000 4000 Feet
\\Simba\proj\PierceWACountyDeptPu\178421\GIS\apr\report\ccc_reportfig.apr March 2004 ag
Figure 4-9
Stream Gauge and Water Quality Sampling Locations
CLEAR/CLARKS CREEK BASIN
Pierce County Water Programs
CH2MHILL

USGS Stream Flow Data

Historical stream flow data have been collected in the Clear/Clarks Creek Basin since 1946, primarily by USGS. Over the years, USGS has installed and operated 17 stream flow gauges. As noted in *Table 4-4*, some stations measure continuous flow, while others measure only peak flows. Since 1946, eight continuous flow gauges have been installed, two of which are currently active: Station 12102075 on Clarks Creek at Tacoma Road and Station 12102190 on Swan Creek at 80th Street East. The Swan Creek station is a seasonal station that does not record flows all year.

Of the 17 historical stream flow gauges in the basin, 12 recorded flows from October 1989 to September 1991. Four of these gauges were intended to measure flows continuously, while the remaining eight were installed to measure peak flows only. *Table 4-4* lists these sites. USGS used flow data from these stations to calibrate and validate their HSPF model of the Clear/Clarks Creek Basin, as part of their 1994 study, *Surface Water Hydrology and Runoff Simulations for Three Basins in Pierce County, Washington* (USGS, 1994). The study was completed in cooperation with the Pierce County Department of Public Works (1) to describe rainfall-runoff processes within the study area, and (2) to develop a simulation model for use as a predictive tool to estimate changes in runoff characteristics versus changes in land uses. Application of this model is described in Section 6.1.

As mentioned previously, USGS still maintains two active stream flow gauges: one on Clarks Creek and one on Swan Creek. The Swan Creek gauge is seasonal, and USGS does not publish yearly statistics on the gauge. They publish yearly statistics for the Clarks Creek continuous flow gauge (Station 12102075). A continuous flow gauge on Clear Creek (Station 12102140, Clear Creek at Pioneer Way below the Fish Hatchery) operated from 1989 to 1998, and was discontinued in 1998. These two continuous flow stations have the most flow data of any of the USGS stations in the Clear/Clarks Creek Basin.

*Table 4-5 l*ists the monthly and annual flow statistics for these two stations**.** For the period of record, the Clarks Creek site shows a mean flow of 66.3 cfs, while the Clear Creek site shows a mean annual flow of 11.9 cfs. Although Clear Creek has a larger drainage basin area than Clarks Creek (12.8 square miles versus 10.8 square miles), it appears that groundwater influences on Clarks Creek are more significant than on Clear Creek due to the mean higher flows. Another reason for the variation in mean flows could be that Clarks Creek is more developed, and has a higher overall EIA value than Clear Creek (see Section 4.4, Land Use). It is important to note that the Clear Creek gauge is *upstream* of the confluence with Swan Creek.

TABLE 4-4
List of Active and Historical Stream Gauges

Station No.	Station Description	Type	Status	Period of Record	Operating Agency	Drainage
12102000	Clarks Creek at Puyallup, WA	CF	Inactive	March '46 to May '48	USGS	Clarks Creek
12102005	Meeker Ditch at 7th Street SW at Puyallup, WA	WQ	Inactive	Aug '98	USGS	Meeker Ditch
12102020	Diru Creek at Inflow to Hatchery near Puyallup, WA	WQ	Inactive	Aug '83	USGS	Diru Creek
12102025	Diru Creek below Hatchery and Pioneer Way East Near Puyallup	CF	Inactive	Oct. '89 to Sept. '91	USGS	Diru Creek
12102040	West Fork Clarks Creek at 104th Street East Near Puyallup, WA	PF	Inactive	Oct. '89 to Sept. '91	USGS	Rody Creek
12102050	Clarks Creek trib at Pioneer Way East near Puyallup, WA	PF,WQ	Inactive	PF: Oct '89 to Sept '91 WQ: Aug '83 to Aug '84	USGS	Rody Creek
12102075	Clarks Creek at Tacoma Road East Near Puyallup, WA	CF,PF,WQ	Active	CF: Mar '95 to Present PF: Oct '92 to Sept '95 WQ: Aug '83 to Aug '84	USGS	Clarks Creek
12102100	Clarks Creek at River Road East Near Puyallup	WQ	Inactive	Aug '83 to Aug '98	USGS	Clarks Creek
12102105	West Fork Clear Creek at 84th Street East Near Tacoma, WA	PF	Inactive	Oct. '89 to Sept. '91	USGS	Clear Creek
12102112	East Fork Clear Creek at 100th Street East Near Tacoma, WA	PF	Inactive	Oct. '89 to Sept. '91	USGS	Clear Creek
12102115	East Fork Clear Creek at 72nd Street East Near Tacoma, WA	PF,WQ	Inactive	PF: Oct '89 to Sept '91 WQ: Nov '83 to Feb '84	USGS	Clear Creek
12102140	Clear Creek at Pioneer Way East Below Hatchery Near Tacoma, WA	CF	Inactive	Oct. '89 to Sept. '91 Apr. '95 to Sept '98	USGS	Clear Creek
12102145	Canyon Creek at 77th Street East Near Tacoma, WA	PF	Inactive	Oct '89 to Sept. '91	USGS	Canyon Creek
12102175	Clear Creek at 31st Ave Ct. East, Tacoma, WA	WQ	Inactive	Aug. '83 to Aug. '98	USGS	Clear Creek
12102180	Swan Creek at 96th Street East Near Tacoma,	PF	Inactive	Oct. '89 to Sept. '91	USGS	Swan Creek

TABLE 4-4
List of Active and Historical Stream Gauges

Station No.	Station Description	Type	Status	Period of Record	Operating Agency	Drainage
	WA					
12102190	Swan Creek at 80th Street East, East Near Tacoma, WA	CF	Active	Oct. '89 to Sept. '91 Oct. '94 to Sept. '97 Oct. '97 to Present (Seasonal)	USGS	Swan Creek
12102200	Swan Creek Near Tacoma, WA	PF,WQ	Inactive	PF: Feb '51 to Sept. '91 WQ: Nov. '83	USGS	Swan Creek
12102202	Swan Creek at Flume Line Road	WQ	Inactive	Nov. '83 to Apr. '84	USGS	Swan Creek
12102212	Swan Creek at Pioneer Way East, Tacoma, WA	CF, WQ	Inactive	CF: Oct. '89 to Sept. '91 WQ: Aug '83 to Aug '98	USGS	Swan Creek
PC-1	Woodland Creek at 84th Street East	CF	Active		PC	Woodland Creek
PC-2	Woodland Creek at SR 512	CF	Active		PC	Woodland Creek
CH2-1	Clear Creek - Upstream of Pioneer Way East and Below Hatchery Near Tacoma, WA	CF	Active	July 2001 -present	CH2M HILL	Clear Creek
CH2-2	Swan Creek Upstream of Pioneer Way East	CF	Active	July 2001 -present	CH2M HILL	Swan Creek
CH2-3	Canyon Creek Upstream of Pioneer Way East	CF	Active	July 2001 -present	CH2M HILL	Canyon Creek

TABLE 4-5
Statistics of Monthly Mean Data for Water Years 1989-1998 (Discharge [cfs])

	12102075 Clarks Creek at Tacoma Road			12102140 Clear Creek at Pioneer Way Below Fish Hatchery	
Month	Mean	Maximum	Minimum	Mean	Maximum
October	59.9	68.0	46.9	9.3	13.8
November	66.8	72.2	58.3	12.7	18.9
December	72.2	84.3	61.3	15.4	28.2
January	72.6	83.3	57.2	18.8	35.3
February	74.9	88.8	63.6	15.9	34.0
March	66.1	87.6	42.3	12.2	18.2
April	69.3	82.3	47.1	12.0	16.2
May	62.9	77.6	41.0	9.4	11.3
June	55.3	67.9	37.6	9.1	10.0
July	53.3	65.0	42.1	8.9	10.1
August	56.0	66.3	42.8	8.6	10.0
September	56.4	64.6	42.2	8.4	10.4
Period of Record	66.3	N/A	N/A	11.9	N/A

Source: USGS, 1998, 2000

Swan Creek makes up a large component of the overall Clear Creek flows at the mouth, and is not represented by the stream flow measurements taken at Station 12102140. The Clarks Creek gauge is downstream of three of the four subbasins. Therefore, most of the drainage area is captured by the Clarks Creek gauge.

Pierce County Stream Flow Data

Pierce County Water Programs operates two stream flow gauges on Woodland Creek. These gauges are listed in *Table 4-4* and shown on *Figure 4-9*. The downstream gauge is located at Woodland Creek and 84th Street East, and the upstream gauge is located at SR 512. The gauges were installed to provide flow volume and fluctuation information to enable the design of capital improvement projects to alleviate flooding along Woodland Creek.

Pierce County also operates four water-level recording gauges at the following locations:

- 144th Street Pothole
- Hemlock Pothole
- Afdem Pond
- Ates Pond

These water level gauges were installed to support current and future CIP project development in these pothole areas to alleviate flooding.

As part of the Clear/Clarks Creek Basin characterization, three recording flow gauges were installed and have been operating since late July 2001. *Table 4-4* lists the stream gauge locations and *Figure 4-9* shows the gauging locations. A typical stream gauge installation is shown in *Appendix "F"*. Information about these gauges is presented as follows:

- **Clear Creek Location**. This stream flow gauge was installed on July 20, 2001, at the site of a discontinued USGS stream flow gauge (Station 12102140) located just upstream of Pioneer Way and below the Trout Lodge Fish Hatchery. CH2M HILL made flow measurements at stages up to 20 cfs. Comparison of these measurements to an existing flow rating curve developed by USGS indicates that the USGS curve is still valid for rating flow in this reach. The reach in this location is relatively flat and uniform. Backwater from the Puyallup River floodplain and the Pioneer Way East culvert may impact the quantity of the stream flow data for very high flows.

- **Canyon Creek Location.** This stream flow gauge was installed on July 20, 2001, approximately 100 feet upstream of Pioneer Way East on the east side of Canyon Road East. The reach in this location is relatively flat and uniform. Backwater from the Pioneer Way culvert will extend to this reach but is not expected to affect the stage measurements. The gauge was moved approximately a forth of a mile upstream to the west side of Canyon Road East.

- **Swan Creek Location**. This stream flow gauge was originally installed in Swan Creek Park on July 20, 2001, approximately 1,000 feet upstream of Pioneer Way East. High flows in December 2001 resulted in channel scour and deposition of a gravel bar at the location of this gauge. On February 14, 2002, the gauge was relocated to approximately 200 feet above Pioneer Way East, below the bypass flow from the sediment pond.

Stream flow was measured at each monitoring station using a wading rod with Price AA or pigmy flow meter and techniques described in *Techniques of Water-Resources Investigations of the United States Geological Survey - Discharge Measurements at Gauging Stations* (USGS, 1984). These vertical axis flow meters were used to measure flow velocity in feet per second. Velocity was obtained by recording the revolutions of the meter cups for an interval of time. Stream flow measurement consisted of establishing a stream cross-section with a tape marked in feet. The wading rod and meter were used to record stream depth and velocity at selected intervals or cells across the stream channel. The stream flow in cubic feet per second for each cell was calculated and then totaled to obtain the total stream flow at that cross-section.

A flow rating curve was developed for Swan and Canyon Creeks by plotting measured flow against stream level. An equation for the resulting curve was used to translate average daily stream level data into average daily flow data. Flow measurements at the Clear Creek Station were used to verify an existing rating curve for a discontinued USGS stream gauging station at that location. The resulting flow statistics and measurements are presented in *Appendix "F"*.

Stream Flow Predictions

Some of the data collected by USGS have been used by the Federal Emergency Management Agency (FEMA) to develop tables showing varying levels of peak discharge throughout the Clear/Clarks Creek system. Flood profiles and floodplain boundaries were established by FEMA

using some of these tables, and are presented in *Flood Insurance Study for Pierce County, Washington* (FEMA, 1987). As part of the Flood Insurance Study, a hydrologic analysis was conducted to estimate peak discharge-frequency values. *Table 4-6* summarizes the results of the peak discharge values for the Clear/Clarks Creek Basin.

The Washington State Hydraulic Manual (WSDOT, 1997) lists USGS gauges that have adequate data to develop recurrence interval storm flows. A statistical analysis (most frequently Log Pearson Type III) is performed on the measured flows to predict the recurrence interval storm event flows (2-, 10-, 25-, 50-, and 100-year). The only gauge in the Clear/Clarks Creek Basin listed in the WSDOT tables is USGS station no. 12102200 at Swan Creek. *Table 4-6* lists the peak recurrence flows.

TABLE 4-6
Peak Discharge Frequency Relationships

Location	Peak Computed Discharge (cfs)					
	2-year	10-year	25-year	50-year	100-year	500-year
USGS Station 12102200 - Swan Creek	117	190	230	262	294	NM
Swan Creek -mouth[b]	NM	172	NM	222	244	293
Squally Creek - mouth[b]	NM	23	NM	31	34	43
Clear Creek - mouth[b]	NM	98	NM	134	151	188
Clear Creek - Pioneer Way[b]	NM	52	NM	70	79	98

[a] Source: WSDOT, 1997
[b] Source: FEMA, 1987
NM = not measured

4.3.5 Floodplains

The Federal Emergency Management Agency (FEMA) mapped the 100- and 500-year floodplain in the Clear/Clarks Creek basin in 1987. The 100-year floodplain is the area that is estimated to be flooded every 100 years on average. Similarly, the 500-year floodplain is the area that is estimated to be flooded every 500 years on average.

Table 4-7 lists the amount of floodplain in the Clear/Clarks Creek basin. Floodplains are also shown on *Figure 4-10*. Detailed floodplain analysis, for the purpose of establishing a regulatory Base-Flood Elevation (BFE), was performed by FEMA for Swan Creek from the Clear Creek Confluence to 64th Street East, Squally Creek from the Clear Creek confluence to about 52nd Street East (extended), and on Clear Creek from the Puyallup River Confluence to about 72nd Street East (FEMA, 1987). NHC completed a restudy of Clear Creek in 2002 and a restudy of Swan Creek and Clarks Creek is planned for 2004. The remaining floodplain area shown on *Figure 4-10* was mapped using FEMA approximate

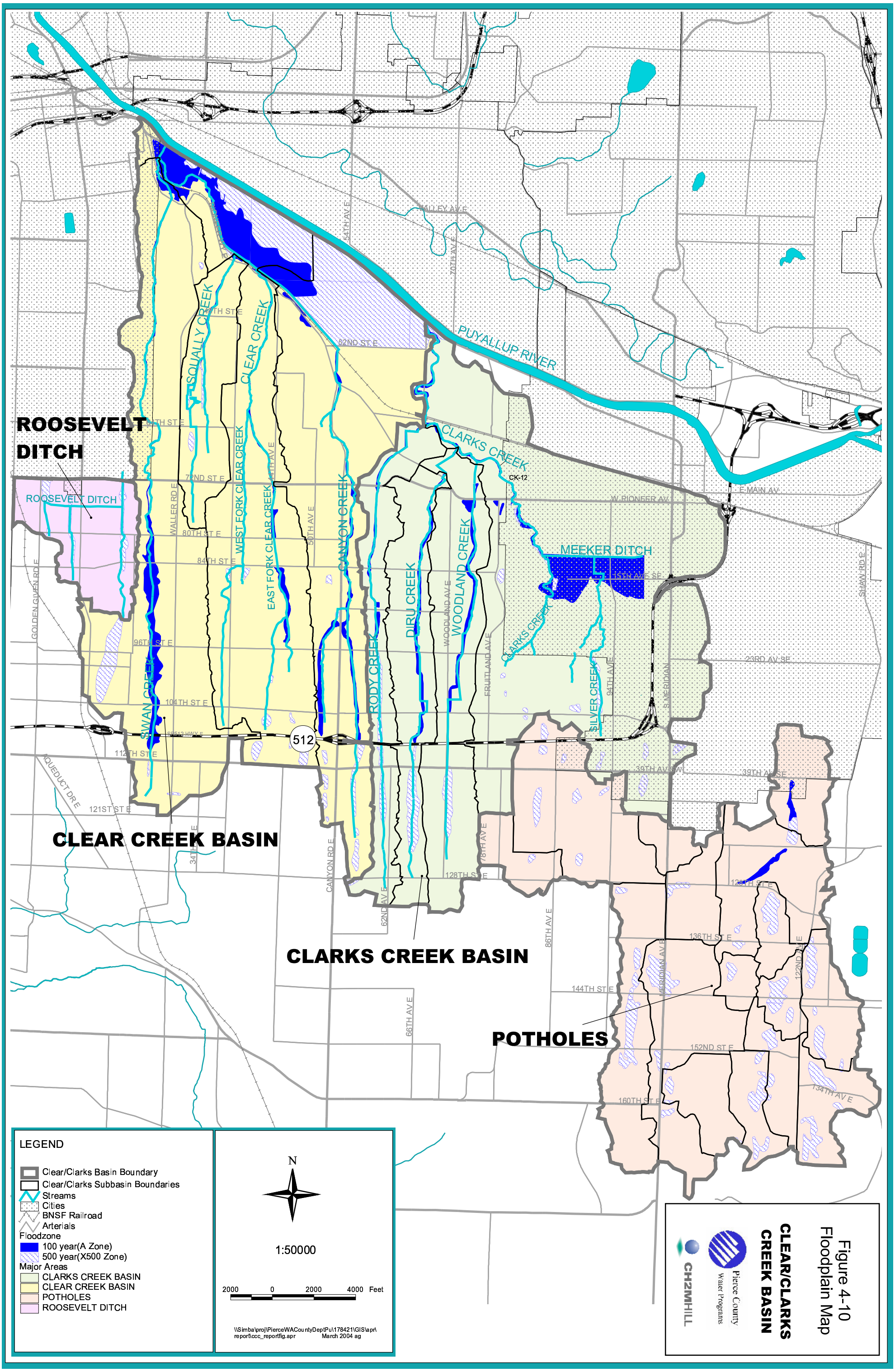


Figure 4-10
Floodplain Map

TABLE 4-7
Summary of 100- and 500-Year Floodplain in Clear/Clarks Basin

	100-Year		500-Year		Total Floodplain	
Subbasin Name	Floodplain Area in Subbasin (acres)	% of Floodplain in Subbasin	Floodplain Area in Subbasin (acres)	% of Floodplain in Subbasin	Floodplain Area in Subbasin (acres)	% of Floodplain in Subbasin
Roosevelt Ditch			41.6	6.5	41.6	6.5
Swan Creek	150.6	6.1	57.8	2.3	208.4	8.4
Squally Creek	4.6	0.8	13.7	2.3	18.3	3.0
Clear Creek	261.7	10.7	214.6	8.8	431.3	17.6
Canyon Creek	139.6	5.4	471.9	18.2	611.5	23.6
Rody Creek	26.5	3.6	37.5	5.0	64.0	8.6
Diru Creek	42.0	5.0	43.5	5.2	85.6	10.3
Woodland Creek	47.3	4.1	25.3	2.2	72.6	6.2
Clarks Creek	241.5	5.8	52.5	1.3	294.1	7.1
110th Avenue Pothole			8.6	3.2	8.6	3.2
117th Street Pothole	14.1	2.4	12.4	2.1	26.5	4.6
128th Street Pothole			8.7	3.5	8.7	3.5
135th Street Pothole			52.5	8.6	52.5	8.6
Lower 144th Street Pothole			30.0	20.1	30.0	20.1
Upper 144th Street Pothole			44.9	14.3	44.9	14.3
Afdem Pothole			2.4	1.2	2.4	1.2
Alderwood Pothole			38.8	12.6	38.8	12.6
Black Swamp Pothole			30.9	3.9	30.9	3.9
Candlewood-Manorwood Pothole	8.8	2.9	5.6	1.9	14.4	4.8
Capital Pothole					0.0	0.0
Heritage Glen Pothole			6.6	6.5	6.6	6.5
Meridian Pothole			46.9	6.5	46.9	6.5
South Central Pothole			33.7	16.1	33.7	16.1
Springfield Pothole			16.5	7.4	16.5	7.4
Tip Top Pothole			26.3	17.3	26.3	17.3
Total	**937.8**	**4.5**	**1323.3**	**6.3**	**2261.2**	**10.8**

Floodplains are shown on Figure 4-10.

hydrologic and hydraulic methods. Approximate methods are FEMA accepted alternatives to detailed study of flood plains. Typically, regulatory BFEs are not established in areas analyzed using approximate methods. Because approximate methods were used to establish much of the original floodplain, it is likely that the floodplain is more extensive than indicated on *Figure 4-10* and in *Table 4-7*.

Figure 4-10 shows that extensive floodplain area exists in the Clear/Clarks Creek basin. Generally, the floodplain covers a more extensive area in the lower elevations of the Puyallup River valley. The extent of floodplain in the valley is strongly influenced by the flood condition in the Puyallup River in addition to the large volume of water discharging from the creeks during flood events. Floodplains in the canyon reaches are narrow due the steepness of the creeks in these reaches. In reaches located in the upland plateau area, the floodplain widens due to the relatively flat, poorly draining soils and wetlands.

Floodplains in the pothole subbasins are usually found at the lowest elevations of the pothole. Although many of the potholes are mapped as 500-year floodplains, floodwaters may still cause some flooding in the depressions during more frequent storm events. *Figure 4-10* shows the potholes with mapped floodplains.

Table 4-7 shows that floodplain covers over 10 % of the basin. A review of the data in *Table 4-7* shows that nearly 70 % of the floodplain area is contained within the Swan, Clear, Canyon, and Clarks Creek subbasins. *Figure 4-10* shows that a significant portion of the 500-year floodplain occurs in the upland plateau area of the Clear and Clarks Creek basin and also in the pothole area.

4.3.6 Groundwater

The USGS recently performed an extensive study of groundwater hydrology in the Clear Clarks Creek Basin (USGS, 1999). In this study, they found that approximately 38 % of the annual precipitation enters the groundwater system as recharge. One-third of the 38 % (or about 12 % of the total rainfall) is withdrawn from wells. The eastern and northern parts of the basin have the highest recharge rate at more than 15 inches a year, an area that generally corresponds to the distribution of the Alderwood-Everett and Puyallup-Sultan soils shown on *Figure 4-2*. The recharge rate for remaining parts of the basin has been estimated at between 5 to 15 inches per year. The latter area generally corresponds to the Kapowsin soils also shown on *Figure 4-2*.

The USGS study also found that groundwater generally moves from the higher elevations of the upland areas of the basin to the Puyallup River. Groundwater moves in a series of five aquifers separated by confining layers of soil. The upper two aquifers contribute significantly to stream flow. The lower three aquifers contribute little or no water to the creeks. The uppermost aquifer is shallow and unconfined. It is located in outwash deposits at the land surface in the northern and eastern part of the basin. Water from the uppermost aquifer discharges to the creeks through seeps and springs where the outwash layer intersects the stream channel. A semi-confining till layer is located below the upper aquifer. This till layer is exposed at the land surface in the western part of the basin. The semi-confining till layer overlays another aquifer. Water from this confined aquifer discharges to the creeks where it is exposed in the incised reaches of the creeks and the canyon walls. Spring water from this aquifer supplies public water most notably at

Maplewood Springs. Although, most of the discharge from this aquifer occurs within the Clear/Clarks basin, a portion of the aquifer underlying the pothole area flows to the Mid-Puyallup Basin and into the Puyallup River.

In a separate analysis, the USGS (1994) performed a numerical analysis of groundwater contributions to the streams. The results of this analysis indicated that substantial flows during low-flow periods were from groundwater recharge.

Similar groundwater effects were also reported by Ecology (1999). The Ecology report studied the interaction between groundwater and surface water for selected streams in the State of Washington. Data from active and discontinued USGS stream gauging stations were used to assess the groundwater component of the stream flows. Contributions to base stream flow were estimated using a hydrograph separation software program to divide the stream hydrograph into a base flow component and a surface runoff component (Ecology, 1999). Only one station was used to compute base flows for the Clear/Clarks Creek Basin: USGS Station 12102140, Clear Creek at Pioneer Way. *Table 4-5* summarizes the monthly mean and annual flow data for Station 12102140. The data suggests that at least for Swan Creek, the base flows estimated by Ecology represent the majority of stream flows from May through October.

4.4 Aquatic and Riparian Habitat

The geography, hydrology, and geology of the two adjacent watersheds have a profound effect on the character and productivity of the resulting habitat. The Clear and Clarks Creek watersheds can both be easily divided into three sections: upper, middle, and lower. The upper sections are hilly and only moderately sloped. The middle sections are deeply entrenched ravines with actively down-cutting channels. In general, the lower sections are in the floodplain of the Puyallup River and are low gradient, channelized, and ditch-like. The upper watersheds are moderately built-out, and hydrology is related to the amount of impervious surface. The upper watersheds have little or no surface flow from late May through September. Stream channels have been highly channelized and are best characterized as grassy ditches. This is also an area of potential groundwater recharge evident by the gaining nature of the streams (described in Section 4.3.5)

In general, riparian communities in the upper watersheds are composed of grasses, pasture, black berries, and ornamental plants. The middle or canyon sections are forested with Douglas fir, Sitka spruce, big leaf maple, and alder, with an understory of salmonberry, elderberry, blackberry, and Indian plum. Because the canyons are generally steep and deep, the riparian buffers are fairly wide. The size of the firs found throughout the canyon reaches suggest that they are about 50 years old.

4.4.1 Historical Fish Presence

Clear Creek supports five species of salmonids: chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), steelhead trout (*O. mykiss*), and cutthroat trout (*O. clarki*) (Don Nauer, WDFW area habitat biologist, personal communication, 2001; Russ Ladley, Puyallup Tribe fisheries biologist, personal communication, 2001). Cutthroat trout are likely to be present in both the anadromous and resident forms. Chinook use spawning habitat in

Clear and Swan Creeks in the vicinity of Pioneer Way, and perhaps a short distance upstream. Stream flows in Canyon Creek is too low during the period when chinook are present to provide spawning habitat. *Figure 4-11* shows the fish presence in the Clear/Clarks Creek basin.

Coho use all of the subbasins to varying degrees. All the coho in Clear Creek and its tributaries are natural populations, and their distribution extends up to a private fish hatchery weir. In Swan Creek, coho distribution probably extends at least 0.5 mile upstream of Pioneer Way East. Estimated coho escapement is in the range of 50 in Clear and Swan Creeks, about 15–20 in Diru Creek, and perhaps less in Rody and Canyon Creeks. Steelhead are said to be present in small numbers in Clear Creek and all of its tributaries (Don Nauer, 2001, personal communication; Russ Ladley, 2002, personal communication).

Chum salmon are the dominant salmonid in the Clear Creek system. About 300 chum spawned in Swan Creek in 2001–2002 in the vicinity of Pioneer Way East, extending upstream to the old water diversion weir (about one mile upstream of Pioneer Way East). In Clear Creek, chum spawn in the hundreds up to the private hatchery weir. Canyon Creek is too steep for chum, except at Pioneer Way, and too flat (with a sand bottom) along the lower reach (Ladley, 2002, personal communication). Squally Creek is said to have significant chum utilization from its confluence with Clear Creek up to Pioneer Way (Russ Ladley, 2001, personal communication).

The Clarks Creek Basin also supports chinook, coho, and chum salmon, and steelhead and cutthroat trout. The Clarks Creek mainstem contains nearly all of the spawning and rearing habitat in the system. Excellent spawning and fair to good rearing conditions are present in the 0.5-mile-long reach between Maplewood Springs and Meeker Ditch. Meeker Ditch is significant in that it drains the Puyallup Fairground and surrounding area, which is highly developed. Channel substrate conditions upstream of Meeker Ditch are clean gravels and cobbles and very clean clear water. Below Meeker Ditch, the water is turbid and the substrate is about 95 % sand or finer grain sizes. In the short section of usable stream channel in Clarks Creek, about 1,000–3,000 chum, 300–500 coho, 300–400 chinook, and 100 steelhead spawn. Some of the rearing juveniles are probably displaced downstream and into Rody and Diru Creeks because the rearing capacity of Clarks Creek is far less than the number of eggs that are deposited.

Rody Creek is used by a few coho and steelhead, but supports about 100 chum spawners downstream of Pioneer Way. Diru Creek is very small, but experiences the escapement of up to 10,000 chum salmon adults due to hatchery releases. In addition, about 15–20 coho, 300 chum, a few steelhead, and a few chinook spawn naturally in the Rody Creek. Generally stream flows in Diru and Rody Creeks are too low during the period when chinook are present to provide spawning habitat.

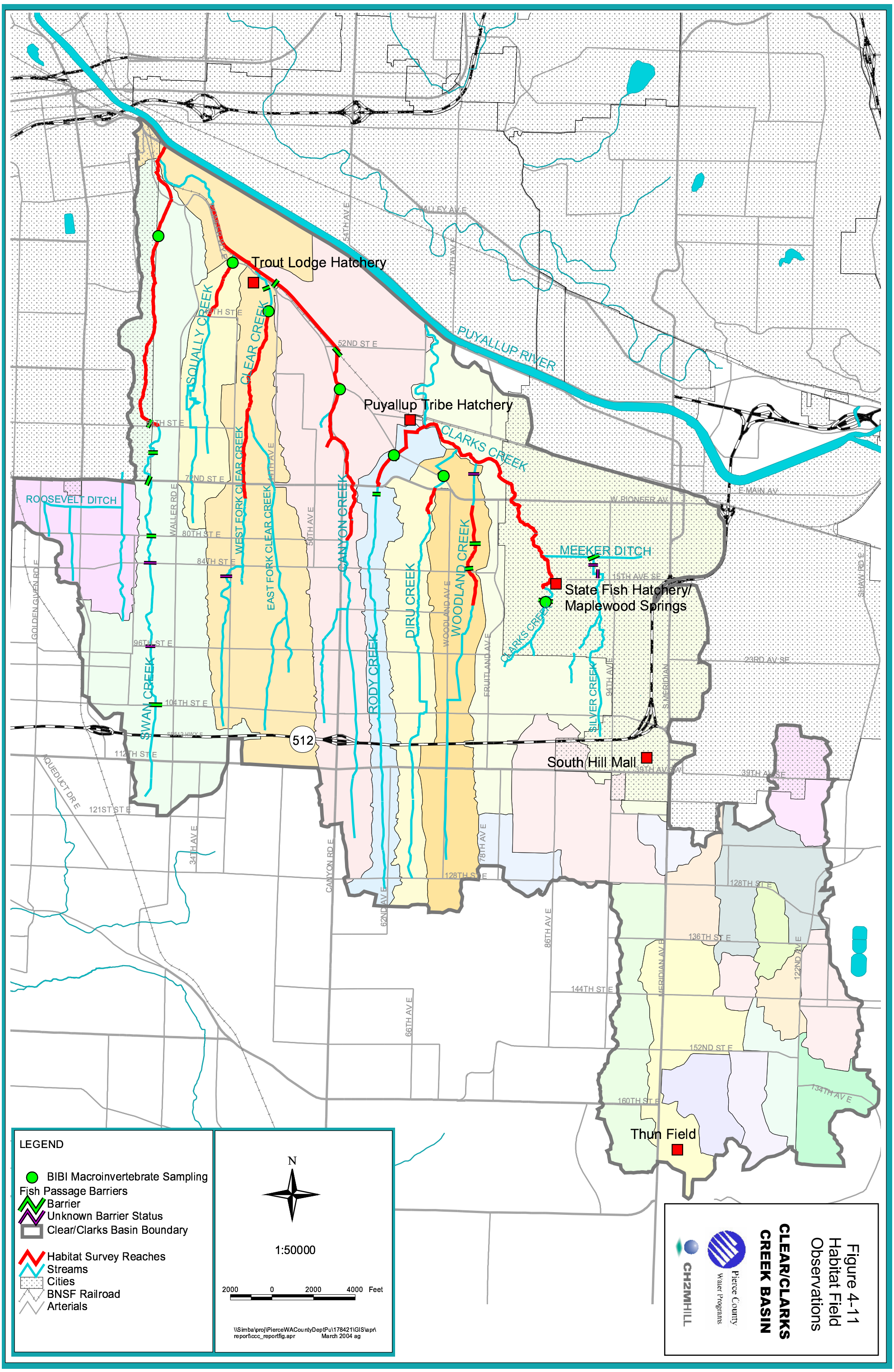


Figure 4-11
Habitat Field Observations

In Clear Creek, 7 pools totaling 195 feet of pool habitat exist. This equates to 2 % of pool habitat.

No more than five pools were observed in each of Rody, Woodland, and Canyon Creeks. Each pool is the result of anthropogenic structures. A small concrete wall on Rody Creek forms a plunge pool. A small detention pond north of Canyon Road East and 72nd Street East exists on Canyon Creek. An excavation for irrigation on Woodland Creek created a pool just south of Pioneer Way East.

Riparian Cover

Most of the ravines in the Clear/Clarks Creek Basin are undeveloped, probably due to the steepness of the side slopes, critical areas regulations and, in some cases such as Swan Creek Park, preservation as green spaces. As a result, the ravines provide a higher quality riparian habitat than is usually seen in urban streams. The width of the riparian corridor is closely related to the width of the ravine that contains the stream, with Swan Creek and Clear Creek having the largest riparian corridors, and Woodland Creek and Clarks Creek having the smallest. In Clarks Creek, almost no riparian corridor exists downstream of DeCoursey Park in the City of Puyallup. On Woodland Creek, the riparian cover is a patchwork of various types that changes dramatically as the creek flows from one private property line to the next.

The dominant riparian vegetation above Pioneer Way East is mixed, 40–50-year old, second-growth conifers and deciduous hardwoods. While conifers are often present, they rarely are the dominant vegetative species. Hardwoods, predominantly alder and occasionally cottonwood, are the dominant riparian species. Similarly, hardwood-type large woody debris (LWD) in the stream channel outnumbers conifer LWD (see LWD discussion below). Salmonberry, elderberry, Indian plum, and blackberry are the dominant shrub species. Some invasive species such as reed canary grass and Japanese knotweed are also present, but are only a minor component of the vegetation.

As with channel type, riparian cover downstream of Pioneer Way East changes dramatically. Agricultural practices, flood control practices, and residential landscaping have removed almost all native riparian vegetation. Most of the ditched stream channels in this section are lined with invasive species such as Himalayan blackberry and reed canary grass. The springs that support perennial flows also provide a cool water source that compensates somewhat for the lack of riparian cover. Riparian cover provides shade that keeps the water at a cool temperature. Cool, clean water is essential for migrating fish. Shade also prevents invasive species such as reed canary grass from taking root. Native riparian vegetation also plays an important role in stream bank stabilization.

LWD and LWD Recruitment

LWD data are summarized in *Table 4-9*, LWD Statistics per Stream. LWD and key LWD pieces were rarely observed in the stream reaches surveyed. Swan Creek and Clear Creek both had the highest instream LWD counts and LWD recruitment potential. Using the USBEM method, LWD was defined as pieces of wood within the bankfull stream height that are at least 10 inches in diameter and at least 10 feet long. Key LWD pieces were also identified. Key pieces are pieces large enough to cause significant channel-forming hydraulics. The size requirements for key

Salmon populations in Clear and Clarks Creeks are significantly influenced by hatchery releases. There are three hatcheries within the Clear/Clarks Creek Basin (see *Figure 1-2*). One of these, the Puyallup Tribe Hatchery, releases fish on station (from the hatchery). The Puyallup Tribe hatchery is located on Diru Creek near Pioneer Way. It produces 400,000 chinook sub-yearling smolts, 200,000 of which are released from the hatchery into Diru Creek . The other 200,000 are planted elsewhere in the Puyallup River system. The Tribe's hatchery produces primarily chum salmon. About 1.7 million fry/smolts are released on station in Diru Creek. About 60,000 steelhead smolts were historically produced by the hatchery, but that practice has been discontinued because water quality problems limit the production capacity of the hatchery during the summer months. With such large releases of juvenile salmon, significant straying of returning adults is inevitable. In the case of chinook salmon, this is exacerbated by the fact that Diru Creek is too shallow for the fish to swim up at the time of year that they return. The Puyallup Tribe is constructing a companion rearing facility on Clarks Creek near its existing hatchery about a mile from the mouth of Clarks Creek that overcomes some of the limitations of the hatchery on Diru Creek. Clarks Creek has a greater base flow and the new facility has been designed to provide a more natural setting for juvenile chinook salmon, which is expected to result in greater survival after the fish are released.

The other two hatcheries in the Clear/Clarks Creek subbasins are the WDFW hatchery at Maplewood Springs (Clarks Creek) and the private hatchery on Clear Creek (see *Figure 1-2*). The WDFW hatchery raises primarily catchable-size rainbow trout for lake planting throughout the region. This is about 1.7 million trout, amounting to about 350,000 pounds per year of fish weighing about 1/5th pound each. Chinook are also reared at Maplewood Springs. All chinook are collected and released in other areas of the Puyallup River system. About 400,000 to 500,000 steelhead smolts are reared at Maplewood Springs. Of these, about 200,000 are released into the Puyallup River system; the others are planted elsewhere in the Puget Sound region. The hatchery on Clear Creek just upstream of Pioneer Way East, is a privately owned hatchery that has been operating at its present location and at its current capacity since 1936. This facility is dedicated to rearing broodstock for egg production. The main business of the hatchery is to supply rainbow trout eggs to hatcheries worldwide. The hatchery company (including its four other hatcheries) is the largest single producer of trout eggs in the world. The monetary value of broodstock at the Clear Creek Hatchery is very high. All hatcheries rely on high quality water and each hatchery is sensitive to declines in water quality.

One federally protected fish species is found in the Clear/Clarks Creek Basin. Chinook were listed for protection under the Endangered Species Act (ESA) in 1999. *Table 4-8* shows the status of chinook and other species of concern that are present in the Clear/Clarks Creek Basin.

TABLE 4-8
Fish Species of Concern Found in Clear/Clarks Creek Basin

Species[a]	Status
Chinook salmon (*O. tshawytscha*)	Federal threatened
Coho salmon (*O. kisutch*)	Federal candidate
Steelhead trout (*O. mykiss*)	State monitor species
River lamprey (*Lampetra ayresi*)	Federal species of concern/ State candidate and species of concern

[a] Includes federal and state endangered, threatened, candidate, and monitor species.
Source: WDFW (1993, updated 2002).

According to the *Preliminary Technical Assistance for Bull Trout Recovery Planning Efforts (Feb. 24, 2004)* issued by the U.S. Fish and Wildlife Service, primary foraging, migration, and overwintering habitat for migratory bull trout within the Puyallup core area is believed to be the mainstem reaches of the White, Carbon and Puyallup Rivers. Spawning occurs in the upper reaches of the Puyallup River Basin where higher elevations produce the cool water temperatures required by bull trout. Rearing occurs throughout the mainstem rivers, but data suggests that the majority of rearing occurs in the upper reaches of the basin. No information is available about the existence of bull trout in Clear Creek or Clarks Creek. The report acknowledges that limited information is available on the distribution of bull trout in the Puyallup basin.

4.4.2 Stream Evaluation

The Urban Stream Baseline Evaluation Method (USBEM) in the Tri-County Urban Issues Study was used to classify salmon habitat quality for the Clear/Clarks Creek Basin. The methodology allows for the determination of baseline conditions for salmon, with particular treatment of urban influences. The analysis is a two-phase process consisting of a pre-classification screening phase and a field observation phase. The USBEM evaluation is documented in *Appendix "E." Figure 4-11* shows the location of the stream reaches surveyed in each subbasin.

Phase I: Pre-Classification Screening

The Phase I pre-classification screening includes analysis of geomorphic channel constraints, watershed or channel alterations, and known or expected fish distributions. The compilation of this information allows for pre-classification of each channel segment into highly suitable habitat, secondary habitat, and negligible habitat. Clear Creek and Clarks Creek were segmented into 29 reaches.

Phase II: Field Observations

USBEM Phase II included a quantitative assessment of habitat characteristics for a portion of the sites determined in Phase I focusing on the canyon and floodplain reaches of the Clear and Clarks creek system. Phase II parameters include riparian condition, substrate composition, embeddedness, bank condition, benthic invertebrate community characteristics, passage barriers, pool frequency, channel pattern/bedform, large woody debris, and water temperature. In addition to field habitat assessment, local residents were interviewed for information on fish use, habitat alteration, land use, water flow fluctuation, and other factors that might affect habitat condition.

The results from the USBEM analysis are used in the process of selecting the appropriate recovery options for the species of concern.

Channel Types

Channel types are largely dependent on gradient and valley form. Both of these characteristics change at the bottom of the hillslope in the Clear/Clarks Creek Basin, as do the channel types. This transition between channel types occurs in most of the streams near Pioneer Way East. The stream gradients upstream of Pioneer Way East range from two to five %, whereas they are generally less than one % downstream of the road. The valley form for all streams above Pioneer Way East is a parallel series of narrow, deeply incised ravines; whereas the valley form below Pioneer Way East is a large floodplain created by the Puyallup River. Likewise, the stream bottom substrate composition above Pioneer Way East is predominantly gravel, and below the road the substrate is predominantly sand and silt. This resulting channel type is a mixed-gradient mixed control (MGMC) (Paustian 1992) or Rosgen B or A channel types (Rosgen 1986) above Pioneer Way East. Below Pioneer Way East, Canyon, Clear, and Clarks Creeks are channelized, straightened, confined, and low gradient. It should be noted that the predominant land use downstream (i.e., north of) of Pioneer Way East is agricultural, and agricultural practices in this area have resulted in significant landscape alterations, channel relocation, and channel confinement, resulting in essentially ditch-like channels

At the intersection of these channel types; from MGMC (Rosgen B) to low-gradient channels, there is a geomorphic form known as an alluvial fan. The fan is created when large bedloads of alluvial material are transported down contained, higher gradient channels and are deposited. These deposits decrease the channel gradient and confinement and the bedload transport capacity is reduced. Alluvial outwashes result in the deposition of large amounts of material with active channel migration. These alluvial fans are most obvious in Swan, Squally, Clear, and Diru Creeks just above and below Pioneer Way East. Alluvial fans commonly produce good salmonid spawning areas.

Spawning Gravel Quality

The drainages of the Clear and Clarks Creeks watersheds overlie coarse, unconsolidated layers of glacial deposits. This surficial geology has a very high sand and gravel content from alluvial deposits, known as Vashon advance gravel, that were laid down from large floods in the late Pleistocene period. As a result, current gravel recruitment to the streams occurs both from down-cutting and exposed stream banks, as well as from the transport of materials from the headwaters. All of the streams in both watersheds have an abundance of gravels.

The abundant gravel sources and the alluvial outwash processes that occur near Pioneer Way continually create and maintain spawning gravels in all of the creeks. The highest quality spawning gravels are present in Swan, Clear, Clarks, and Rody Creeks, with moderate-quality gravels in Diru and Woodland Creeks. Despite the abundance of clean gravels, the capacity for spawning in these drainages is limited by low flow rates in the early fall for chinook and barriers to fish passage. At the time of this survey, the instream flows in Swan, Clear, and Diru Creeks ended lower in the watershed than did suitable spawning gravels.

In Clarks Creek, the only suitable spawning gravels observed were in a 1,600-foot-long section adjacent (west) and below the WDFW hatchery. This short reach has high-quality spawning

habitat. Thousands of salmon are known to spawn there each year. The spawning gravels in this section were the best observed in either watershed; however, the reach was limited in length. The reach is bordered by a wide, swamp-like ponding of Clarks Creek below the hatchery and an instream dam built to create a small reservoir above the hatchery. Downstream of the hatchery to the Puyallup River, Clarks Creek is a wide, deep, slow-moving glide covered with a substrate of thick organic muck and large aquatic plants.

Fine Sediment

Fine sediment deposits were observed in all creeks below Pioneer Way East, and in Squally, Woodland, and Clarks Creeks above Pioneer Way East. In Squally Creek, the sediment has a large sand component, and the flow in this section becomes very shallow, wide, and braided, with large pockets of standing water. The Squally Creek sediments appear to be from glacial deposits that are currently exposed in the stream banks. Deposition immediately upstream of Pioneer Way East in the Squally Creek channel appears to be partially the result of large amounts of road fill having been placed in the channel during construction of Pioneer Way East. The road fill appears to have caused a backwatering effect, creating a semi-inundated swamp-like habitat with multiple stream channels.

In contrast, sediments observed in Woodland Creek and Clarks Creek have a darker color and finer texture and appear to have entered the channel at street crossings as a result of surface drainage. The section of Woodland Creek above and below the 84th Street East crossing and the portion of Squally Creek downstream of the 48th Street East crossing are currently sources of fine sediments.

Sediments have a negative effect on the water quality of a stream system. The sediments increase the turbidity of the water, reduce light and harm the aquatic life by smothering eggs and benthic creatures and filling in spaces between rocks that could have been used as habitat for aquatic organisms. A significant reduction in light penetration can result in lower release of oxygen into the water. Fine particulates can clog or damage sensitive gill structures in fish, decrease their resistance to disease, prevent proper egg development, and interfere with feeding activities. Sediments also carry nutrients into the stream system increasing vegetation growth, especially invasive vegetation. Sediments clog stream channels and fill reservoirs. The increased intensity of floods due to channels clogged with sediments often leads to more pollutants entering the streams as waters over flow their banks.

Turbidity is the standard measure to evaluate the impact of sediments on a stream system. The greater the amount of total suspended solids (TSS) in the water, the murkier it appears and the higher the measured turbidity. However, turbidity values show wide variation making it difficult to determine a background turbidity value. Another way to evaluate the sediments is by determining the overall biological health of the stream.

Benthic macroinvertebrates are an excellent measure of the biological health of the stream. B-IBI results indicate the overall biological health of the Clear/Clark basin is rated as poor with a few streams rated as fair. The B-IBI results are listed in *Table 4-11*.

Erosion and Bedload Movement

Active stream bank and channel bed erosion was observed in all the creeks surveyed. The amount of erosion in these basins, in the form of channel downcutting, channel sidecutting, and hillslope mass wasting is active and severe in these basins largely the result of the geology of large, unconsolidated, glacial outwash deposits coupled with excessive peak flows. Five-foot-high exposed banks are common in the basins, and were most pronounced from the middle to the top of the canyon reaches. The worst erosion was noted on Swan Creek immediately downstream of 64th Street, on Clear Creek immediately downstream of 72nd Street, and on Woodland Creek both upstream and downstream of 84th Street. Some of the erosion was observed downstream of culverts, particularly below Swan, Clear, and Rody Creeks. Other areas of erosion were not affected by structures and appear to be the result of high peak flows through unconsolidated substrate.

Nearly all of the surveyed Clarks Creek channel was stable, low gradient channel without evidence of active erosion. However, rip-rap and other hard bank stabilization has been constructed, particularly behind homes on the eastern bank of Clarks Creek in the City of Puyallup. Some limited bank erosion (less than 2-foot-high exposed banks) was observed in the shallow gravel reach behind the WDFW hatchery.

In addition to active erosion, there was evidence of substantial bedload movement in Swan, Clear, Rody, Diru, Woodland, and Clarks Creeks. Bedload movement is the transport of sediment on bottom of the stream. Some amount of bedload movement is expected in steep gradient stream but excessive movement causes salmon eggs to wash out of spawning nests. The location and coloration of large gravels and cobbles in these reaches were indicative of channels with active bedload movement. With the exception of Woodland Creek, sand and gravel deposits at or above bank full levels were observed. An instream flow gauge, installed by CH2M HILL, was buried by several inches of gravel after six months of operation. Some reaches of Woodland Creek were found to consist of hard clay or compacted till layers and lacked any gravel at all. These reaches probably experience regular scouring flows that prevent retention of materials of any size.

Pools

Swan and Clarks Creek are the only streams surveyed that have substantial pool habitat. Over 3,700 feet (26 %) of Swan Creek is classified as pool habitat in the surveyed reach. Swan Creek contains 72 pools, of which 13 are constructed log “V”-weirs. During the survey, most of the pools were dry in the reach downstream of 64th Street East, including the 13 pools associated with the “V”-weirs.

Approximately 3,300 feet (28 %) of Clarks Creek is classified as pool habitat. Most of Clarks Creek downstream of the WDFW hatchery is glide habitat. However, there is a large, instream pond between the hatchery and a City of Puyallup park.

No pools were observed in Squally Creek or Diru Creek. In all other streams surveyed, pools account for a very small %age of the total stream habitat upstream of Pioneer Way East. Below Pioneer Way East, pool habitat is more abundant, and is the second most frequent habitat, after glide habitat.

LWD pieces depend on the size of the stream. The minimum size requirements of a key piece are 1.3 feet in diameter and 26 feet in length.

TABLE 4-9
LWD Statistics per Stream

Stream	LWD Count	Key LWD Count	Length Surveyed (feet)	LWD per Mile
Swan	255	36	14,684	92
Squally	9	0	1,644	29
Clear	172	6	11,253	81
Canyon	18	0	9,391	10
Rody	1	0	2,083	3
Diru	26	0	1,803	76
Woodland	12	1	7,839	8
Clarks	16	0	11,768	7

LWD recruitment potential is fairly good in the canyon reaches of all streams. The riparian buffers were generally wide, but not necessarily dense. Some hardwood stands were considered mature, but conifers were only occasionally in the 40–50-year age class. The sparse density appeared to be the result of historic clearing and logging, establishment of invasive species, and landslides. For Squally Creek in particular, invasive species such as creeping nightshade are preventing the establishment and growth of woody species.

As with other habitat indicators, the presence of LWD downstream of Pioneer Way East is significantly different for all but Swan Creek. Nine pieces of large woody debris were observed in almost 16,000 feet of stream channel surveyed below Pioneer Way East. Of these nine pieces, eight pieces were observed in the 7,000 reach of Clarks Creek. Recruitment potential is almost non-existent in this area, and there appears to be ongoing stream channel cleaning to maintain stream channel capacity. Swan Creek is the exception with 25 large woody debris pieces located downstream of Pioneer Way.

Fish Presence and Passage

Fish presence or absence was not specifically a parameter of the survey method, but observations were recorded. Juvenile coho salmon were observed in the low-gradient sections of Clear Creek, along and immediately upstream of Pioneer Way East. The same was true for Swan Creek and lower Canyon Creek. In addition, catchable-size trout were also observed in lower Clear Creek along Pioneer Way East. In the fall, adult chum salmon were observed in Diru Creek below the Tribe's hatchery and in Clarks Creek behind the WDFW hatchery. In Clarks Creek, redd (spawning area) establishment was evident.

Numerous barriers to fish passage were observed. In Swan Creek, a perched box culvert at 64th Street East creates about a five-foot-high waterfall onto concrete rubble below. At the time of the survey (late summer and early fall), the invasive species in Squally Creek filled the channel and

precluded passage of adult salmonids. Clear Creek has a 48-inch-diameter corrugated metal pipe culvert perched approximately six feet downstream of 72nd Street East that is a barrier. Clear Creek also has an impassible weir at the Trout Lodge hatchery. Rody Creek has a four-foot-high concrete wall with downstream slab in the channel creating a barrier to passage approximately 150 yards upstream of Pioneer Way East. The growth of reed canary grass within the active channel of lower Woodland Creek is so great that it could preclude passage of adult salmonids during the summer growing season. Clarks Creek contains a 10-foot-high dam at the WDFW hatchery reservoir, located a few hundred yards upstream of the southern hatchery access road.

Barriers to fish passage were identified during the CH2M HILL field investigation and from the Pierce Conservation District (PCD), WRIA 10 Puyallup River, Fish Passage Inventory database. CH2M HILL assessed culverts using the WDFW Level A Criteria (WDFW, 2000). *Table 4-10* lists the locations of barriers to fish passage in the Clear/Clarks Creek Basin.

TABLE 4-10
Fish Passage Barrier Locations

Problem ID[a]	Location [b]	PCD Site ID	Status	Barrier Type	Fish Use
SW-23	Swan Creek - 64th Street East	105 r031521a	Barrier	Slope/outfall	Yes
SW-31	Swan Creek - Pipeline Road (City of Tacoma)	105 r062416a	Barrier	Outfall/slope	Yes
SW-3	Swan Creek - 72nd Street East (City of Tacoma)	105 s013119a	Barrier	Outfall	Yes
SW-1	Swan Creek - 80th Street East	105 r031522a	Barrier	Slope	Unknown
SW-29	Burlington Northern Santa Fe Railroad	None	Unknown	Velocity, Level B Required	Yes
SW-32	Swan Creek - 84th Street East	105 r031522b	Unknown		Unknown
SW-33	Swan Creek - 96th Street East	105 r031600a	Unknown		Unknown
SW-34	Swan Creek - 104th Street East	105 r031523a	Barrier	Slope	Unknown
CL-30	Clear Creek - Gay Road East	105 r031520a	Unknown	Velocity, Level B Required	Yes
CL-31	Clear Creek - Pioneer Way East	105 r031616a	Unknown	Span/toe ratio, dam upstream, Level B Required	Yes
CL-27	Clear Creek – Hatchery	None	Barrier	Dam	Yes
CL-32	Canyon Creek - Railroad (BNSF Railroad)	105 r041320b	Barrier	Slope	Yes
CY-28	Canyon Creek - Driveway culvert upstream of Clear Creek Confluence	105 r041321a	Barrier	Slope	Yes

TABLE 4-10
Fish Passage Barrier Locations

Problem ID[a]	Location [b]	PCD Site ID	Status	Barrier Type	Fish Use
CY-28	Canyon Creek - Driveway culvert upstream of Clear Creek Confluence	105 r041322a	Unknown	Unknown	Yes
RY-18	Rody Creek – Concrete Weir in Channel	None	Barrier		Yes
RY-14	Rody Creek - 72nd Street East	105 r040618a	Barrier	Outfall	Yes
RY-20	Rody Creek - Pioneer Way East	105 r031821a	Unknown	Level B Required	Yes
WO-8	Woodland Creek – 80th Street East Culvert	None	Barrier	Outfall	Unknown
WO-30	Woodland Creek – Culvert under WSU Experimental Farm	None	Unknown	Level B Required	Unknown
WO-22	Woodland Creek – 12 foot cascade downstream of 84th Street E	None	Barrier		Unknown
CK-17	Meeker Creek - 11th Street SW (City of Puyallup)	105 r032522a	Unknown	Level B required	Yes
CK-18	Roadside Ditch tributary to Meeker Ditch - 11th Street SW (City of Puyallup)	105 r051115a	Barrier	Slope	Yes
CK-19	Unnamed Tributary to Meeker Ditch - 12 Avenue SW (City of Puyallup)	105 r060922b	Unknown		Yes
CK-20	Clarks Creek - Fish Hatchery (State of Washington)	105 r060920b	Barrier		Yes

[a] Fish passage barriers are shown in Figure 4-11
[b] Culverts are owned by Pierce County unless otherwise noted.

B-IBI Sampling

Benthic macroinvertebrate sampling was conducted for six of the streams in the Clear/Clarks Creek Basin. The Benthic Index of Biological Integrity (B-IBI) is a measure of stream health developed by the University of Washington. Sampling locations are identified in *Table 4-11* with corresponding B-IBI 10-metric scores. See *Figure 4-11* for a map of sampling locations.

TABLE 4-11
B-IBI Scores from Clear/Clarks Creek Drainages

Stream Name	Testing Organization	Location	Date	Score	Rate
Clear Creek	Pierce County Water Programs	Behind the Schmidt residence, 44th Ave	09/25/1999	20	Poor
Swan Creek	Pierce County Water Programs	Swan Creek Park, 500' upstream of detention pond	09/28/1999	20	Poor
Swan Creek	CH2M HILL	435' upstream of detention pond	09/18/2001	22	Poor
Squally Creek	CH2M HILL	50' upstream of Pioneer Way Culvert	09/18/2001	30	Fair
Canyon Creek	CH2M HILL	300' upstream of Pioneer Way Culvert	09/18/2001	26	Poor
Rody Creek	CH2M HILL	300' above Pioneer Way, below small dam	09/20/2001	26	Poor
Diru Creek	Pierce County Water Programs	Immediately upstream of Pioneer Way	09/17/2003	18	Poor
Clarks Creek	CH2M HILL	40' upstream of footbridge, behind WDFW fish hatchery	09/18/2001	26	Poor
Swan Creek	Puyallup Tribe	Swan Creek Park, 500' upstream of detention pond	9/2001	22	Poor
Clarks Creek	Puyallup Tribe	Upstream of WDFW fish hatchery	9/2001	34	Fair
Swan Creek	Puyallup Tribe	Swan Creek Park, 500' upstream of detention pond	09/30/2002	16	Very Poor
Swan Creek	Puyallup Tribe	Swan Creek Park, 100' upstream of first site	10/08/2002	26	Poor
Clarks Creek	Puyallup Tribe	Upstream of WDFW fish hatchery	10/08/2002	28	Fair

Pierce County Water Programs in cooperation with the Stream Team, CH2M HILL and the Puyallup Tribe have been monitoring the biological integrity of streams in Pierce County though analysis of the benthic invertebrate population density and diversity since 1999. Stream reaches were selected to approximate the B-IBI site recommendations of Karr (1986) as closely as possible.

Samples were collected according to the Karr B-IBI protocol (http://www.salmonweb.org) and sent to an independent taxonomy laboratory for identification. Rating guidelines for Puget Sound B-IBI scores are also provided at the website. According to the rating system, a score of 46–50

indicates excellent stream condition, 38–44 indicates good condition, 28–36 indicates fair condition, 18–26 indicates poor condition, and 10–16 indicates very poor stream condition.

The B-IBI scores in the Clear/Clarks Creek Basin ranged from very poor to fair, 20 to 34 with an average of 25.5 (poor). Clarks Creek, tested in both 2001 and 2002, received the highest score of the basin with a 34 and a 28. Squally Creek received a score of 30 in 2001. Both Canyon Creek and Rody Creek received a 26 in 2001. Swan Creek was scored at 20 in 1999 and 22 in 2001. Two samples were taken on Swan Creek in 2002. One of the samples was taken in an area that had been disturbed by drainage facility maintenance activity and received the lowest score in the basin, 16. The maintenance negatively affected the streams conditions so another sample site was chosen 100 feet upstream, which received a much improved score of 26. Because the score of 16 did not accurately represent the overall conditions of the stream, the score was excluded from the analysis. One sample was taken in Diru Creek in 2003. Most of the organisms found in this sample were worms. A predominance of worms indicates a lack of biological diversity and typifies a sediment laden environment.

Continued biological monitoring is planned in the Clear/Clarks Creek Basin and the rest of the basins in Pierce County. A number of streams will be selected on a yearly basis to be sampled for B-IBI. Data collected through biological monitoring will provide a reliable information base with which to track the changing conditions of the stream systems.

4.4.3 Water Features Crucial to Fish Habitat

Perennial Stream Flow Tied to Groundwater

A critical water feature observed in Swan, Squally, Clear, Diru, and Rody Creeks is significant groundwater influence. All the streams in the basin are “gaining streams.” A gaining stream is one where groundwater discharges into the stream and increases flow in a reach. Instream flow in Swan, Squally, Clear, Diru and Rody Creeks increases significantly in their lower reaches from groundwater, without the input of surface tributaries. Groundwater contribution, on the dates surveyed in August, was most pronounced in Clear and Swan Creeks, where approximately 80 % and 100 %, respectively, of the flow observed at Pioneer Way East did not exist at the 72nd Street East crossing. Evidence such as scour, landslides, culvert perching, and severe downcutting suggests that the “flashy” hydrology in these drainages is relatively recent. It is not clear whether this “flashy” surface hydrology has affected the amount and duration of subsurface flow that is occurring. However, it is probable that groundwater recharge is diminished with the increased surface runoff.

Surface Water Temperature Linked to Groundwater

Cool water temperature is crucial to salmonids. Instream temperatures during the months of stream surveying in August and September 2001 ranged from 9.5°C to12.5°C. This is considered an excellent temperature range for salmonid rearing. The temperatures are lower than commonly found in lowland Puget Sound streams, and are also indicators of subsurface flow.

4.5 Wetland Habitat and Uplands Habitat

The following two sections describe wetland and upland habitats of the Clear/Clarks Creek Basin based on a review of aerial photographs (Clear/Clarks Creek Watershed, Pierce County, April 2000), Pierce County GIS data (Clear and Clarks Creek Basin, Pierce County, December 2001), and on a brief field reconnaissance.

The Clear/Clarks Creek Basin supports several plant communities including conifer, deciduous, and mixed conifer-deciduous forests, grassland (agriculture), and shrub land. These plant communities can be divided into three habitat types: upland, riparian, and wetland. Riparian habitat was described in Section 4.4. The wetland and upland habitats are described in this section.

4.5.1 Wetland Habitat

Wetlands provide important habitats for plants and animals in addition to their value in flood storage and maintaining local hydrology. Fish, amphibians, waterfowl, birds of prey, and wetland mammals, such as beaver and muskrat, depend on various types of wetlands for food, forage, nesting, and cover. Wetlands also help to maintain water quality through biofiltration and groundwater recharge for streams. Wetlands are natural storage basins for floodwater as described in Section 4.3.2, Natural Drainage Features. *Figure 4-12* shows the wetlands in the Clear/Clarks Creek basin.

Limited quantified information is available regarding wetland loss trends in Pierce County or the Clear/Clarks Creek Basin. However, historical photographs and site plans for developments constructed prior to wetland regulations provide evidence that considerable wetland areas have been lost or altered in the Clear/Clarks Creek Basin due to urban development and agricultural land uses. Some of the wetlands adjacent to and part of the stream systems in the Puyallup River Valley were lost by filling, dewatering with drainage tile, and the channelizing of streams during the early 1900s to promote agriculture and other development to support people.

Wetlands in the Clear/Clarks Creek Basin are associated primarily with the south-to-north-oriented drainages. Many of the most substantial wetlands in the Clear/Clarks Creek Basin are located in the Puyallup River Valley. The low gradient and the confluences of several streams in the valley provides optimum physical conditions for wetlands to form. Wetlands such as those at the confluence of Squally Creek and Clear Creek tend to be large and complex, providing a variety of habitat types.

Clear/Clarks Creek Basin currently encompasses 827 acres of freshwater wetland habitat, which represents approximately four % of the total basin area. *Table 4-12* summarizes wetlands in the Clear/Clarks Creek Basin. The Clear Creek Basin has the greatest number and acreage of wetlands of all 16 subbasins. However, wetlands in the Diru Creek subbasin occupy nearly 10 % of the subbasin area, the highest %ages of wetlands in the creek drainages of the Clear/Clarks Creek Basin. Wetlands in the Lower and Upper 144th Street and the South Central Pothole occupy more than 10 % of the basin area. No wetlands have been documented in the 117th Street, 128th Street, Capital, Heritage Glen and Tip Top Potholes.

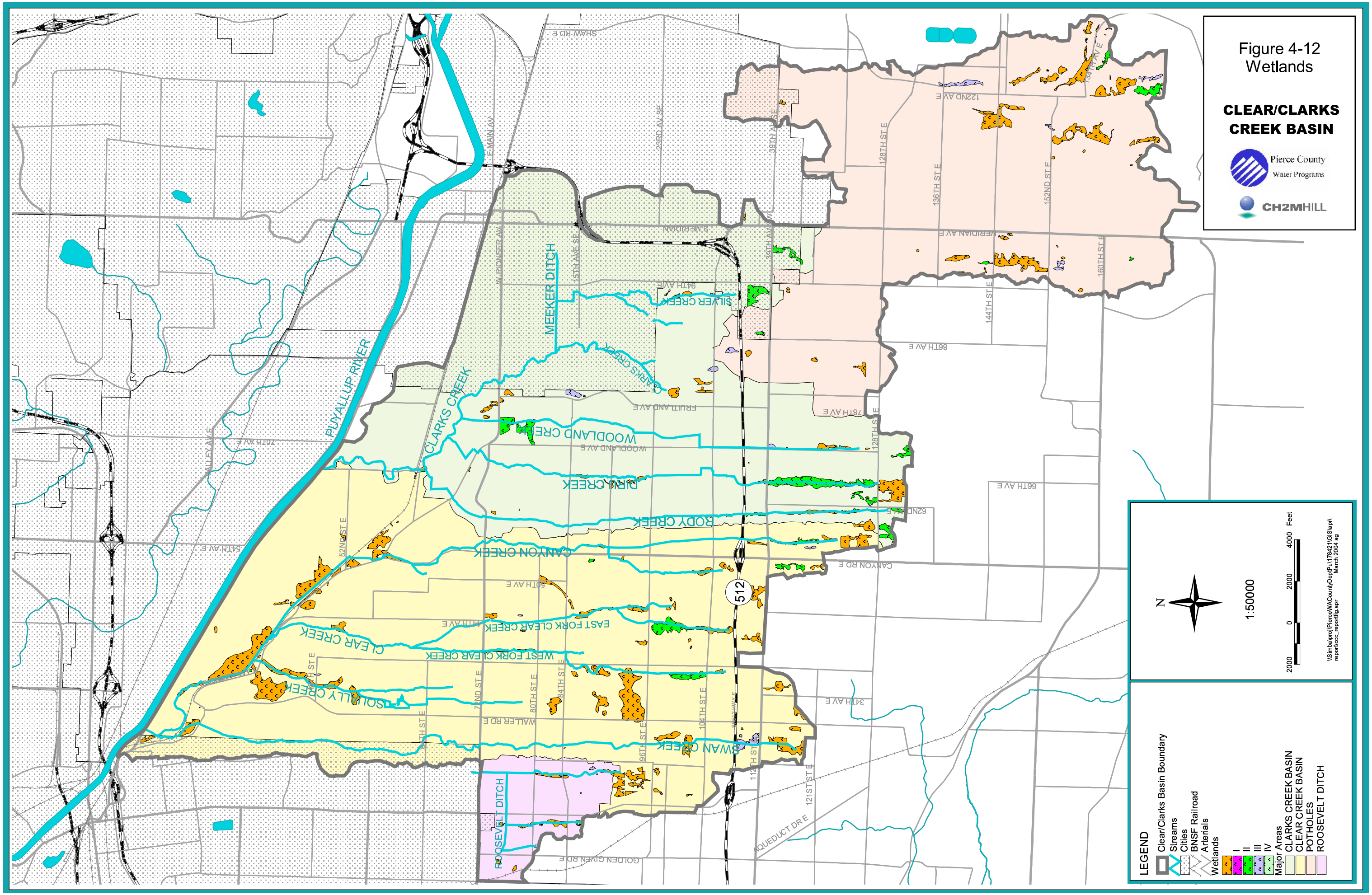


Figure 4-12
Wetlands
CLEAR/CLARKS
CREEK BASIN
Pierce County
Water Programs
CH2MHILL
PUYALLUP RIVER
CLARKS CREEK
MEEKER DITCH
SILVER CREEK
CLARKS CREEK
WOODLAND CREEK
PARK CREEK
BODY CREEK
CANYON CREEK
EAST FORK CLEAR CREEK
WEST FORK CLEAR CREEK
CLEAR CREEK
SQUALLY CREEK
SWAN CREEK
ROOSEVELT DITCH
512
N
1:50000
2000 0 2000 4000 Feet
LEGEND
Clear/Clarks Basin Boundary
Streams
Cities
BNSF Railroad
Arterials
Wetlands
I
II
III
IV
Major Areas
CLARKS CREEK BASIN
CLEAR CREEK BASIN
POTHOLES
ROOSEVELT DITCH

TABLE 4-12 Summary of Number and Acreage of Wetlands in Clear Clarks Basin				
Subbasin Name	Number of Wetlands	Wetland Area (acre)	Basin Area (acres)	% of Wetland Area in Basin (%)
Roosevelt Ditch	17	19.8	639	3.1
Swan Creek	24	140.1	2,484	5.6
Squally Creek	6	33.6	606	5.5
Clear Creek	39	165.7	2,447	6.8
Canyon Creek	39	110.6	2,589	4.3
Rody Creek	23	30.7	743	4.1
Diru Creek	19	70.2	835	8.4
Woodland Creek	11	32.5	1,163	2.8
Clarks Creek	24	49.4	4,129	1.2
110th Avenue Pothole	3	1.5	268	0.6
117th Street Pothole	0	0	578	0
128th Street Pothole	0	0	249	0
135th Street Pothole	13	34.7	612	5.7
Lower 144th Street Pothole	2	24.6	150	16.5
Upper 144th Street Pothole	20	54.0	313	17.2
Afdem Pothole	1	3.0	199	1.5
Alderwood Pothole	7	18.2	307	5.9
Black Swamp Pothole	5	6.4	793	0.8
Candlewood-Manorwood Pothole	1	0.9	303	0.3
Capital Pothole	0	0	120	0
Heritage Glen Pothole	0	0	102	0
Meridian Pothole	3	1.8	721	0.2
South Central Pothole	10	26.3	210	12.5
Springfield Pothole	4	3.5	223	1.6
Tip Top Pothole	0	0	314	0
Total	**271**	**827.7**	**20,931**	**4.0**

Wetlands in the northern end of the basin are associated with Clear Creek and are bounded by steep topography as the ravines drop off the plateau into the Puyallup River Valley. Wetlands in the ravines are part of the riparian corridor and are hydrologically connected with the streams. Landslides in the upper ends of the drainages block streams and create wetlands where water is impounded upstream. Beaver activity can also cause wetlands to form in the basin. Because the ravines are steep and largely undevelopable, the wetlands they contain have remained fairly

undisturbed. The slopes of the ravines are mostly vegetated with second-growth forest. Although separate from direct impacts from development, these ravine wetlands can be affected by indirect, nonpoint impacts, such as sedimentation and increased runoff from upstream sources.

Wetlands on the plateau are less confined by steep topography and so are more sensitive to direct pressure from development. In the past, stormwater impoundments were sometimes located in wetland areas. Development can also result in a larger volume of stormwater runoff directed to the wetland areas. As a result, formerly emergent wetland areas become inundated which limits the wetland area to the fringe of open water. Wetlands in these fringe areas are primarily emergent and scrub-shrub communities.

Wetlands located in the eight Pothole subbasins are especially important for groundwater recharge. Pothole basins do not have surface drainage; therefore, runoff generally infiltrates into the soil and drains from the basin via subsurface flow. This groundwater recharges streams and rivers in the lower basin, making wetlands in these areas a significant factor in maintaining instream flows.

Wetland habitats in the basin include primarily freshwater emergent, scrub-shrub, and forested plant communities. *Figure 4-12,* Wetlands, illustrates the location of these wetland categories. The three types of wetland plant communities were identified during the field investigation and are briefly discussed below.

Emergent Wetlands

Emergent wetlands are located primarily in the lower and upper basin where topography is gentle, usually associated with impoundments that are permanently inundated. Dominant species of these wetlands include soft rush, small-fruited bulrush, slough sedge, cattails, velvet grass, and reed canary grass. In addition to grass species, Douglas spirea, red alder, and willows are also present.

Scrub-Shrub Wetlands

Scrub shrub wetlands are located throughout the Clear/Clarks Creek Basin. Scrub-shrub habitat was often associated with emergent and forested wetland habitat. Dominant species in these wetlands include willows, red alder, black cottonwood, and Douglas spirea.

Forested Wetlands

Forested wetlands are located primarily in riparian areas that are inaccessible to development within the steep ravines in many of the subbasins. Dominant species in these wetlands include black cottonwood, western red cedar, and red alder.

4.5.2 Upland Habitat

Upland habitat in the Clear/Clarks Creek Basin includes primarily coniferous and deciduous forestland, grassland, and landscaped areas associated with residential, commercial, and light industrial development. Most of the uplands in the basin have been disturbed, leaving fragmented patches of forest land and grassland in a matrix of suburban development. With these changes in land use, invasive plants, most notably Scotch broom and bent grass, have established themselves throughout the basin.

Forest Land

The lower reaches of the many of the creeks that drain the basin have considerable intact forest land associated with them. Many of these large tracts of forest land are also associated with parks such as Swan Creek Park, Orangegate Park, and Clarks Creek Park. In many cases, these greenbelts and parks are one and the same. One of the most substantial forest lands observed in the basin is located in the headwaters of Clarks Creek. This forest land is especially important because the City of Puyallup supplements its drinking water supply from springs that emerge in the subbasin.

Douglas fir dominates most of the upland forest in the basin. The understory is dominated by salal, service berry, and red osier dogwood, with red alder saplings in open pockets. The dominant species in the forest edge are young Douglas fir, western red cedar, red alder, big leaf maple, and Himalayan blackberry. Most of the conifer and deciduous forest in the basin has been changed from its pre-European settlement condition by two to three timber harvests and over the last century conversion to agriculture and residential land uses.

Grassland

Grass species dominate the agricultural areas in the basin. Trees are sparse and are limited mainly to certain riparian areas and to wetlands with soils that are too wet to farm. Agricultural and developmental disturbances have significantly modified the species composition in the basin.

Landscaped Areas

Vegetation in residential and commercial areas is dominated by non-native ornamental trees and shrubs. Turf and non-native grasses are also a prevalent ground cover in the non-forested areas.

4.6 Water Quality

Fishing and swimming are impaired uses within most of the streams and rivers in the watershed. Compliance with the State Surface Water Quality Standards (WAC 173-201a) is not occurring in Clarks Creek, Clear Creek and Swan Creek due to high fecal bacteria levels (Lower Puyallup Watershed Action Plan, 1995). According to Ecology's 1998 303(d) list[1], four streams are currently listed as not attaining water quality standards:

- Clarks Creek (fecal coliform and pH)
- Clear Creek (fecal coliform)
- Meeker Ditch (fecal coliform, temperature, dissolved oxygen, pH)
- Swan Creek (fecal coliform)

A stream on the 303(d) list is placed on a schedule for preparation of a TMDL. The City of Puyallup has been managing preparation of a TMDL study for Clarks Creek.

A TMDL for BOD, Ammonia and Residual Chlorine was prepared for the Puyallup River watershed in 1993 (which included pollutant loading contributions from the Clear/Clarks Creek Basin). The TMDL divides capacity for BOD, Ammonia and Residual Chlorine among the point

[1] The only 303(d) list approved by the U.S. E.P.A. is the 1998 303(d) list.

dischargers in the Puyallup River Basin, including Pierce County stormwater. The discharge limits are administered through NPDES permits. (Ecology, 1983 and 2000). Other water bodies within the basin are likely to be included on the State's 2004 303(d) list, and additional TMDLs will be developed with wasteload allocations for Pierce County.

2004 Washington State Assessment of Water Quality

Washington State's 2004 assessment of water quality sorts water quality determinations into five categories as follows:

Category 1. Meets tested standards for clean water. (Note that a water body can be Category 1 for certain parameters, but listed on the 303(d) list for impairment from a different pollutant).

Category 2. Waters of concern. Segments of streams that currently meet State water quality standards overall, but either where some exceedance have occurred, where there is a record of declining water quality even though the average is acceptable, or the expected level of urban development indicates that the stream is likely to become impaired unless remedial steps are taken.

Category 3. No data or no usable data is available.

Category 4. Polluted waters that do not require a TMDL:

- Category 4a – Has a TMDL
- Category 4b - Has a pollution control plan
- Category 4c - Impaired by a non-pollutant, such as containing a barrier to fish passage

Category 5. Polluted waters that require a TMDL [The 303(d) list]

Table 4-13 shows the 2004 assessment of water quality for the Clear/Clarks Basin.

Change between 1998 and 2004

The 1998 303(d) listing of Clarks Creek for fecal coliform and pH is unchanged in the 2004 listing. However, the 2004 assessment adds fish habitat, fish passage barriers and dissolved oxygen as impairments to the quality of water for fish. Fish habitat is a significant beneficial use. The general pattern is repeated in Swan Creek, Clear Creek, and Meeker Ditch.

TABLE 4-13
2004 Assessment of Water Quality for the Clear/Clarks Creek Basin[a]

Creek	Reach Extent	State Assessment Category	Water Quality Parameter
Swan Creek	Pioneer Way East to Clear Creek	5	Fecal Coliform
Swan Creek	Pioneer Way East to Clear Creek	4c	Fish Habitat[b], Instream Flow
Swan Creek	80th Street E to 64th Street East 112th Street E to 99th Street East	4c	Fish Passage Barrier
Squally Creek	48th Street East to Pioneer Way East	4c	Fish Habitat, Instream Flow
Clear Creek	Gay Road to Puyallup River	5	Fecal Coliform
Clear Creek	Gay Road to Puyallup River	4c	Bioassesment, Fish Habitat, Instream Flows
Clear Creek	64th Street East to 48th Street East	4c	Fish Habitat, Instream Flows
Clear Creek	Gay Road to Swan Creek	2	Dissolved Oxygen
Rody Creek	80th Street East to Clarks Creek	4c	Fish Habitat, Fish Passage Barrier
Diru Creek	Township 20, Range 4, Section 29	4c	Fish Habitat, Instream Flows
Meeker Ditch	5th Street SW to 4th Street SW	5	Fecal Coliform, pH
Meeker Ditch	9th Street SW to Clarks Creek	4c	Fish Habitat, Instream Flow
Meeker Ditch	5th Street SW to 4th Street SW	2	Dissolved Oxygen, Fecal Coliform, Temperature
Clarks Creek	Township 20, Range 4, Section 30	5	Fecal Coliform, pH
Clarks Creek	WDFW Fish Hatchery to 10th Avenue SW	4c	Fish Habitat, Fish Passage Barrier
Clarks Creek	1,500 feet upstream of Stewart Road to Puyallup River	2	Dissolved Oxygen
Clarks Creek	WDFW Fish Hatchery to 10th Avenue SW	1	Temperature

[a] Source: Washington State Department of Ecology website
[b] Fish habitat is defined by Ecology as "habitat, which is used by fish at any life stage at any time of the year including potential habitat likely to be used by fish, which could be recovered by restoration or management and includes off-channel habitat".

The Category 4c list of waters impaired for fish use was not a part of the 1998 Water Quality Assessment. Fish passage barriers are addressed in the fish habitat descriptions of this chapter.

The *Lower Puyallup Watershed, Phase 1 Report* (1992) stated that water quality testing in the Lower Puyallup had been sporadic and had been performed by a number of different agencies using different analytical methods. Nevertheless, many of the sampling results have been used by Ecology to place the streams on the 303(d) list. Statewide, data submittals for the preparation of Washington State's 2004 303(d) list increased 10-fold over 1995.

Water quality data have been collected in Swan Creek, Clear Creek, Diru Creek, Rody Creek, and Clarks Creek from 1983 through 2003. The USGS performed sampling on Clear Creek, Clarks Creek, Diru Creek, and Swan Creek during 1983 and 1984. Pierce Conservation District

(PCD) has been collecting samples from Clarks Creek at numerous locations since the late 1980s. KCM collected samples from Clarks Creek and Meeker Ditch in 1996 for the City of Puyallup, in cooperation with the PCD and the Puyallup Tribe. Ecology collected samples from Clear, Clarks, and Swan Creeks during an intensive sampling program in 1990 to calibrate their water quality model in support of the Puyallup River TMDL Study. The Puyallup Tribe has been collecting water quality samples from Clear, Clarks, Swan and Diru Creeks since 1998. The sources of water quality data include the United States Geological Survey (USGS), August 1983 through September 1984; KCM, Inc., 1996; and the Puyallup Indian Tribe, 1998 through 2001.

Table 4-14 shows a summary of water quality data for various tributaries within the Clear/Clarks Creek Basin. Note that the average water temperature at all of the sampling sites among the tributaries exceeded 8.0°C (46ºF) but was substantially less than 18ºC (64.4ºF) permitted for Class A waters of the State. Average dissolved oxygen in milligrams per liter (mg/l) among the tributaries ranged from 9 to 14 mg/l. The average nitrate levels were between 0.5 to 2.7 micrograms per liter (μg/l). The lowest measurements were at the middle of Swan Creek and in Diru Creek downstream of the hatchery. Average phosphorus levels ranged between 0.1 μg/and 0.2 μg/l. The fecal coliform geometric mean for the different tributaries ranged from 20 to 2,500 MPN/100 ml. With a standard of 100MPN/100 ml, Clarks Creek at several locations, the East Fort of Clear Creek at 72nd Street East, and Swan Creek at 72nd Street East are problems. Potential sources of fecal coliform bacteria vary among the creeks. A study for the City of Puyallup is currently investigating the source of the fecal contamination in Clarks Creek through Microbial Source Tracking. The preliminary results shown below indicate that the main sources of fecal bacteria are from birds and rodents, with minimal contributions from canines, felines and humans. A USGS study observed higher densities of fecal coliform during storms, which suggests that storm runoff might be a source of fecal bacteria in the streams (USGS, 1987). State water quality standards are reproduced in *Table 4-15*.

Revised Water Quality Standards

Ecology adopted major revisions to the State water quality standards in 2003. EPA must approve them before they can become effective. This should occur in 2004. Among the changes is a significant reduction in maximum temperature. The reduction in temperature reflects the designation of specific waterbodies as char spawning and early tributary rearing areas. The proposed standards are expected to have major effects on future 303(d) listings in the Clear/Clarks Creek Basin and County-wide.

4.6.1 Roosevelt Ditch Basin

Roosevelt Ditch is a large fenced ditch that flows north from 80th Street East to 72nd Street East. A tributary ditch transports stormwater from 88th Street East to Roosevelt Ditch. The ditch is regularly maintained by the Pierce County Water Programs. Maintenance includes the trimming of grass and cattails, as well as the removal of blackberry bushes and small trees that threaten capacity of the ditch.

TABLE 4-14
Average Water Quality Data and Geometric Mean for Fecal Coliform for Lower Puyallup Tributary Sampling Sites

Station	Temp (°C)	Dissolved Oxygen (mg/l)	Nitrate - Nitrite (µg/l)	Total Phosphorus (µg/l)	Fecal Coliform** (MPN/100 ml)
Clear Creek at mouth	8.7	14.2	1.9	0.2	88.2
Clear Creek at 31st St E	10.3	10.9	1.9	0.2	109.6
East Fork Clear Creek at 72nd St E	10.5	10.1	N/A	0.1	2510.0
Swan Creek at mouth	10.5	11.7	1.1	0.1	66.4
Swan Creek at 72nd St E and 84th St E	9.2	10.0	0.7	0.2	1997.1
Rody Creek at Pioneer Way E	11.5	10.6	2.4	0.1	128.8
Diru Creek below Hatchery	10.9	11.6	0.5	0.2	36.8
Diru Creek above Hatchery	9.9	12.1	2.5	0.1	33.9
Clark Creek at mouth	10.1	11.0	2.1	0.2	301.6
Clark Creek at 66th St E	9.9	12.4	2.2	0.2	202.9
Clark Creek at convergence with Woodland Creek	10.9	9.4	1.3	0.2	745.8
Clark Creek near Pioneer Way E	10.1	12.1	2.0	0.1	579.5
Clark Creek below Hatchery	9.4	12.1	2.3	0.1	19.0
Clark Creek above Hatchery	9.2	11.3	2.7	0.1	27.6
.Water Quality Standard as of March/2004	<18° C	>=8 mg/l	None	None	100 / 100ml

Sources:
1 - USGS Water-Resources Investigations Report 86-4154, 1987.
2 - KCM, Inc., 1996.
3 - Puyallup Indian Tribe, 2001.

TABLE 4-15 Water Quality Criteria for Freshwater Class A in the State of Washington (WAC 173-201)	
Parameter	**Standard as of March 2004**
Fecal Coliform Bacteria	
Shall not exceed a geometric mean value of:	100 col./100 ml
With not more than 10% of samples exceeding:	200 col./100 ml
Dissolved Oxygen	
Shall exceed:	8.0 mg/L
Temperature[1]	
Shall not exceed:	18°C
Turbidity	
When background turbidity is 50 NTU or less, shall not exceed background turbidity by:	5 NTU
When background turbidity is more than 50 NTU, shall not have more than an increase of:	10%
pH	
Shall be within the range of:	6.5 to 8.5

1. Proposed standard is 17.5°C pending EPA approval

Nonpoint pollution is a water quality concern in the Roosevelt Ditch Basin. Portland Avenue East and other heavily traveled roads are a likely source of organic compounds, oil and grease. Sediments are another source of nonpoint pollution that probably affects water quality in Roosevelt Ditch. However, there are no water quality data available for Roosevelt Ditch.

4.6.2 Clear Creek Basin

The Washington State Department of Ecology (Ecology) rates Clear Creek to be a fishable, but not swimable. Ecology placed the creek on the 1998 303(d) list for fecal coliform bacteria. Nutrients and siltation were important factors in the determination, while pathogen indicators (fecal coliform bacteria) and low dissolved oxygen levels were moderate factors. Periodic low dissolved oxygen levels were determined to be a moderate problem, and are most likely caused by elevated nutrient concentrations. The sources of these problems were a combination of land development, runoff, septic on-site sewer systems, pasture land, animal management areas, channelization of streams, dredging, vegetation removal, stream bank modification, and highway runoff (Ecology, 1990). *Table 4-15* summarizes water quality data for Clear Creek.

In Clear Creek, altered hydrology from impervious surfaces in the upper watershed has led to erosion and sedimentation similar to that in Swan Creek. In Clear Creek, the channel has incised as much as 10 feet with vertical exposed banks below the 72nd Avenue East culvert. The most severe erosion observed in the Clear Creek Basin was below this culvert, with exposed banks continuous on both sides of the creek for 150 feet downstream of the culvert. A private

homeowner, interviewed on 72nd Avenue East, described how his backyard fence has required rebuilding due to the slumping land below. Exposed banks and slides of shorter length were also observed between the 45th Street East cul-de-sac and Pioneer Way East on Clear Creek.

The Port of Tacoma constructed a habitat restoration project at the mouth of Clear Creek, which was completed in 1998. The 11-acre site containing a maze of ponds and wetlands was designed to enhance salmon habitat. While the effects and benefits of the project are still being analyzed by the Port, it is expected to have a positive effect on water quality.

TABLE 4-16
Clear Creek Sampling Summary

Organization/Location	Parameter						
Sampled by the Puyallup Tribe	Temp (C)	DO (mg/L)	Nitrate-Nitrite (mg/L)	Total P (mg/L)	Fecal Coliform (col./100mL)	Turbidity (NTU)	pH
Clear Creek at Gay Road East							
Mean	10.0	11.7	1.8	0.18	66	12.2	6.9
Maximum	13.42	15	2.1	0.30	1300	97.3	7.3
Minimum	6.64	8.93	1.4	0.07	10	0.4	6.32
Number of Samples	28	28	10	10	5	13	24

Source: Puyallup Tribe of Indians, 2003

Swan Creek Subbasin

Swan Creek is listed for fecal coliform in the 1998 and 2004 303(d) lists. Ecology rates Swan Creek as neither swimable nor fishable. *Table 4-17* summarizes water quality data for Swan Creek.

The 1992 Lower Puyallup Watershed Characterization Report cited nutrients and fecal coliform (the pathogen indicator) as probably stemming from pasture land, animal management areas, urban runoff and dredge mining.

Samples taken by Pierce Conservation District found a minimum level of dissolved oxygen in Swan Creek to be 7.75 mg/L. Swan Creek had pH levels ranging from 6.17 to 8.07and a mean turbidity value of 28 NTU. High levels of sediment build up were reported in the lower reaches of Swan Creek, reflected the elevated turbidity values of 28 NTU. The State standard is 5 NTU.

The Midland area, located between 74th Avenue East and Portland Ave, and extending from SR 512 to 72nd Street East (see Section 4.2), is exhibiting water quality problems associated with the combination of low percolation rates and septic tanks. The effluent that is intended to percolate down through the soil instead rises with the water table during the wet season creating a water quality problem.

Pierce County Water Programs constructed a sedimentation/detention pond on Swan Creek in the valley in 1991 to meter high flows and allow sediments to precipitate. In the past, sediment was dredged from under the Pioneer Way Bridge over Swan Creek to prevent flooding. Dredging is

detrimental to fish according to the US Fish and Wildlife Service. Maintenance is performed annually or after major storm events to remove sediments accumulated in the pond.

The City of Tacoma has constructed an off-channel wetland adjacent to Swan Creek, between Pioneer Way East and the railroad tracks. Flows enter the restored wetlands through a bypass channel. The vegetation and quiescent environment improve water quality and provide habitat for juvenile salmonids.

TABLE 4-17
Swan Creek Sampling Summary

Organization/Location		Parameter						
Sampled by Pierce Conservation District		pH	DO (mg/l)	Nitrate (mg/l)	% DO	Air Temp C	Water Temp C	Discharge (cfs)
Swan Creek Park, upstream of hiking bridge								
	Max	8.0	16.0	8.8	135.0	25.0	14.5	309.0
	Min	5.0	0.0	0.0	0.0	0.0	3.0	2.0
	Average	7.5	11.6	1.8	100.4	13.1	9.8	15.5
	# of Samples	73	72	72	72	71	73	64
Swan Creek Park, downstream of hiking bridge								
	Max	7.7	14.0	17.6	115.0	27.0	15.0	150.0
	Min	6.5	6.0	0.0	57.0	4.4	7.0	2.0
	Average	7.4	10.9	2.2	97.2	14.5	10.7	15.5
	# of Samples	73	72	72	72	71	73	64
2605 92nd Street East								
	Max	7.5	10.5	2.0	100.0	13.0	14.0	17.5
	Min	6.5	7.0	0.0	60.0	3.3	4.0	1.0
	Average	6.9	8.6	0.8	74.4	7.2	8.7	5.1
	# of Samples	14	14	14	14	14	14	12

Source: Pierce Conservation District

Squally Creek Subbasin

No water quality sampling data was located for Squally Creek. However, a 1993 feasibility study for a detention pond investigated water quality of Squally Creek qualitatively. The study identified land-use and potential nonpoint pollution sources. In 1993 the Squally Creek Subbasin was zoned for one-acre single–family residences. Land use existing in the basin consisted of livestock grazing, small farms and residences. Steep, easily eroded roadside ditches along 57th Street East and 64th Street East were listed as a source of sediments. Heavily used roads, particularly Waller Road East, were noted as a potential source of metals, oils and grease, suspended solids, and organic compounds. Debris dumping was cited as a problem. Construction with inadequate erosion and sedimentation controls was also listed as a source of pollutants. Agriculture and hobby farms were noted as possible source of pollutants such as nitrates and fecal coliform (KCM, Inc., 1993).

In Squally Creek, sediment has a large sand component. Flow in the lower reaches of the creek are very shallow, wide, and braided, with large pockets of standing water. Because of the color, size, and sand-like similarities, the Squally Creek sediments appear to be from glacial deposits that are currently exposed in the stream banks. Deposition immediately upstream of Pioneer Way in the Squally Creek channel also appears to be partially the result of large amounts of road fill placed in the channel during construction of Pioneer Way East. The fill appears to have caused a backwatering effect, creating a semi-inundated swamp-like habitat with multiple stream channels. The portion of Squally Creek downstream of the 48th Street East crossing is also currently a source of fine sediments.

A detention facility was constructed along Squally Creek in 1995 with the intent of reducing erosion and sedimentation in the basin. The pond does not include any dedicated water quality features, although as it reduces peak storm event flows, it helps to reduce erosion and sediment deposits lower in the stream system. The pond might contribute to the bacterial and fecal problem in Clear Creek due to the water fowl that use the pond. The open, often stagnant water in the pond could increase water temperature directly downstream of the pond. But, Squally Creek has good riparian characteristics in the canyon reaches of the stream that extend up to 58th Street East; this probably mitigates some of the water temperature increase from Squally Creek Pond. In the lower reaches of the stream from Pioneer Way East to the confluence with Clear Creek, the excess of sediments contributes to invasive riparian vegetation.

Canyon Creek Subbasin

No water quality sampling data was located for Canyon Creek, the most easterly tributary to Clear Creek. The Canyon Creek Subbasin is a very narrow basin that drains an area of approximately four square miles on either side of Canyon Road East. Zoning in the headwaters of the creek and along Canyon Road to 104th Street East is urban, high-density residential and commercial. There is a commercial node at 84th Street East. The remainder of the subbasin is zoned Rural Separator. Despite rural zoning, the subbasin has experienced a significant amount of development in the last fifteen years along Canyon Road East bringing with it urban stormwater, increased peak flows eroding canyon sections of the stream banks, and sediment deposits in valley reaches.

The County is designing a detention facility to curtail over-the-road flooding at 90th Street East (Canyon Creek Bypass Project No. D138-003). Facilities typically include certain features to improve water quality. Pre-design water quality data would benefit an understanding of existing water quality conditions and help to identify the most effective aspects of facility design from a water quality perspective.

4.6.3 Clarks Creek Basin

Clarks Creek is on the 1998 303(d) list for fecal coliform bacteria and pH. Clarks Creek has inherently high nutrient levels because of high nitrogen levels in the groundwater that feeds the upper reaches of Clark Creek. It is not known if the high levels of nitrogen in the groundwater are naturally occurring. Nitrate leaching into groundwater occurs when the depth to groundwater is shallow and underlying soil is sandy allowing the nitrate to be easily moved by water. Nitrogen fertilizers and animal manure are possible sources of nitrates that may enter groundwater. However, the decaying of organic matter in soil is a natural process that also adds

nitrates into the system. The USGS Ground-Water Hydrology of the Tacoma-Puyallup Area reports that nitrate concentrations at Maplewood Springs have shown and increasing trend of 0.05 mg/l per year. This may be an indication that land use, not natural causes, is affecting the nitrate levels in groundwater. As the basin is developed and ground water infiltration is impeded, it is possible to see a reduction in the amount of nitrate in the soil system. *Table 4-18* summarizes water quality data for Clarks Creek.

Ecology rates Clarks at fishable but not swimable. Nutrients and pathogen indicators are likely the cause of non-attainment. Runoff, storm sewers, vegetation removal, and stream bank modification are frequent causes of non-attainment. Other contributing sources include irrigated and specialty crops, land development, and flow regulations (Lower Puyallup Watershed, Phase 1 Report, 1992). The City of Puyallup has sponsored a pollution reduction study leading to a fecal coliform TMDL for the Clarks Creek basin and a cleanup action plan.

The KCM Technical Memorandum (KCM, Inc., 1996) reports high levels of fecal coliform, bacteria, and nutrients over most of the Clarks Creek Basin. The only area excluded from this generalization was the area upgradient from the fairgrounds (no runoff received from the South Hill Mall area). Runoff from the fairgrounds, the South Hill Mall area, and the land along Meeker Ditch were identified as likely sources of pollutants to the ditch. The problem from the fairgrounds may have been corrected by a series of stormwater and collection system improvements and the discontinuation of direct animal wash water discharges to the storm system.

The Memorandum also lists the WDFW fish hatchery as an apparent source of nutrients and possibly TSS to Clarks Creek. The duck pond at DeCoursey Park was reported as an apparent source of fecal coliform bacteria and nutrients. The mouth of Clarks Creek registered high levels of bacteria and nutrients. The KCM Technical Memorandum concluded that pollutants continue to enter the creek throughout its length.

High levels of nitrogen are found in Clarks Creek due to the high nitrogen levels in the groundwater feeding the creek. The nitrogen might occur naturally in the groundwater; however, at this time it is not known. The upper reaches of Clarks Creek exhibit relatively low fecal coliform counts, while the downstream area (through DeCoursey Park in Puyallup) had a very high level of fecal coliform. This area has a large population of wildlife (ducks and geese) because many people feed them (PCD, 1990).

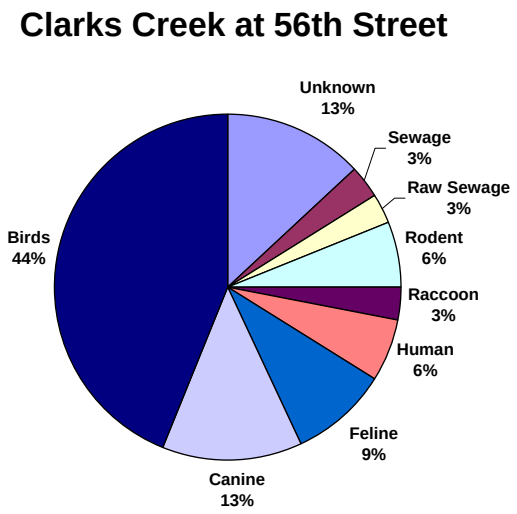


Figure 4-13
Clarks Creek Microbial Source Tracking Results
(MST) was used to identify the sources of fecal contamination. DNA taken from water samples is compared to library of 50,000 source samples to determine the general category of the source. (Clarks Creek Pollution Prevention Program, City of Puyallup, 2003).

TABLE 4-18
Clarks Creek Sampling Data

Organization/ Location		Parameter							
Sampled by KCM, Inc.		TSS (mg/L)	Total P (mg/L)	SRP (mg/L)	NH3 (mg/L)	NO3+NO2 (mg/L)	Fecal C #/100 mL	BOD (mg/L)	DO (mg/L)
Clarks Creek at 56th Street East									
	Max	204	0.625	0.04	0.13	3.08	7000	8.38	13
	Min	0.67	0.038	0.025	0.011	1.55	44	1.96	9.38
	Average	39.77	0.138	0.029	0.038	2.35	1756	5.17	11.29
	# of Samples	8	8	8	8	8	8	8	8
Clarks Creek near Pioneer Avenue (in the City of Puyallup)									
	Max	29	0.179	0.053	0.149	2.49	740	1.88	12
	Min	1.3	0.055	0.029	0.02	1.31	40	1.06	9.78
	Average	7.9	0.1	0.0	0.1	2.0	185.1	1.5	10.8
	# of Samples	9	9	9	9	9	9	5	9
Clarks Creek Downstream of Meeker Ditch									
	Max	55	0.246	0.053	0.117	2.6	1120	2.6	12.2
	Min	1	0.05	0.031	0.016	1.4	46	1.3	9.71
	Average	12.1	0.1	0.045	0.051	2.09	205.3	1.9	10.7
	# of Samples	9	9	9	9	9	9	5	9

TABLE 4-18
Clarks Creek Sampling Data

Organization/ Location		Parameter							
Sampled by KCM, Inc.		TSS (mg/L)	Total P (mg/L)	SRP (mg/L)	NH3 (mg/L)	NO3+NO2 (mg/L)	Fecal C #/100 mL	BOD (mg/L)	DO (mg/L)
Clarks Creek at Confluence with Meeker Ditch									
	Max	5	0.103	0.094	0.116	2.7	100	1.06	11
	Min	0.75	0.042	0.037	0.006	2.05	4	1.06	9.74
	Average	1.7	0.1	0.050	0.048	2.31	41.7	1.1	10.3
	# of Samples	9	9	9	9	9	9	5	9
Clarks Creek near Maplewood Springs									
	Max	33	0.138	0.046	0.09	3.01	340	2.08	11.3
	Min	0.5	0.036	0.036	0.011	1.99	12	1.6	10.1
	Average	6.0	0.1	0.042	0.030	2.37	120.3	1.8	10.6
	# of Samples	9	9	9	9	9	9	5	9
Clarks Creek									
	Max	19	0.192	0.062	0.16	2.58	160	2.1	11.6
	Min	1.8	0.052	0.02	0.008	1.62	80	1.2	8.7
	Average	9.6	0.1	0.042	0.063	1.98	114.0	1.7	10.0
	# of Samples	8	8	8	8	8	8	4	8
Sampled by the Conservation District		pH	DO (mg/l)	Nitrate (mg/l)	% DO	Air Temp (C)	Water Temp (C)	Discharge (cfs)	
Clarks Creek at DeCoursey Park									
	Max	7.5	16.5	22.0	125	24.0	12.2	165	
	Min	6.9	1.0	0.0	14	4.0	7.8	6	
	Average	7.2	10.5	5.0	92.9	13.4	9.9	101.4	
	# of Samples	37	37	37	33	35	36	24	
Clarks Creek at 2612 Tacoma Road, upstream of bridge									
	Max	7.5	15.5	17.6	137.0	27.0	15.0	60	
	Min	2.0	8.0	0.0	68.0	7.5	5.0	60	
	Average	7.1	10.8	3.7	99.3	15.6	10.7	60	
	# of Samples	26	23	25	20	24	25	1	
Clarks Creek at WDFW Fish Hatchery									
	Max	7.5	14.0	5.0	125.0	24.0	11.0	49.0	
	Min	7.0	9.0	0.0	67.0	3.5	1.0	3.0	
	Average	7.3	11.4	2.6	96.3	13.8	8.9	16.3	
	# of Samples	28	28	27	27	27	27	22	

TABLE 4-18 Clarks Creek Sampling Data								
Organization/ Location		Parameter						
Sampled by the Conservation District		pH	DO (mg/l)	Nitrate (mg/l)	% DO	Air Temp (C)	Water Temp (C)	Discharge (cfs)
Clarks Creek at Washington State University Extension								
	Max	8.0	15.5	13.2	162.0	26.0	14.0	21.0
	Min	1.5	5.0	1.0	40.0	6.0	5.0	17.0
	Average	7.0	10.3	3.5	93.3	15.5	10.4	19.0
	# of Samples	27	26	26	26	26	26	2

Rody Creek Subbasin

Rody Creek is an intermittent stream that is tributary to Clarks Creek. Ecology rates it as fishable, but not swimable. Nutrients and pathogen indicators are the primary factors in this determination. Sources included runoff (high), pasture land, animal management areas, land development, and highway runoff (moderate) and septic systems (slight) (Ecology 1990). *Table 4-20* summarizes water quality data for Rody Creek.

Limited sampling has occurred on Rody Creek. Preliminary Microbial Source Tracking (MST) for Rody Creek undertaken for the Clarks Creek TMDL study indicates that birds and rodents are the leading contributors to the fecal contamination problem. Dogs and humans comprise the next two highest contributors. The human factor may be due to reliance on on-site sewer systems because the Rody Creek drainage area is outside of a sanitary sewer service area. Results of the MST on Rody Creek are presented below in *Figure 4-14*.

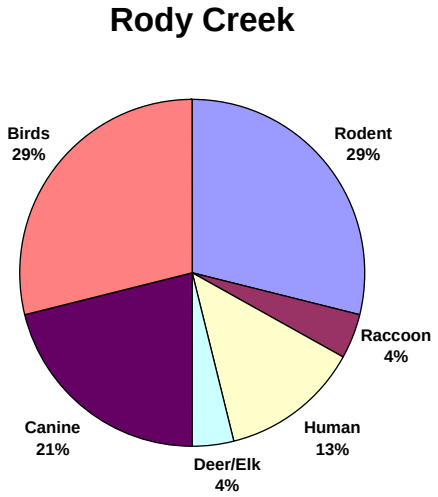


Figure 4-14
Rody Creek Microbial Source Tracking Results

(MST) was used to identify the sources of fecal contamination. DNA taken from water samples is compared to library of 50,000 source samples to determine the general category of the source. (Clarks Creek Pollution Prevention Program, City of Puyallup, 2003).

TABLE 4-19 Rody Creek Sampling Data									
Organization/ Location		Parameter							
Sampled by KCM, Inc.		TSS (mg/L)	Total P (mg/L)	SRP (mg/L)	NH3 (mg/L)	NO3+NO2	FECAL C	BOD	DO
Mouth of Rody Creek						(mg/L)	#/100 mL	(mg/L)	(mg/L)
	Max	204	0.625	0.04	0.13	3.08	7000	8.38	13
	Min	0.67	0.038	0.025	0.011	1.55	44	1.96	9.38
	Average	39.77	0.138	0.029	0.038	2.35	1756	5.17	11.29
	# of Samples	8	8	8	8	8	8	8	8

Diru Creek Subbasin

Diru Creek is listed on the 1998 303(d) list for fecal coliform. Of all the streams listed in the Clarks/Clear Basin for fecal coliform, Diru had the lowest fecal coliform counts. *Table 4-20* summarizes water quality data for Diru Creek.

Diru Creek has been designated by Ecology as swimable but not fishable. The 2002 and 2004 303(d) reports list habitat and in-stream flow problems as limiting fish populations.

Water quality in Diru Creek is important because its waters supplement the well-water used by the Puyallup Tribe's fish hatchery. In addition, Diru Creek contributes to Clarks Creek where the Tribe is constructed a rearing facility and planning to release juvenile fish.

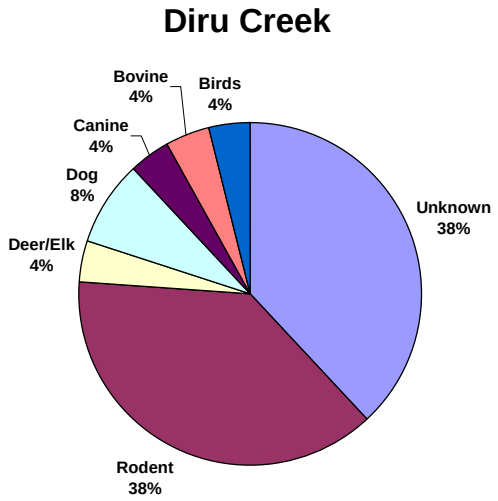


Figure 4-15

Diru Creek Microbial Source Tracking (MST) Results
MST was used to identify the sources of fecal contamination. DNA taken from water samples was compared to a library of 50,000 source samples to determine the general category of the source. (Clarks Creek Pollution Prevention Program, City of Puyallup, 2003).

TABLE 4-20
Diru Creek Sampling Data

Organization/ Location		Parameter							
Sampled by KCM, Inc.		TSS (mg/L)	Total P (mg/L)	SRP (mg/L)	NH3 (mg/L)	NO3+NO2 (mg/L)	FECAL C #/100 mL	BOD (mg/L)	DO (mg/L)
Mouth of Diru Creek									
	Max	84	0.451	0.053	0.064	2.9	280	2.84	13.4
	Min	0.25	0.035	0.026	0.01	1.46	2	1.02	10.5
	Average	13.05	0.12	0.04	0.02	2.18	63.43	1.77	11.28
	# of Samples	8	8	8	8	8	8	5	8

Source: KCM, 1993

Woodland Creek Subbasin

Woodland Creek is a tributary of Clarks Creek that has not been evaluated under the WAC standards and therefore has not been rated by Ecology. The stream flows approximately four miles before flowing in the Clarks Creek downstream of Pioneer Way East. Woodland and Clarks Creek have sediment deposits downstream of Pioneer Way East like all of the other streams in the basin. But unlike the Rody Creek and Diru Creek, the sediments observed in Woodland and Clarks Creeks extend above Pioneer Way East. Sediments also have a darker color and finer texture characteristic of sediments that have entered the channel at street crossings. The sections of Woodland Creek above and below 84th Street East are currently sources of fine sediments. *Table 4-21* summarizes water quality data for Woodland Creek.

The width of the riparian corridor is closely related to the width of the ravine that contains the stream, Woodland Creek and Clarks Creek have the smallest riparian corridors of all the streams in the basin. The most severe incising occurs in Woodland Creek, above and below the 84th Street East crossing. Along Woodland Creek, the exposed soil layers appear to have higher clay content, and have subsequently resisted sloughing and slumping. However, downcutting in Woodland Creek was observed at depths of as much as eight feet, often in places with a channel width of only two to three feet.

Very limited sampling data is available for Woodland Creek. Further sampling of Woodland Creek will take place as the City of Puyallup works to complete their TMDL study. Woodland Creek will be sampled as part of the study, before summer 2004. In addition, the Microbial Source Tracking results presented below describe the sources of fecal contamination. The human contribution to the fecal coliform problem may be due to the preponderance of residences in the basin using on-site sewer systems. Most of the basin is outside of a sanitary service area.

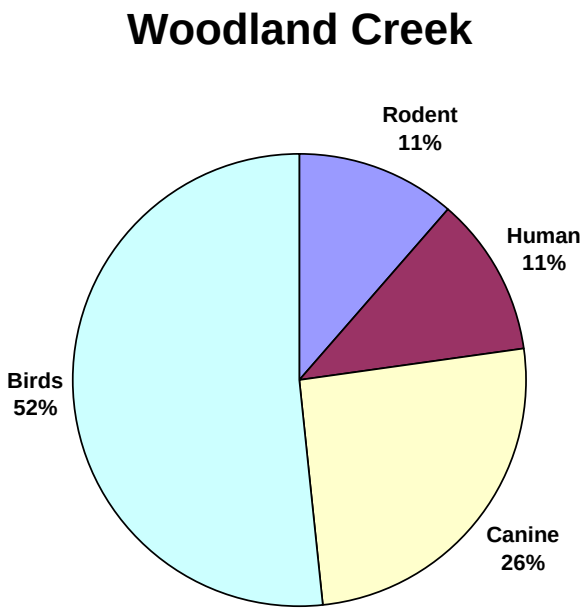


Figure 4-16
Woodland Creek Microbial Source Tracking Results
(MST) was used to identify the sources of fecal contamination. DNA taken from water samples is compared to library of 50,000 source samples to determine the general category of the source. (Clarks Creek Pollution Prevention Program, City of Puyallup, 2003).

TABLE 4-21
Woodland Creek Sampling Data

Organization/ Location	Parameter							
Sampled by KCM, Inc.	TSS (mg/L)	Total P (mg/L)	SRP (mg/L)	NH3 (mg/L)	NO3+NO 2 (mg/L)	FECAL C #/100 mL	BOD (mg/L)	DO (mg/L)
Mouth of Woodland Creek								
Max	326	0.531	0.041	0.095	1.86	480	2.7	13.5
Min	1.9	0.029	0.015	0.015	0.612	2	2.36	12
Average	91.45	0.19825	0.0255	0.0405	1.0975	172	2.53	13
# of Samples	4	4	4	4	4	4	2	3

Meeker Ditch

Meeker Ditch within the City of Puyallup is the largest tributary to Clarks Creek, receiving runoff from residential and commercial areas (including parts of the South Hill Mall), the State Fairgrounds, and numerous hobby farms. Meeker Ditch has exhibited historical water quality problems, and is on the 1998 303(d) list for fecal coliform bacteria, temperature, dissolved

oxygen, and pH. Likely sources include urban runoff and a lack of best management practices at the Fairgrounds animal handling operations. The City of Puyallup has apparently been addressing this last problem during the past several years. *Table 4-22* summarizes water quality data for Meeker Ditch.

Ecology rated Meeker Ditch in 1990 as neither swimable nor fishable. Nutrients, siltation, oil and grease, high temperature, and odor were factors in this determination. Cited sources of contamination included land development, runoff, channelization (putting the original stream into its present ditch), and vegetation removal. Dredged was noted as having a moderate effect on the designation (Ecology 1990). The County has received complaints about elodea (a type of aquatic vegetation) problem in Meeker Ditch.

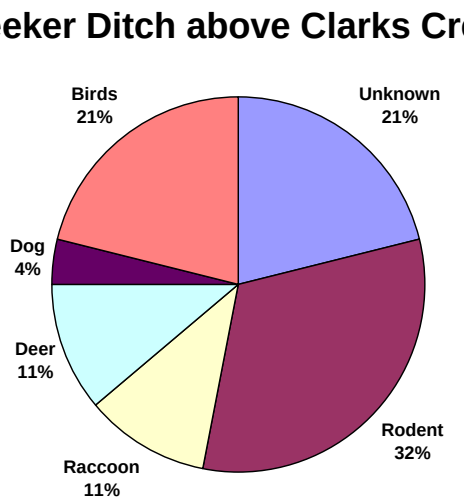


Figure 4-17
Meeker Ditch Microbial Source Tracking Results
(MST) was used to identify the sources of fecal contamination. DNA taken from water samples is compared to library of 50,000 source samples to determine the general category of the source. (Clarks Creek Pollution Prevention Program, City of Puyallup, 2003).

TABLE 4-22
Meeker Ditch Sampling Data

Organization/ Location		Parameter							
Sampled by KCM, Inc.		TSS (mg/L)	Total P (mg/L)	SRP (mg/L)	NH3 (mg/L)	NO3+NO2 (mg/L)	FECAL C #/100 mL	BOD (mg/L)	DO (mg/L)
Upstream from the confluence w/Clark									
	Max	186	1.1	0.106	0.792	0.769	5600	4.18	9.99
	Min	309.8	3.435	0.682	4.603	5.618	12660	11.36	78.83
	Average	34.4	0.382	0.076	0.511	0.624	1407	2.84	8.76
	# of Samples	9	9	9	9	9	9	5	9

TABLE 4-22 Meeker Ditch Sampling Data									
Organization/ Location		Parameter							
Sampled by KCM, Inc.		TSS (mg/L)	Total P (mg/L)	SRP (mg/L)	NH3 (mg/L)	NO3+NO2 (mg/L)	FECAL C #/100 mL	BOD (mg/L)	DO (mg/L)
Upper end of Meeker Ditch									
	Max	274	0.871	0.095	0.182	1.08	1800	5.98	10.7
	Min	0.83	0.089	0.027	0.057	0.356	56	2.08	7.04
	Average	46.8	0.238	0.061	0.106	0.788	774	3.41	9.06
	# of Samples	9	9	9	9	9	9	5	9

4.6.4 Potholes Basin

Potholes infiltrate collected stormwater into the ground or it is conveyed via the South Hill Pump Station directly to the Puyallup River. Water quality issues for the potholes differ from the stream basins by being associated with protection of ground water quality. Groundwater contamination from storm drainage sources can include: pathogens/ bacteria, metals, organic compounds, pesticides, and oil and grease. Spills and illicit discharges can also be harmful to groundwater quality if they go undetected. Sediments can affect the functioning of stormwater disposal facilities by clogging on-site sewer system drainfields or stormwater infiltration facilities or reducing the infiltration capacity/rate.

Groundwater contamination from any source is a problem because the area uses a significant amount of groundwater for drinking water. Although most public water supplies come from deep aquifers generally thought to be protected from surface contamination, the degree of protection necessary has been recognized by the federal government in declaring this area part of a “sole source aquifer”.

According to the USGS Water Resources Investigation Report 99-4013, ground water quality in the potholes area is generally good. Nitrate concentrations in this study were reported to be 2.0 mg/l which is well below the primary drinking water standard of 10.0 mg/l. Analysis of data collected since 1975 performed for the investigation report indicates that nitrate concentrations in groundwater from Maplewood Springs are increasing at a rate of 0.05 mg/l per year. Nitrate in ground water is usually derived from sources at or near the surface and the increasing trend observed in groundwater from Maplewood Springs is thought to be a result of changing land use within the basin.

Infiltration capacity/rate of stormwater disposal facilities can be compromised by excessive sediments. To some extent this has been a problem within the potholes basins. The 128th Street Pothole has had a reoccurring problem with clogging of the infiltration system. This was especially noticeable during the winters of 1998 - 2000 when a combination of heavy rains and nearby construction caused clogging of the infiltration system and the resultant flooding of 128th Street East.

CHAPTER FIVE
Identification of Problems

Chapter Five documents the current flooding, riparian/aquatic habitat, water quality and other surface water management problems in the Clear/Clarks Creek Basin that were identified during the basin characterization. Problems listed in Chapter Five are analyzed in chapters six, seven, and eight. The analyses in chapters six, seven, and eight also supplement the problems listed here with forecasts of problems likely to occur due to the soils in the Basin, the topography, rainfall patterns, planned land use, existing regulations and the way regulations are administered and enforced.

5.1 Sources Used for Problem Identification

The storm drainage and surface water management-related problems covered in this chapter are derived from several sources. In some cases, reports and studies cited in the existing conditions description (Chapter Four) identified problems. Other problems were reported by citizens and County staff during or after major storms and are on record in the Service Response System (SRS). The SRS is maintained by Pierce County Water Programs and integrated into the County's geographic information system (GIS). Citizens and businesses also reported problems during public meetings, or by responding to questionnaires. Cities, County departments, drainage districts, Pierce Conservation District, the Puyallup Tribe of Indians, and State and federal agencies shared information on aquatic habitat, water quality, flooding, consistency with land use, and storm drainage concerns. The sources of information include:

- **Pierce County Service Request System (SRS) database**
  The SRS database contains complaints and service requests for all County services from 1998 to the present. The SRS database contains entries that pertain to drainage, flooding, water quality, aquatic habitat, or erosion/sedimentation problems used for this report.

- **Pierce County Water Programs Flood of 96 (F96) and Flood of 97 (F97) databases**
  During the winters of 1996 and 1997, Pierce County experienced severe storms. During these events, Pierce County Water Programs Division set up a call center to handle the large volume of complaints. Information related to the large storm events was used to create the Flood of 96 and Flood of 97 databases**.**

- **Pierce County Water Programs Complaint Files (1991 – 2001)**
  Pierce County Water Programs has other written surface water complaint records on file. In some cases, the complaints had additional data associated with them. The additional data varied in content and included such items as service requests for the maintenance department, notes from a field visit, communication between County departments, petitions, and legal documentation.

- **Pierce County "Water Over Road" Sign Postings Record**
  Pierce County also provided a list of road intersections and road segments where Roads Maintenance or Water Programs staff posted "Water Over Road" signs during storm events.
- **Pierce County Water Programs Questionnaire Responses (Spring 2001)**
  The County mailed a questionnaire to residents within the Clear/Clarks Creek Basin in April 2001. The survey offered property owners and other interested parties within the basin an opportunity to comment on flooding, habitat, water quality and other storm drainage problems.
- **Riparian Habitat Field Visits (Summer and Fall 2001, Spring 2003)**
  Information from field visits conducted by CH2M HILL staff noted some of the same problems that were cited by other sources. In some cases, the cause of those problems was observed.
- **Pierce County Water Programs Staff**
- **Pierce Conservation District**
- **Pierce County Transportation Planning & Road Maintenance staff**
- **Draft Repetitive Loss Plan (Pierce County, January 2001)**
- **303(d) List (Washington State Department of Ecology, 1998)**
- **Pierce County Storm Drainage and Surface Water Management Master Plan, James M. Montgomery Consulting Engineers, Inc., 1991**
- **Existing Conditions Research Findings Presented in Chapter Four**
- **Additional Analysis of Arterial Culverts**
  Additional analysis was extended to arterial roadway culverts shown by the results of hydraulic modeling to be at risk of flooding when:
  - The expected increase in effective impervious area in the upstream tributary area under future land use conditions was greater than 25%; and
  - Less than 0.5 feet of freeboard exists between the top of the culvert and the roadway.

5.2 Problem Investigation

Information from the first seven sources was compiled into a database and the location of the complaint was noted on a map. With this spatial representation and complaint descriptions, problems were grouped into drainage issues.

For example, if there were several complaints regarding flooding at a specific intersection, the complaints were grouped into a single drainage problem/issue. Each drainage issue was given a unique identification number beginning with a designation corresponding to the subbasin (e.g., Swan Creek problems have the prefix "SW").

A basin map, showing active and unresolved drainage issues, was used during interviews with Pierce County Water Programs staff knowledgeable about the Basin. Water Programs staff provided insight on the causes of some of these drainage issues. They identified the problems already corrected and the solutions implemented. Certain problems had Small Works or CIP projects to correct them pending in the near future. For example, some of the flooding problems within the "pothole area" were fixed with construction of the South Hill pump station and related improvements (South Hill Drainage Improvements, Pierce County Department of Public Works and Utilities, Water Programs Division, November 2001). Certain problem solutions were referred to other County or local agencies.

Drainage complaints that were classified as active, unknown, or closed without resolution, required further investigation. Follow-up calls, when contact numbers were available, provided additional insight as to the specifics of the complaint, if the problem still existed, how frequent the problem, and what work had been done to correct the problem, either privately or by the County. The classification of the problem was then updated in the database.

An updated basin map was refined with these additional sources of information. The refined map was used to interview Pierce County Road Maintenance and Water Programs Maintenance staff.

Maintenance staff responds on a daily basis to drainage problems in the field. When problems cannot be corrected with routine maintenance and repair, they are referred to staff responsible for long-range planning and capital projects. These two sections of the Public Works and Utilities Department were able to identify the causes of the remaining storm drainage problems.

Tables 5-1, 5-2, 5-3, and 5-4 list the storm drainage problems of the Clear Creek, Clarks Creek, Potholes Area, and Roosevelt Ditch drainage basins that require further analysis and solution alternatives.

The locations of the storm drainage problems itemized in the tables are illustrated in *Figures 5-1, 5-2, and 5-3*. Separate figures illustrate the problem locations in the major drainage divisions of the Clear/Clarks Creek Basin.

Figure 5-1 presents the Clear Creek Basin and the adjoining Roosevelt Ditch drainage area. *Figure 5-2* shows problems in Clarks Creek Basin. *Figure 5-3* displays problem locations within the Potholes drainage area.

TABLE 5-1a
Swan Creek Flooding, Riparian/Aquatic Habitat, Erosion and Water Quality Problems

Problem ID	Type	Location	Description
SW-1	Flooding/ Riparian/ Aquatic Habitat	80th Street East	Swan Creek overtops 80th Street East. Roadway runoff causes property flooding in the 2600 block of 80th Street East. Culvert is a barrier to fish passage due to slope.
SW-2	Flooding	2400 block of 80th Street East	Obstructed culvert at 2400 block of 80th Street E causing roadside flooding.
SW-3	Erosion, Riparian/ Aquatic Habitat	Swan Creek at 72nd Street East culvert outfall	72nd Street East culvert is a barrier to fish passage due to the vertical drop at outfall. High flow velocity has eroded west bank and is compromising bank stability. A house is located less than 50 feet from eroded bank.
SW-4	Flooding	Swan Creek at Pioneer Road East	In 1996, sediment washed down Swan Creek and caused road and property flooding at the downstream commercial shop on the east side of Swan Creek. There is a storm drain system that backed up along Pioneer Way most likely due to the high water level during this 100-year storm event. Additionally, there is a culvert downstream under the BNSF railroad that may have caused backing up of Swan Creek. An existing sedimentation pond upstream of Pioneer Way has been cleaned annually since 1996. No flooding has been reported since 1996.
SW-5	Flooding	84th Street East	Road and property flooding occurs on 84th Street East, about 400 feet east of Waller Road East. Flooding may be due to insufficient conveyance capacity or backwater in the 84th Street East storm drain system.
SW-6	Flooding	County pond at 84th Street East	County detention facility (Waller Road East Pond 2) at 84th Street East and Swan Creek overflowed during 1996 event.
SW-7	Flooding	Intersection of 24th Avenue East and 90th Street East.	Flooding observed at intersection of 24th Avenue East and 90th Street East. Stormwater may also overtop roadway.
SW-8	Flooding	Field drainage	Construction of Waller Road Pond 3 obstructed natural drainage course in pasture adjacent to Swan Creek, downstream of Pond 3.
SW-9	Flooding	2600 block of 112th Street East	Excessive vegetation in roadside ditch causes roadway flooding 150-feet west of Swan Creek crossing at 112th Street East.
SW-10	Flooding	Swan Creek headwaters south of 112th Street E	Poor drainage caused by saturated soils and flat topography. Standing water observed in roadside ditches and natural drainage system. Extensive wetlands in the area, but numerous wetland and fill and grade violations reported.

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-1a - *continued*

Problem ID	Type	Location	Description
SW-11	Flooding	9500 block of Portland Avenue East	Roadway runoff causes driveway and garage flooding.
-12	Flooding	2800 block of 96th Street E	Roadway runoff causes property flooding. Driveway culvert is plugged.
SW-13	Flooding	9900 block of Waller Road E	Backyard flooding occurs due to filling in of Swan Creek.
SW-14	Flooding	10600 block of Waller Road East	Roadway runoff causes property flooding.
SW-15	Flooding	Waller Road and SR-512	Field flooding occurs south of SR 512 on west side of Waller Road East. A berm may have formed on the over bank obstructing runoff from the adjacent field. Yard flooding on 26th Avenue E, likely due to SR 512 culvert backwater, also occurred in 1996.
SW-16	Flooding	24th Avenue East from 84th Street East to 92nd Street East	Insufficient inlet capacity causes road and property flooding.
SW-17	Riparian/ Aquatic Habitat	Swan Creek at 80th Street East	Trash dumped into creek channel
SW-18	Water quality	Swan Creek north of 80th Street E	Reach on 303d list for fecal coliform - north of 64th Street East.
SW-19	Water quality	Swan Creek	Reach on upper Swan Creek is on the 303d list for fecal coliform levels.
SW-20	Riparian/ Aquatic Habitat	Waller Road East at 92nd Street East	Trash dumped into creek
SW-21	Erosion	Swan Creek at 72nd Street East	Downstream erosion
SW-22	Erosion	Swan Creek from 72nd Street East to 64th Street East	Channel erosion is occurring downstream of 72nd Street East to 64th Street East due to high stream flow. Exposed vertical banks are 2 to 3 feet high.
SW-23	Erosion[b], Riparian/ Aquatic Habitat	Swan Creek downstream of 64th Street East	High stream flows have scoured a four to five foot hole at the 64th Street East culvert outlet and undermined the culvert headwall and apron. The culvert is also a barrier to fish passage due to steep slope and drop at outfall.
SW-24	Erosion	Downstream of 64th Street East	A 300-foot long landslide occurred on the west bank 4,500 foot downstream of 64th Street East.
SW-25	Erosion	Downstream of 64th Street East	The channel is eroding in the 8,000 foot reach downstream of 64th Street East due to high stream flow. Exposed vertical banks are 10 to 12 foot high.
SW-26	Erosion	Downstream of Burlington Northern Santa Fe Railroad	Channel down cutting is occurring downstream of railroad culvert due to high stream flow.
SW-27	Water quality	Upstream of 64th Street East	Intermittent flow occurs upstream of this location in late summer
SW-28	Riparian/ Aquatic Habitat	Swan Creek from 84th Street East to 99th Street East	This reach has a discontinuous riparian corridor with a reduced or non-existent buffer

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-1a - *continued*

Problem ID	Type	Location	Description
SW-29	Riparian/ Aquatic Habitat	Swan Creek at Burlington Northern Santa Fe Railroad	Culvert is a partial fish passage blockage due to excessive velocity.
SW-30	Flooding	Pioneer Way East (City of Tacoma)	Private property flooding reported at Pioneer Way East
SW-31	Riparian/ Aquatic Habitat	Swan Creek at Pipeline Road (City of Tacoma)	The Pipeline Road culvert is a barrier to fish passage.
SW-32	Riparian/ Aquatic Habitat	Swan Creek at 84th Street East culvert outfall	The culvert may be a barrier to fish passage.
SW-33	Riparian/ Aquatic Habitat	Swan Creek at 96th Street East culvert outfall	The culvert may be a barrier to fish passage.
SW-34	Riparian/ Aquatic Habitat	Swan Creek at 104th Street East culvert outfall	The culvert is a barrier to fish passage due to slope.
SW-35	Habitat	Downstream of Pioneer Way East	Sediment in channel
SW-36	Water Quality	Swan Creek	Excessive nutrients
SW-37	Water Quality	Swan Creek	Low dissolved oxygen/ High pH

a. Some locations are associated with multiple problem types. Primary problem type is listed first.

b. Erosion problems are addressed primarily as Water Quality (turbidity) and Aquatic/Riparian Habitat (sedimentation) problems. The erosion issue is much broader, extending into questions of slope stability, risk of damage to private property, and public safety.

TABLE 5-1b
Squally Creek Flooding, Riparian/Aquatic Habitat, Erosion and Water Quality Problems

Problem ID[a]	Type	Location	Description
SQ-1	Flooding	7000 block of Waller Road East	Front yard and house flooding was reported in 1990. A low bank is present on east side of roadside ditch.
SQ-2	Flooding	West side of 5600 block Vickery Avenue East	Roadway flooding occurs due to undersized roadside ditch and culvert system.
SQ-3	Water quality, Riparian/ Aquatic Habitat	Squally Creek at 48th Street East	Trash in the creek from dumping into the creek.

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-1b - *continued*

Problem ID[a]	Type	Location	Description
SQ-4	Erosion	Clear Creek confluence	Eroding banks and sedimentation occurs where Squally Creek flows into Clear Creek.
SQ-5	Erosion	Downstream of 48th Street East	Small slide has occurred blocking the channel and adding a barrier to fish passage.
SQ-6	Water quality, Riparian/ Aquatic Habitat	Pioneer Way East	Invasive riparian vegetation in and along the creek
SQ-7	Erosion	Downstream of Squally Creek Detention Pond	Squally Creek Detention Pond was designed for a 25-year storm event so does not have capacity for peak flows from larger events, incising stream channel
SQ-8	Water quality	Throughout stream system	No water quality data exists

TABLE 5-1c
Clear Creek Flooding, Riparian/Aquatic Habitat, Erosion and Water Quality Problems

Problem ID	Type	Location	Description
CL-1	Flooding	44th Street East near Gay Road	Road and property flooding because of a low bank on the east side of the roadside ditch
CL-2	Flooding	6600 block of 44th Avenue East	Road flooding occurs due to two obstructed driveway culverts.
CL-3	Flooding	Intersection of 96th Street East and 48th Ave East 4700, 4800, and 4900 block of 96th Street East, north side	Road flooding occurs due to obstructed culvert at intersection. Property flooding occurs due to absence of drainage system on 96th Street East.
CL-4	Flooding	Clear Creek at 104th Street East	Reed canary grass is pervasive in the natural drainage channel causing chronic road and property flooding at 104th Street East.
CL-5	Flooding	West Fork Clear Creek, 88th Street East to 84th Street East	Extensive road and property flooding occurs on the West Fork of Clear Creek from 88th Street E to 84th Street East. Road flooding occurs at 88th Street E. Property flooding has been reported at the 3700 block of 88th Street East and the 8700 block of Vickery Avenue East.
CL-6	Flooding	East Fork Clear Creek at 76th Street East	A wire fence has been installed at the downstream end of the culvert and may be obstructing flow. One-half foot head differential was noted during a site visit. Private property flooding has been reported downstream. This property is located in floodplain. The 1991 Stormwater Master Plan identified this culvert as having insufficient conveyance capacity.

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-1c- *continued*

Problem ID[a]	Type	Location	Description
CL-7	Flooding	4700 block of 105th Street East	Chronic property flooding reported in a depression area south of roadway. Depression drains to Clear Creek with a 36-inch diameter culvert crossing at 105th Street East. Fence posts placed in channel by downstream property owner likely causes a backwater condition at the 105th Street East culvert aggravating the flooding problem. Topography suggests that the culvert is in the historic drainage way.
CL-8	Flooding	4500 block of 112th Street East	Property flooding caused by dumping in drainage ditch.
CL-9	Flooding	9300 block of 40th Avenue East	Yard flooding
CL-10	Flooding	4700 block of Pioneer Way East	Excessive vegetation in the roadside ditch on south side of Pioneer Way East between 44th Street East and 52nd Street East.
CL-11	Flooding	4700 block of 53rd Street East	Depression on private property collects surrounding runoff[1]
CL-12	Flooding	5400 block of 57th Avenue East	Driveway flooding from public road drainage
CL-13	Flooding	4000 block of 53rd Ct. Street East	Stormwater runoff from private road causes property flooding[1]
CL-14	Riparian/ Aquatic Habitat	Clear Creek from 104th Street East to Vickery Avenue East	Trash in creek channel
CL-15	Riparian/ Aquatic Habitat	4500 Block at Pioneer Way East	On the County's Dirty Dozen list as an illegal junk/wrecking yard, plus several occupied recreational vehicles and a large amount of solid waste cover the site
CL-16	Water Quality	Clear Creek below Pioneer Way East	Reach is on the 303d list due to fecal coliform levels.
CL-17	Riparian/ Aquatic Habitat Water Quality	Clear Creek from Pioneer Way East to the Puyallup River.	Erosion upstream has caused sedimentation in channel from Pioneer Way East to the Puyallup River
CL-18	Riparian/ Aquatic Habitat	Pioneer Way E to Gay Road East	Invasive aquatic vegetation present in the reach extending from Pioneer Way to Gay Road East
CL-19	Erosion	West Fork of Clear Creek downstream of 72nd Street East	The stream bank is eroding due to high stream flow in West Fork in vicinity of 72nd Street East. Exposed vertical banks are 12-feet-high in the reach 500 feet downstream and 5-feet high in reach 100-feet upstream of 72nd Street East. A 3-foot deep scour hole is present at culvert outlet.

[1] This is a private property internal drainage issue.

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-1c - *continued*

Problem ID[a]	Type	Location	Description
CL-20	Erosion	East Fork of Clear Creek at 72nd Street East	Stream bank erosion and channel down cutting are occurring on the East Fork in the 500 foot reach downstream of 72nd Street East due to high stream flow. The culvert is perched 3 feet above the eroded channel.
CL-21	Erosion	Clear Creek between Pioneer Way East and 45th Street East	Stream bank erosion and minor slides
CL-22	Erosion	Downstream of 64th Street East	The stream bank is eroding and the channel down cutting.
CL-23	Water Quality	West Fork of Clear Creek at 72nd Street East	Intermittent flow occurs upstream of this location
CL-24	Riparian/ Aquatic Habitat	Pioneer Way to Gay Road East	The natural channel has been straightened in this reach. The riparian buffer has been significantly reduced.
CL-25	Riparian/ Aquatic Habitat	84th Street East to 99th Street East	This reach has a discontinuous riparian corridor with reduced or non-existent buffer on the West Fork.
CL-26	Riparian/ Aquatic Habitat	76th Street East to 80th Street East	This reach has a discontinuous riparian corridor with reduced or non-existent buffer on the East Fork.
CL-27	Riparian/ Aquatic Habitat	Fish Hatchery	The instream dam is a barrier to fish passage.
CL-28	Flooding	West Fork Clear Creek at 72nd Street East	An extensive debris jam has blocked the upstream end of the culvert.
CL-29	Flooding	East Fork Clear Creek at 72nd Street East	The upstream end of the culvert is blocked with extensive debris jam.
CL-30	Riparian/ Aquatic Habitat	Gay Road East	This culvert may be a barrier to fish passage due to high flow velocity.
CL-31	Flooding	East Fork Clear Creek between 88th Street E and 84th Street East	Extensive road and property flooding occur from 88th Street E to 84th Street East.
CL-32	Riparian/ Aquatic Habitat	Clear Creek at Pioneer Way East	This culvert may be a fish passage barrier.
CL-33	Erosion	5000 block of Vickery Avenue East on main stem Clear Creek	Stream bank erosion in West Fork in 100-ft reach in vicinity of 5000 block of Vickery Avenue East. Fill became saturated and resulted in mass wasting of hillside on west bank with 200-ft- landslide chute to Clear Creek. Approximately 100 ft along the west bank of Clear Creek was damaged.

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-1d
Canyon Creek Flooding, Riparian/Aquatic Habitat, Erosion and Water Quality Problems

Problem ID	Type	Location	Description
CY-1	Flooding	Pipeline Road, Canyon Road, 90th Street East	Canyon Creek overtops Pipeline Road, Canyon Road, and 90th Street East.
CY-2	Flooding	Intersection of Canyon Road and 112th Street East	Road flooding occurs at the intersection of Canyon Road and 112th Street East.
CY-3	Flooding	West Fork of Canyon Creek at 116th Street East	West Fork of Canyon Creek overtops 116th Street East. Water-on-Road sign and evidence of roadway overtopping observed in 2/03. Downstream culverts on 112th Street East and SR-512 may cause backwater in system. Debris clogged the culvert at 112th Street East twice.
CY-4	Flooding	8600 block of Canyon Road	Poor maintenance of private system causes private property flooding at 8600 block of Canyon Road.
CY-5	Flooding	East Fork of Canyon Creek, 12400 block of 58th Avenue East and 12100 and 12200 blocks of 59th Avenue East	East Fork of Canyon Creek causes widespread roadway and property flooding
CY-6	Flooding	Canyon Creek at 84th Street East	Hydraulic analysis predicts overtopping of 84th Street East during 100-year storm from the culvert
CY-7	Flooding	West Fork of Canyon Creek at 92nd Street East	Concern about inadequate conveyance capacity of culvert
CY-8	Flooding	West Fork of Canyon Creek at 104th Street East	Concern about inadequate conveyance capacity of culvert
CY-9	Flooding	East Fork at 96th Street East	Roadway flooding may occur on East Fork at 96th Street East.
CY-10	Flooding	East Fork Canyon Creek at 104th Street East	Roadway flooding may occur in the future. The 1991 Stormwater Master Plan identified this culvert as having [illegible]fficient conveyance capacity.
CY-11	Flooding	East Fork Canyon Creek at 112th Street East	Culvert may be undersized.
CY-12			Combined with other entries
CY-13			
CY-14			
CY-15	Water Quality	46th Avenue E and 58th Avenue East	Septic odors present at Quiet Ridge subdivision retention pond.
CY-16	No record.		May have skipped number in sequence
CY-17	Water Quality	12300 block of 58th Avenue East	Report of failing septic system
CY-18	Erosion	Canyon Creek at 80th Street East.	Stream bank is eroding.

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TABLE 5-1d - *continued*

Problem ID[a]	Type	Location	Description
CY-19	Erosion	Tributary	Channel erosion and bank sliding, location could not be found
CY-20	Erosion	Upstream of second Canyon Road crossing.	Stream bank is eroding
CY-21	Erosion	Downstream of second Canyon Road crossing	Stream bank is eroding and channel down cutting with 10-foot-high exposed banks in 1,000-foot reach downstream of second Canyon Road crossing due to high stream flow
CY-22	Erosion	Downstream of 72nd Street East	Channel is down cutting
CY-23	Riparian/ Aquatic Habitat Water Quality	Clear Creek confluence to Pioneer Way East.	Upstream erosion has caused sedimentation in channel from Clear Creek confluence to Pioneer Way East.
CY-24	Water Quality	72nd Street East	Intermittent flow occurs upstream of this location.
CY-25	Riparian/ Aquatic Habitat	Clear Creek confluence to Pioneer Way East	Invasive aquatic vegetation is pervasive in the channel.
CY-26	Riparian/ Aquatic Habitat	Clear Creek confluence to Pioneer Way East	The natural channel has been straightened and the buffer significantly reduced.
CY-27	Riparian/ Aquatic Habitat	84th Street E to 99th Street East	This reach has a discontinuous riparian corridor with a reduced or non-existent buffer
CY-28	Riparian/ Aquatic Habitat	4200 block of Pioneer Way E; Driveway culvert upstream of Clear Creek Confluence	The driveway culvert is a fish passage barrier due to steep slope
CY-29	Flooding	Canyon Creek at 72nd Street East	The upstream end of culvert is blocked with an extensive debris jam
CY-30	Flooding	5600 block of 103rd Street East	Chronic flooding occurs due to backwater at 103rd Street E. The 1991 Stormwater Master Plan identified this culvert as having insufficient conveyance capacity.
CY-31	Flooding	Pipeline Road	East Fork Canyon Creek overtops Pipeline Road. The 1991 Stormwater Master Plan identified this culvert as having insufficient conveyance capacity.
CY-32	Riparian/ Aquatic Habitat	Burlington Northern Santa Fe Railroad	The BNSF railroad culvert is a fish passage barrier due to steep slope
CY-33	Flooding	44th Street E between 47th Avenue E and 50th Avenue E and in the Gay Road East vicinity	Extensive property and road flooding has been documented in this area. This area is located in the Clear Creek floodplain and has been identified as a repetitive loss area.
CY-34	Flooding	4700 block of 53rd Street East	Private property flooding occurs.
CY-35	Flooding	5400 block of 57th Avenue East	Road runoff is causing driveway flooding.
CY-36	Flooding	4700 through 5300 block of Pioneer Way East	Excessive vegetation in roadside ditch causing overtopping of Pioneer Way East.

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TABLE 5-2a
Rody Creek Flooding, Riparian/Aquatic Habitat, Erosion and Water Quality Problems

Problem ID	Type	Location	Description
RY-1	Riparian/ Aquatic Habitat	72nd Street East	The upstream end of culvert is blocked with extensive debris jam
RY-2	Flooding	6800 block of Bentley Road East	Road runoff flows down driveway and washes around home.
RY-3	Erosion	80th Street East	Stream bank is eroding.
RY-4	Flooding	5700 block of 80th Street E	Roadside ditch is flooding the driveway.
RY-5	Flooding	11600 block of 62nd Avenue East	Roadway runoff from 62nd Avenue East causes property flooding.
RY-6	Flooding	11900 62nd Avenue East	Roadside ditch overtops.
RY-7	Flooding	96th Street E at Pipeline Road	Rody Creek overtops 96th St. East. The 1991 Stormwater Master Plan identified this culvert as having insufficient conveyance capacity.
RY-8	Flooding	98th Street East	Road and property flooding of Rody Creek at 98th Street East. According to property owner, 6002 98th Street East, flooding occurs annually due to clogging of the inlet by debris. Water backs up causing property and septic tank flooding. Flooding also reported upstream at 10100 block of 98th St East and 10300 block of 61st Ave East (possible reduction with recent maintenance project). 1991 Plan identified this culvert as "insufficient conveyance capacity."
RY-9	Flooding	Pioneer Way East	Roadway flooding may occur at Pioneer Way East; culvert may be a fish passage barrier
RY-10	Flooding	90th Street East	Roadway flooding may occur at 90th St East
RY-11	Flooding	104th Street East	Fear of roadway overtopping
RY-12	Flooding	Rody Creek at 112th Street East	Possible roadway overtopping
RY-13	Flooding	Creek at 128th Street East	Possible roadway overtopping
RY-14	Erosion	72nd Street East	Channel down cutting occurring in 100-ft reach downstream of 72nd St East. Culvert is a barrier to fish passage due to excessive outfall drop (3 ft)
RY-15	Water quality	84th Street East	Intermittent flow occurs upstream of this point
RY-16	Riparian/ Aquatic Habitat	Clarks Creek to Pioneer Way East	The natural channel has been straightened channel with the buffer reduced. Invasive riparian vegetation also is present
RY-17	Riparian/ Aquatic Habitat	86th Street E to 99th Street East	This reach has a discontinuous riparian corridor with a reduced or non-existent buffer
RY-18	Riparian/ Aquatic Habitat	Upstream of Pioneer Way East	The instream weir is a barrier to fish passage

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-2b
Diru Creek Flooding, Riparian/Aquatic Habitat, Erosion and Water Quality Problems

Problem ID	Type	Location	Description
DU-1	Flooding	Cross culvert on 66th Avenue East	Private driveway floods on 66th Avenue East
DU-2	Flooding	9700 block of 66th Avenue East	Roadside ditch and culvert system has limited capacity of which causes road flooding.
DU-3	Flooding	9800 block of 67th Avenue Ct. East	Stormwater inundation occurs in roadway depression.
DU-4	Flooding	10200 block of 67th Avenue East	Road flooding occurs due to blocked culvert inlet.
DU-5	Flooding	9900 block of 63rd Avenue Ct. East	Driveway and garage flood.
DU-6	Flooding	Creek at 90th Street East	Possible roadway overtopping
DU-7	Flooding	96th Street East	Roadway flooding may occur at 96th Street East. The 1991 Stormwater Master Plan identified this culvert as having insufficient conveyance capacity.
DU-8	Flooding	104th Street East	Roadway flooding may occur at 104th Street East. The 1991 Stormwater Master Plan identified this culvert as having insufficient conveyance capacity.
CU-9	Flooding	Whole stream	Water quality
DU-10	Riparian/ Aquatic Habitat	Clarks Creek confluence to Pioneer Way East	Invasive riparian vegetation is present in the 2,200-foot reach from Clarks Creek confluence to Pioneer Way East.
DU-11	Erosion	Downstream of 72nd Street East	Stream bank is eroding in the 100 foot-long reach downstream of 72nd Street East. Exposed vertical banks are 8-feet-high.
DU-12	Water Quality	84th Street East	Intermittent flow occurs upstream of this location
DU-13	Riparian/ Aquatic Habitat	Clarks Creek confluence to Pioneer Way East	The natural channel has been straightened and the buffer reduced in 2,200-foot reach from Clarks Creek confluence to Pioneer Way East
DU-14	Flooding	6600 block of Pioneer Way East	Flooding occurs due to backwater at private driveway culvert on Diru Creek near confluence with Clarks Creek

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-2c
Woodland Creek Flooding, Riparian/Aquatic Habitat, Erosion and Water Quality Problems

Problem ID	Type	Location	Description
WO-1	Erosion	Woodland Creek at 84th Street East	Bank erosion, channel down cutting downstream of 80th Street East due to high stream flow. Three foot deep channel incision. Reduced riparian buffer
WO-2	Flooding	Woodland Avenue E south of 102nd Street E	The area south of 102nd Street East is a closed depression with a restrictive outlet pipe. Frequent and extensive flooding occurs in this area. There were also numerous reports of property flooding in this area during the 1997 flood event.
WO-3	Flooding	East side of Woodland Avenue at 119th Street E	Road and property flooding occur due to plugged driveway culvert.
WO-4	Flooding	6900 block of 113th Street Ct. East	Grate inlet is blocked.
WO-5	Flooding	102nd Street East	Roadway flooding may occur at 102nd Street E.
WO-6	Flooding	72nd Avenue E from 93rd Street East to 96th Street East	Woodland Creek overtops 93rd Street East, 94th Street East and driveway culverts on 72nd Avenue East.
WO-7	Flooding	84th Street East & Woodland Creek	Concern that the creek with overtop 84th Street East
WO-8	Flooding	80th Street East	Woodland Creek overtops 80th Street East. The 1991 Stormwater Master Plan identified this culvert as having insufficient conveyance capacity. This culvert is also a barrier to fish passage due to excessive outfall drop.
WO-9	Flooding	6800 block of 128th Street East	Raised roadway is causing private property flooding. County investigated problem in 1993 and determined it was related to an improved road that was constructed the previous year.
WO-10	Flooding	10900 block of Woodland Avenue East	Road flooding occurs due to blocked culvert.
WO-11	Flooding	9100 block of Woodland Avenue East	Property flooding occurs at 9100 block of Woodland Avenue East.
WO-12	Flooding	9100 block of Woodland Avenue East	Property flooding occurs at 9100 block of Woodland Avenue East.
WO-13	Flooding	6800 block of 90th Street East	Road and driveway flooding occur on 6800 block of 90th Street East.
WO-14	Flooding	Intersection of Woodland Avenue East and 84th Street East	Minor depression is causing stormwater ponding at southeast corner of intersection due to no outlet.
WO-15	Flooding	6900 block of 81st Ct. East	Stormwater runoff from private road causes flooding at 6900 block of 81st Ct. East.
WO-16	Flooding	8700 block of 72nd Avenue East	Low, seasonal storm flow is washing out driveway.

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-2c – *continued*

Problem ID	Type	Location	Description
WO-17	Flooding	Woodland Creek at 96th Street East	Blocked culvert is causing road flooding.
WO-18	Flooding	Intersection of 96th Street East and 74th Avenue East	Runoff sheet flows from asphalt ditch on west side of 74th Avenue East and floods intersection.
WO-19	Flooding	7200 block of 102nd Street East	Catch basin inlet is full of gravel and causing road flooding.
WO-20	Flooding	11500 block of 74th Avenue East	Stormwater runoff from roadway and adjacent property runoff causes private property flooding.
WO-21	Flooding	Woodland Avenue from 80th Street East to 76th Street East	According to residents, new development on Woodland Avenue between 80th Street East to 76th Street East altered drainage patterns, which have resulted in flooding. Stormwater runoff was diverted to east side of road when road was expanded.
WO-22	Riparian/ Aquatic Habitat	84th Street East	There is an instream barrier to fish passage due to 12-foot high cascade in channel.
WO-23	Riparian/ Aquatic Habitat	Upstream of Pioneer Way East	Invasive riparian vegetation is present in this reach.
WO-24	Erosion	84th Street East	Scour is occurring at culvert outlet.
WO-25	Erosion	Downstream of 84th Street East	Channel is down cutting downstream of 84th Street East due to high stream flow. Channel incision is 5-feet-deep.
WO-26	Riparian/ Aquatic Habitat	Upstream of 80th Street East	Upstream erosion has caused sedimentation in channel.
WO-27	Erosion, Riparian/ Aquatic Habitat	Downstream of 80th Street East.	Stream bank erosion and channel down cutting downstream of 80th Street East due to high stream flow. Three foot deep channel incision. Reduced riparian buffer.
WO-28	Water quality	84th Street East	Intermittent flow occurs upstream of this location.
WO-29	Riparian/ Aquatic Habitat	Clarks Creek confluence to Pioneer Way East	The natural channel has been straightened and the buffer reduced.
WO-30	Riparian/ Aquatic Habitat	WSU Experimental Farm	The culvert is a barrier to fish passage due to velocity.
WO-31	Water Quality	At & near the mouth	Contributing fecal matter to Clarks Creek, 63% from birds and mammals

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-2d
Clarks Creek Flooding, Riparian/Aquatic Habitat, Erosion and Water Quality Problems

Problem ID	Type	Location	Description
CK-1	Riparian/ Aquatic Habitat	Tacoma Road, Stewart Avenue, 66th Avenue East	Invasive aquatic vegetation in channel has caused Clarks Creek to overflow its banks and flood surrounding property
CK-2	Flooding	9200 block of 104th Street East	Structure on property floods because it is located at the same elevation as the creek. Development in the area may have increased the creek water surface elevation.
CK-3	Water Quality	Meeker Ditch	This reach is on the 303d list due to fecal coliform, temperature, dissolved oxygen and pH levels
CK-4	Flooding	1000 block of 16th Street SW (Meeker Ditch), 12th Avenue SW, and 2210 Pioneer Way. (City of Puyallup)	Flooding occurs in the 1000 block of 16th Street SW (Meeker Ditch), 12th Avenue SW, and 2200 block of Pioneer Way East.
CK-5	Riparian/ Aquatic Habitat	Clarks Creek north of 15th Avenue SW. (City of Puyallup)	Poor riparian and aquatic habitat and water quality occur in Clarks Creek north of 15th Avenue SW.
CK-6	Flooding	8400 block of 96th Street East	Roadside ditch in 8400 block of 96th Street East overtopping during rainfall events.
CK-7	Flooding	10800 block of 82nd Avenue NW	Flooding occurs in 10800 block of 82nd Avenue NW.
CK-8	Flooding	7400 block of Stewart Avenue and 6300 block of 76th Avenue East. (City of Puyallup)	Flooding occurs in 7400 block of Stewart Avenue and 6300 block of 76th Avenue East.
CK-9	Flooding	7800 block of 112th Street East	Road and property flooding occur due to undersized storm drain system under Woodland Elementary School.
CK-10	Flooding	Fruitland Avenue between 104th Street E to 96th Street East.	Ditch and culvert system is undersized and is a chronic maintenance problem.
CK-11	Water Quality	Tacoma Road	Septic systems area failing.
CK-12	Water Quality	Clarks Creek	This reach on 303d list due to fecal coliform levels and pH levels.
CK-13	Riparian/ Aquatic Habitat	Puyallup River confluence to Puyallup City Limits	Invasive aquatic vegetation in channel
CK-14	Riparian/ Aquatic Habitat Water Quality	Puyallup River confluence to Puyallup City Limits	Upstream erosion has caused sedimentation in channel.
CK-15	Erosion	Creel at 99th Street East	Stream banks are eroding.

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-2d – *continued*

Problem ID	Type	Location	Description
CK-16	Riparian/ Aquatic Habitat	Clarks Creek confluence with Puyallup River to Puyallup City Limits	The channel is disconnected from floodplain with reduced buffer from confluence with Puyallup River to Puyallup City Limits.
CK-17	Riparian/ Aquatic Habitat	Meeker Creek - 11th Street SW (City of Puyallup)	The culvert is a possible barrier to fish passage.
CK-18	Riparian/ Aquatic Habitat	Roadside ditch tributary to Meeker Ditch - 11th Street SW (City of Puyallup)	The culvert is a barrier to fish passage due to steep slope.
CK-19	Riparian/ Aquatic Habitat	Unnamed Tributary to Meeker Ditch - 12th Avenue SW (City of Puyallup)	The culvert is a possible barrier to fish passage.
CK-20	Riparian/ Aquatic Habitat	Clarks Creek - Fish Hatchery (State of Washington)	The hatchery dam is a barrier to fish passage.
CK-21	Water Quality	Clarks Creek	Excessive nutrients. Connected to CK-13, invasive vegetation and CK-12, pH standard exceeded.

TABLE 5-3
Potholes Flooding, Aquatic Habitat, and Water Quality Problems

Problem ID[a]	Type	Location	Description
PH-1	Flooding	10300 block of 128th Street E	Dry wells overflowing causing road flooding.
PH-2	Flooding	Flooding from Meadow Park Pond overflow - Resolved with pond expansion.	Flooding from Meadow Park Pond overflow - Resolved with pond expansion.
PH-3	Flooding	Drainage dispute between adjacent property owners that has been resolved	Field flooding at the 13600 Meridian (Meridian Greens Golf Course).
PH-4	Flooding	Same as PH-3	Field flooding at the 13600 Meridian (Meridian Greens Golf Course).
PH-5	Flooding	89th Avenue Ct. E	Black Swamp pothole is flooding surrounding properties and surcharging storm drain system on 89th Avenue Ct. E.
PH-6	Flooding	11500 block of 92nd Avenue E	Drainage swale overtops 92nd Avenue E and causes road and property flooding. Backwater through existing 24-inch diameter stormdrain causes overtopping of inlet structures. One inlet structure is located off the street and in the front yard of the property in the 11500 block of 92nd Avenue E.
PH-7	Flooding	Road and property flooding at 12300 block of 149th Street E	Road and property flooding at 149th Street E
PH-8	Flooding	Road and property flooding at 145th Street E and 144th Street E. - Resolved through maintenance	Road and property flooding at 145th Street E and 144th Street E

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-3 - *continued*

Problem ID[a]	Type	Location	Description
PH-9	Flooding	14600 block of 127th Street E	Road flooding at 14600 block of 127th Street E
PH-10	Flooding	Stormwater runoff from private road causes flooding on private property at 11500 block of 82nd Avenue Ct. E	Stormwater runoff from private road causes flooding on private property at 11500 block of 82nd Avenue Ct. E
PH-11	Flooding	Restaurant parking lot built in swale is causing private property flooding.	Restaurant parking lot built in swale is causing private property flooding.
PH-12	Flooding	13300 block of 112th Avenue E and 11300 block of 136th Street E	Roadway runoff is causing property flooding.
PH-13	Flooding	Property flooding in a closed depression - Resolved with County project.	Property flooding in a closed depression
PH-14	Flooding	9600 block of 148th Street Ct. E	Road flooding at 9600 block of 148th Street Ct. E
PH-15	Flooding	150th Street E; 9700 block of 156th Street E; 15700 block of 97th Street E	Roadway and properties are in a closed depression.
PH-16	Flooding	99th Avenue East	Road flooding reported at 99th Avenue E
PH-17	Flooding	Cascade Park and Firgrove subdivision	Roadway and property flooding reported in subdivision due to obstructed roadside ditch and culvert system.
PH-18	Flooding	98th Avenue Ct. E. and 152nd Street E (Willow Tree Subdivision)	Infiltration facility overflow to roads and surrounding property during periods of high groundwater.
PH-19	Flooding	9600 block 159th Street Ct. E	Runoff from commercial development to the west is causing roadway flooding at 9600 block of 159th Street Ct. E.
PH-20	Flooding	10700 block of 83rd Avenue E	Private detention pond overflowing at 10700 block of 83rd Avenue E
PH-21	Flooding	15200 block of 103rd Avenue Ct. E	Dry well is under capacity.
PH-22	Flooding	141st Street Ct. and 144th Street E	Road and property flooding at 141th Street Ct. and 144th Street E
PH-23	Flooding	South Hill Pump Station at Hemlock Pond	Permission to use current pump station discharge outlet is temporary

TABLE 5-4
Roosevelt Ditch Flooding, Riparian/Aquatic Habitat, Erosion and Water Quality Problems

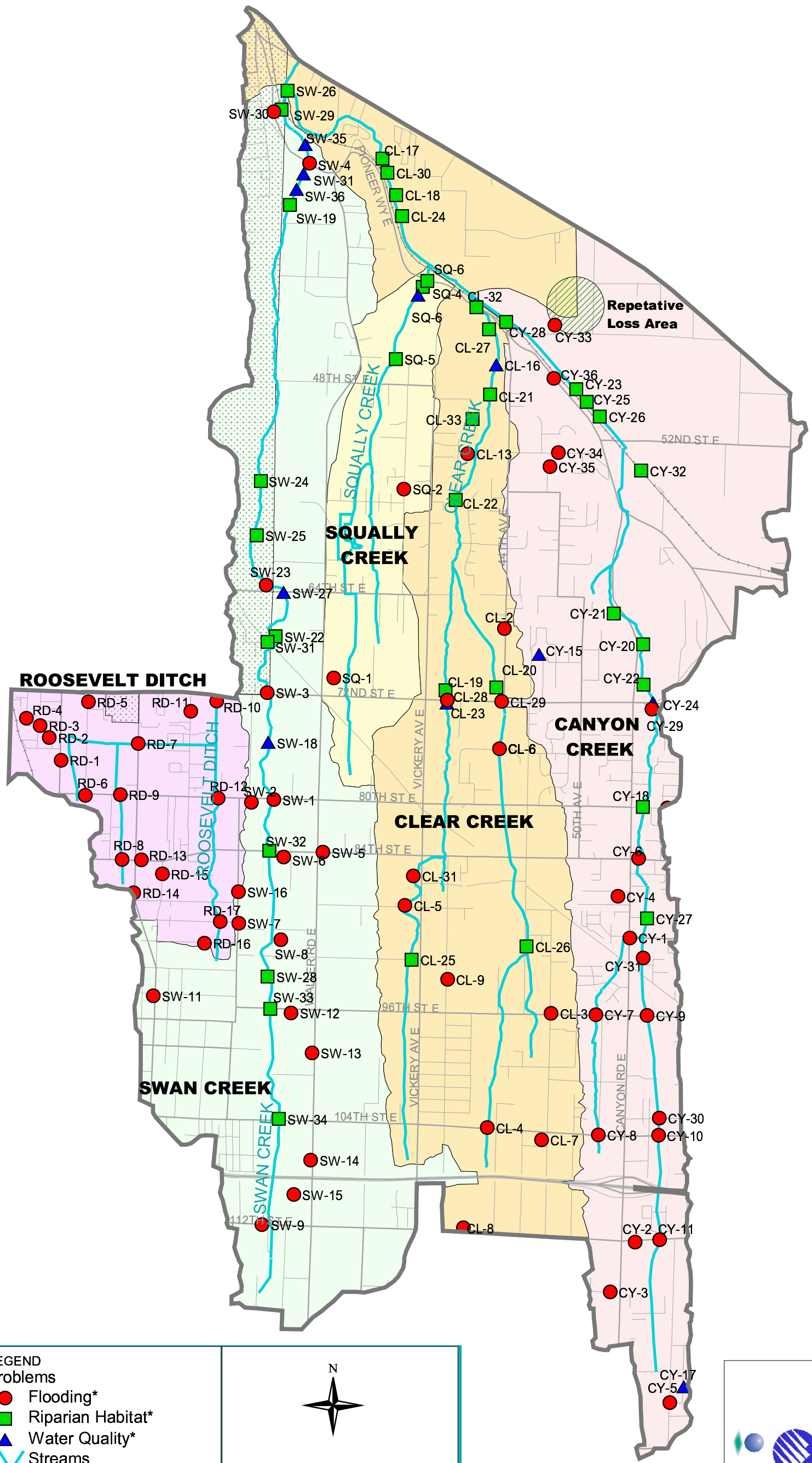
Problem ID	Type	Location	Description
RD-1	Flooding	7700 and 7800 block of Golden Givens Road East	Stormwater inundates the road shoulder and adjacent driveway
RD-2	Flooding	Coventry Court Apartment on 10th Avenue Ct E	Detention pond may be undersized or has a clogged outlet. Pond has been reported to overflow into the apartment yards.

Shaded rows are problems to refer to the maintenance division & small works roster

TABLE 5-4 - *continued*

Problem ID[a]	Problem ID[a]	Problem ID[a]	Problem ID[a]
RD-3	Flooding	900 block of 75th Street East	Apartment storm drain system needs maintenance
RD-4	Flooding	9th Avenue E and 75th Street East	Storm drain system is undersized and causes property flooding.
RD-5	Flooding	7200 block of 12th Avenue East	Road and property flooding due to absence of drainage system. A roadside ditch to the north of the house flows south towards the house but has no outlet.
RD-6	Flooding	12th Avenue E, just south of 80th Street East	Road flooding occurs due to obstructed roadway ditch and culvert system.
RD-7	Flooding	7600 block of Portland Avenue East	Storm drain system overtops Portland Avenue East and causes roadway and property flooding in 7600 block.
RD-8	Flooding	Roosevelt Ditch at 85th Street East	Possible roadway overtopping during severe storms
RD-9	Flooding	Roosevelt Ditch at 80th Street East	Possible roadway overtopping during severe storms
RD-10	Flooding	2100 block of 72nd Street East	Road flooding occurs due to insufficient grate inlet capacity in sag.
RD-11	Flooding	7300 block of 20th Avenue East	The natural drainage channel receiving stormwater drainage from private property and the roadway has been filled in downstream of the road. This channel is on private property. Fill has also been placed in the roadside ditch near the 7400 block of 20th Ave East.
RD-12	Flooding	2200 block of 80th Street East	The roadside ditch has an adverse slope causing road and property flooding
RD-13	Flooding	1600 block of 85th Street East	Diverted stormwater causes overtopping of ditch and culvert system at 85th Street East and roadway and property flooding
RD-14	Flooding	8700 and 8800 block of Portland Avenue East	Roadway flooding occurs due to depressions in the road.
RD-15	Flooding	8700 block of 18th Avenue East	Ditch and culvert system overtop 18th Avenue East causing road and property flooding.
RD-16	Flooding	2100 block of 91st Street East	Roadway runoff is causing property flooding.
RD-17	Flooding	90th Street East	Roadway flooding may occur at 90th Street East.

Shaded rows are problems to refer to the maintenance division & small works roster



LEGEND
Problems
- Flooding*
- Riparian Habitat*
- Water Quality*
- Streams
- Cities
- BNSF Railroad
- Arterials

*Labels refer to flooding, water quality and riparian habitat problem IDs, see Table 5-1.

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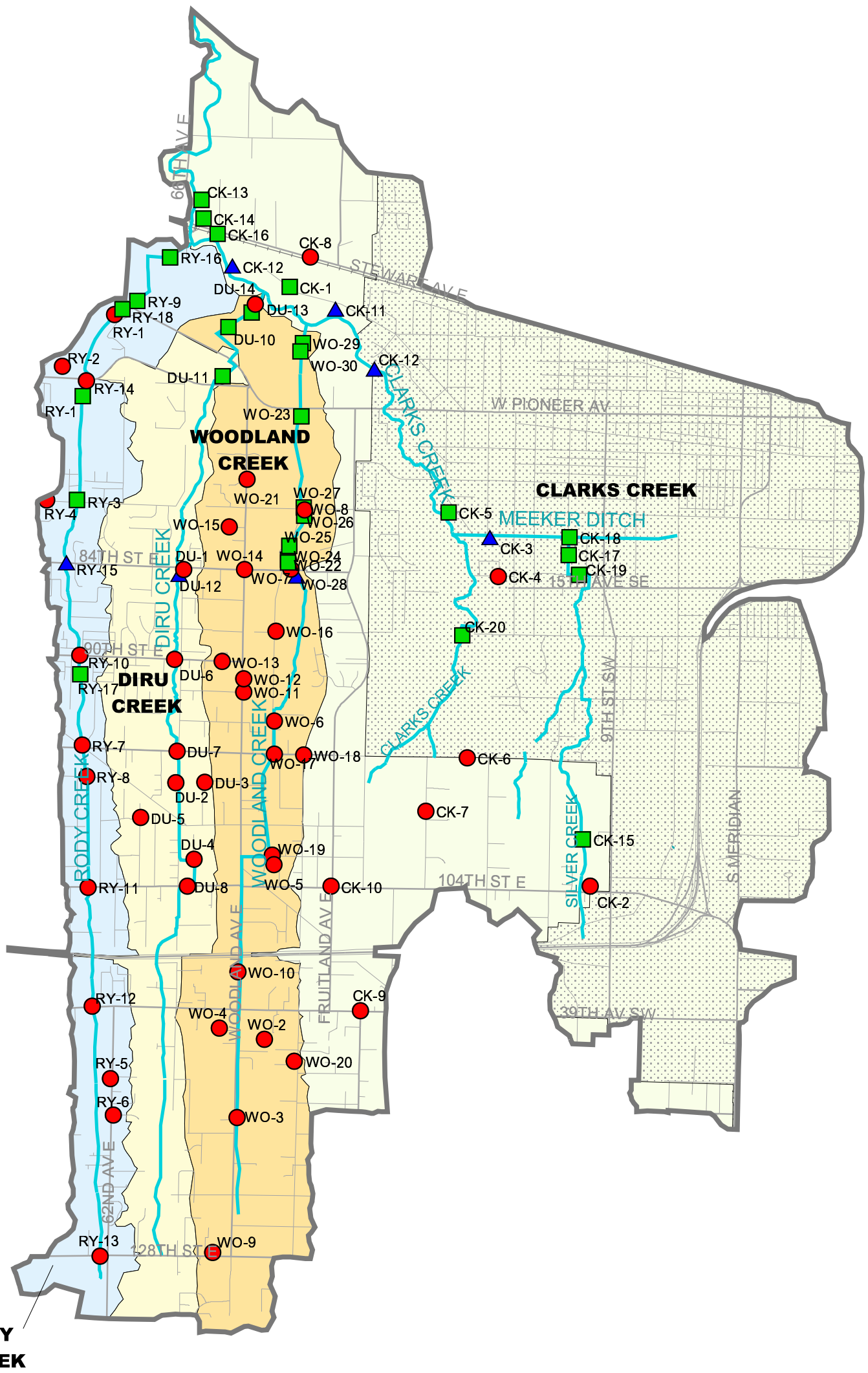
Figure 5-1
Flooding, Riparian Habitat, Water Quality and Erosion Problem Areas
Clear Creek Basin and Roosevelt Ditch

CLEAR/CLARKS CREEK BASIN

Pierce County Water Programs

CH2MHILL



LEGEND

Problems

- Flooding*
- Riparian Habitat*
- Water Quality*
- Streams
- Cities
- BNSF Railroad
- Arterials

*Labels refer to flooding, water quality and riparian habitat problem IDs, see Table 5-2.

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Figure 5-2
Flooding, Riparian Habitat, Water Quality and Erosion Problem Areas
Clarks Creek Basin

CLEAR/CLARKS CREEK BASIN

Pierce County Water Programs

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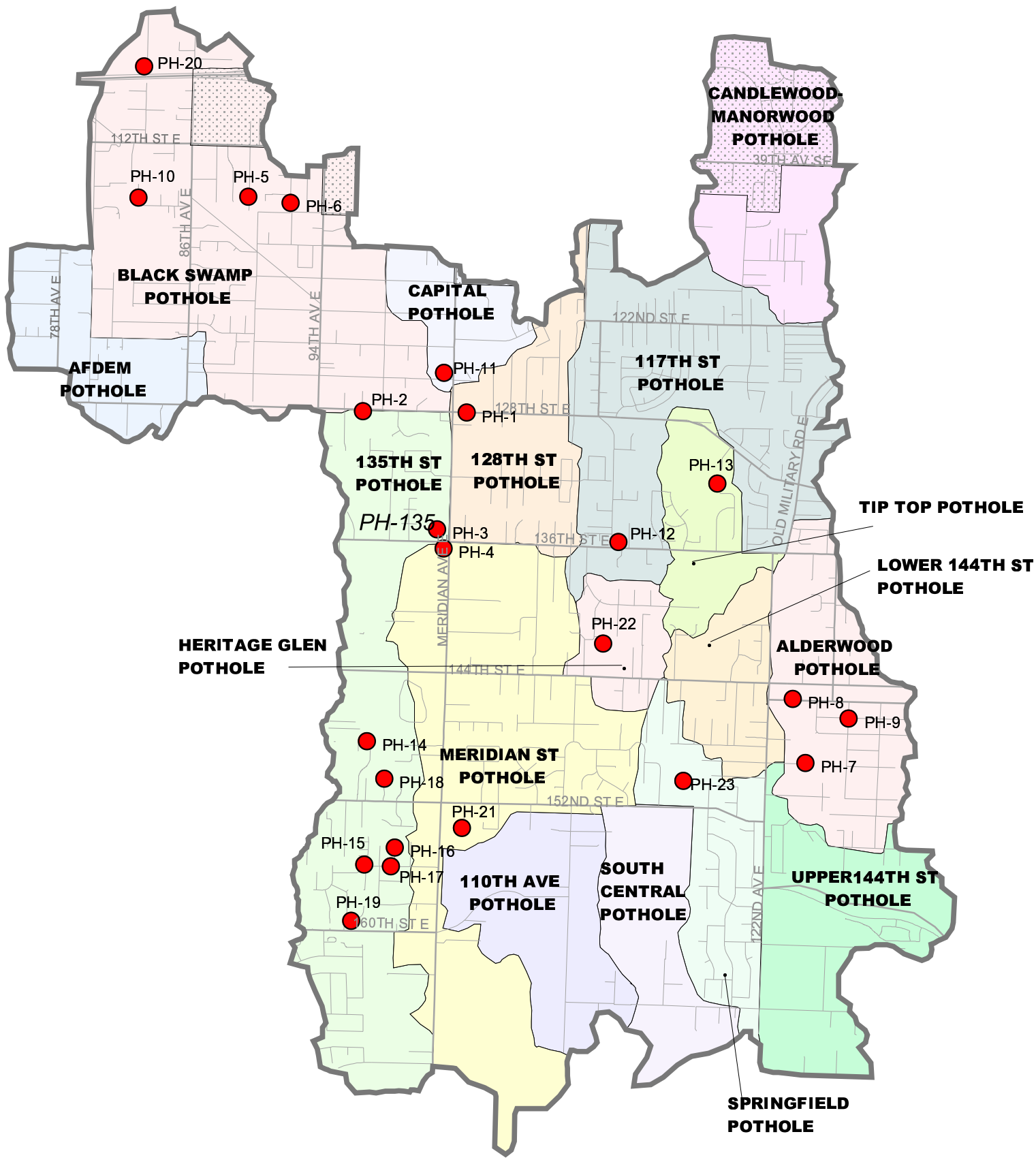

LEGEND

Problems

- Flooding*
- Riparian Habitat*
- Water Quality*
- Streams
- Cities
- BNSF Railroad
- Arterials

*Labels refer to flooding, water quality and riparian habitat problem IDs, see Table 5-3.

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Figure 5-3
Flooding, Riparian Habitat, Water Quality and Erosion Problem Areas Pothole Area Basin

CLEAR/CLARKS CREEK BASIN

Pierce County Water Programs

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CHAPTER SIX
Stormwater Drainage and Flooding Analysis

Chapter Six presents an overview of existing and potential future drainage and flooding problems in the Clear/Clarks Creek Basin. The drainage problems identified in Chapter Five were analyzed to determine the extent and frequency of flooding at each location. This chapter describes existing problem areas within each subbasin. It forecasts future flooding problems that are likely to result from land development set out in the Comprehensive Plan. The chapter also presents potential solutions to these problems, including capital improvement projects (CIPs), maintenance activities, and programmatic measures. The end of this chapter lists specific projects to address existing and forecast drainage problems. Chapter Nine factors the solutions laid out in this chapter into the Basin Plan recommendations.

6.1 Flow Modeling and Analysis

This section summarizes the models and analytical methods used to evaluate the drainage and flooding problems within the Clear/Clarks Basin. Pipe systems, inlets, catch basins, stream channels, roadside ditches, and culverts were subjected to drainage and flooding analysis. Section 6.1.1 discusses the methods used to estimate flows within the major drainages. Section 6.1.2 discusses the hydraulic methods used to analyze problems resulting from stream flows. More detailed information on modeling methods and assumptions of these analyses can be found in *Appendix "G"*.

6.1.1 Stream Flow

Hydrologic modeling was performed to determine the long-term flood-frequency, flow duration, and runoff characteristics for the Clear/Clarks Creek watersheds. Hydrologic modeling simulates the volume of stormwater given various topographic, rainfall, soil, and land use conditions. The results of the hydrologic analysis are used as input to the hydraulic analyses presented in Section 6.1.2. These results are also used to qualitatively assess hydrologic impacts to the water quality and habitat conditions presented in Chapter Seven and Chapter Eight.

The Hydrologic Simulation Program—Fortran (HSPF) model (USGS, 1997) was used to develop peak flow rates and flow duration for the creeks and major conveyances in the basin. The HSPF model used in this analysis was originally developed by the United States Geological Survey (USGS) in the early-1990's to support earlier basin planning efforts (USGS, 1994) and included the entire Clear Creek Basin and the Rody and Diru Creek subbasins in the Clarks Creek Basin. This model was recently refined by Northwest Hydraulic Consultants (NHC) to support a Federal Emergency Management Agency (FEMA) restudy of the Clear Creek floodplain (NHC, 2003). NHC revised the USGS model to provide a refined subbasin delineation and also updated the land-use information for current and future conditions.

The HSPF model developed by NHC was extended to include the entire Clarks Creek Basin. As part of the effort, additional subbasins were delineated, new flow routing tables (FTABLES)

were created, and existing and future conditions land use parameters were developed. Generally all subbasins were delineated using 2-ft contour mapping and the 2001 drainage inventory provided by Pierce County. *Figure 6-1* shows the HSPF Reaches and subbasins used for the hydrologic analysis.

Development of the HSPF model is documented in *Appendix "F."*

Frequency Analysis

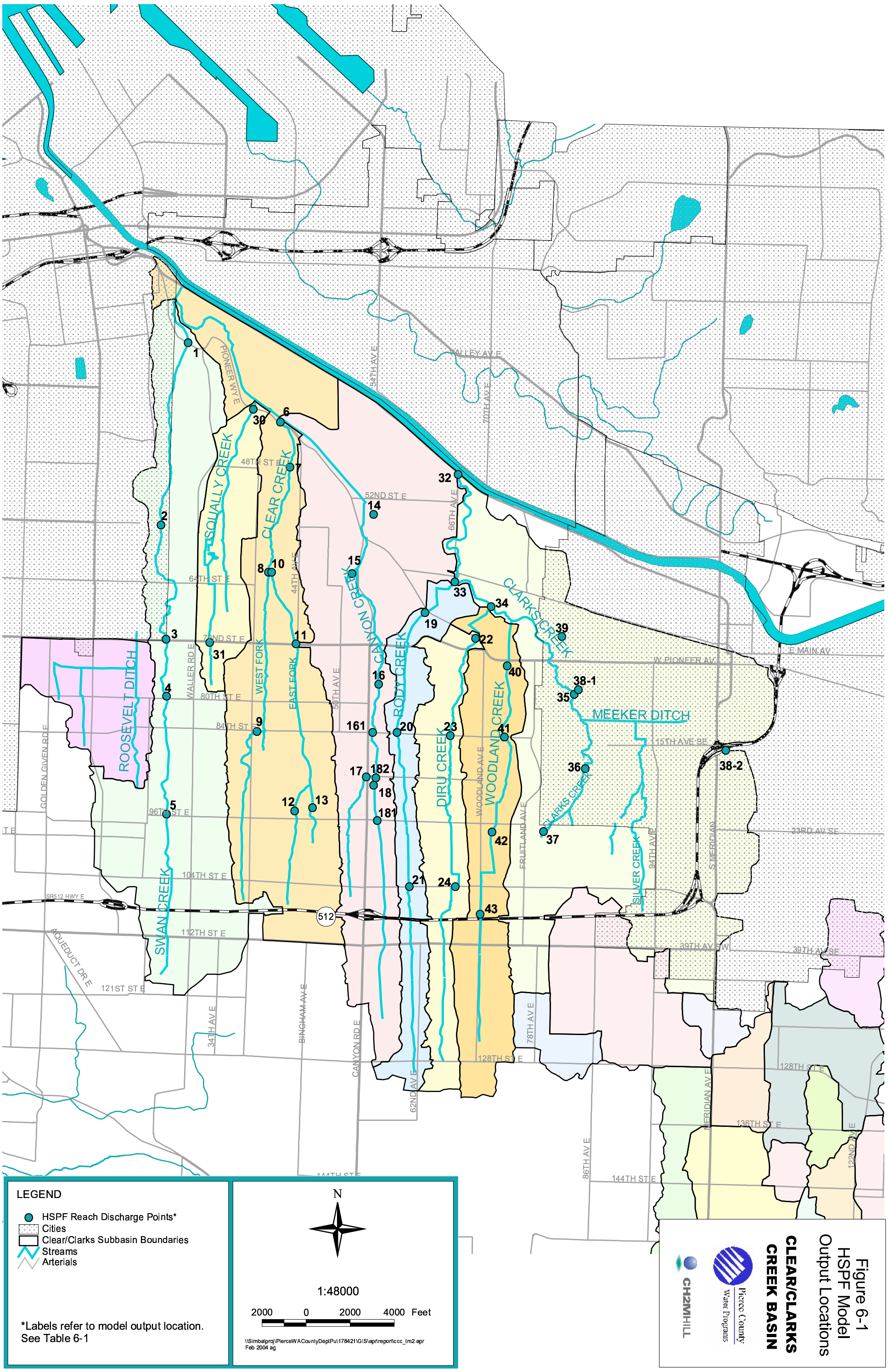
The long-term flood frequency analysis used the synthetic extended 158-year precipitation time-series developed for Pierce County (MGS Engineering, 2001). The time series was created by combining applicable high-quality one-hour records from rainfall measuring stations located in Western Washington, Oregon, and British Columbia. Performing a 158-year continuous simulation is useful because it allows for interpolation (rather than extrapolation) of the extreme storm events of interest (e.g., 50- to 100-year).

Peak flood frequency is the probability that a given peak flood event will occur in any year. Flood frequency is expressed as a "return period" (the inverse of the probability) and represents the average interval between the occurrences of a specific magnitude flood. For example, a peak flood with a 50% probability of occurring in any given year is equivalent to a 2-year return period (1/0.5 = 2). Data on the frequency of floods is used to evaluate the hydraulic performance of structures and to estimate the average interval of flooding. Peak flood frequency is used primarily as input to hydraulic models to estimate the flooding potential at roadway cross culverts.

Typically, peak flood values computed from the frequency analysis are also used as input into hydraulic models to compute a corresponding peak stage frequency, i.e., the frequency that the elevation of the water surface of a stream will exceed a certain depth (or elevation). Stage frequency can be estimated directly from HSPF data for areas with widespread and extended inundation.

Table 6-1 shows the results of the peak flood frequency and peak stage frequency analysis for existing and future land use conditions. Peak flood frequency was computed at 41 locations in the Watershed using the standard Log Pearson Type III distribution (USGS, 1982). Peak stage frequency was also computed for the Woodland Creek reach in the vicinity of 112th Street East. HSPF model output locations (reach discharge points) are shown on *Figure 6-1*. Additional information on the frequency analysis is provided in *Appendix "F"*.

The HSPF analysis predicted that peak flows will increase for all return periods and all subbasins throughout the Clear and Clarks Creek Basins under future land use. *Table 6-1* shows that highest peak flows are predicted to occur in the subbasins with the largest tributary areas: Swan Creek, Clear Creek, Canyon Creek, and the mainstem of Clarks Creek.


LEGEND
HSPF Reach Discharge Points*
Cities
Clear/Clarks Subbasin Boundaries
Streams
Arterials
*Labels refer to model output location.
See Table 6-1
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Pierce County
Water Programs
CLEAR/CLARKS
CREEK BASIN
Figure 6-1
HSPF Model
Output Locations
ROOSEVELT DITCH
SQUALLY CREEK
CLEAR CREEK
WEST FORK
EAST FORK
CANYON CREEK
RODY CREEK
DIRU CREEK
WOODLAND CREEK
CLARKS CREEK
MEEKER DITCH
SILVER CREEK
SWAN CREEK
PIONEER WY E
VALLEY AV E
54TH AV E
70TH AV E
66TH AV E
52ND ST E
48TH ST E
64TH ST E
72ND ST E
80TH ST E
84TH ST E
96TH ST E
104TH ST E
112TH ST E
121ST ST E
128TH ST E
136TH ST E
144TH ST E
WALLER RD E
GOLDEN GIVEN RD E
AQUEDUCT DR E
34TH AV E
BINGHAM AV E
CANYON RD E
62ND AV E
78TH AV E
86TH AV E
FRUITLAND AV E
94TH AV E
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MERIDIAN AV E
122ND AV E
W PIONEER AV
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TABLE 6-1
Existing and Future Flood Frequency

HSPF Reach[a]	Location	2-Year Peak Flow (cfs)			25-Year Peak Flow (cfs)			100-Year Peak Flow (cfs)		
		Existing	Future	%Diff	Existing	Future	% Diff.	Existing	Future	% Diff.
Swan Creek										
1	Pioneer Way East	150.7	180.9	20.0	295.3	338.8	14.7	371.8	424.5	14.2
2	67th Street East (Extended)	117.6	136.7	16.2	232.3	257.9	11.0	293.1	322.8	10.1
3	72nd Street East	100.8	116	15.1	196.9	216.4	9.9	248.9	270.7	8.8
4	80th Street East	96.9	112	15.6	188.2	207.5	10.3	238.1	259.2	8.9
5	96th Street East	73.1	90.6	23.9	142.0	162.6	14.5	180.9	200.4	10.8
Squally Creek										
30	Pioneer Way East	54.2	58.7	8.3	114.3	123.3	7.9	150.1	162.2	8.1
31	72nd Street East	4.3	4.9	14.0	9.2	10.6	15.2	12.0	14.1	17.5
Clear Creek										
6	Pioneer Way East	91.5	96	4.9	190.4	195.7	2.8	243.2	249.0	2.4
7	49th Street East (Extended)	67.4	70.4	4.5	151.8	155.2	2.2	195.7	199.2	1.8
10	East Fork at 64th Street East	31.7	32.7	3.2	62.4	63.5	1.8	75.8	76.9	1.5
11	East Fork at 72nd Street East	38.8	39.7	2.3	64.9	65.7	1.2	75.6	76.6	1.3
12	Upper East Fork Clear at 96th Street East	13.9	14.7	5.8	28.1	28.9	2.8	34.7	35.4	2.0
13	East Fork Clear at 96th Street East	9.8	10.1	3.1	23.4	23.9	2.1	29.6	30.1	1.7
8	West Fork at 64th Street East	22.5	24	6.7	63.1	64.6	2.4	87.8	88.9	1.3
9	West Fork at 84th Street East	19.4	20.9	7.7	40.1	42.4	5.7	52.1	54.9	5.4
Canyon Creek										
14	Pioneer Way East	99.6	103.1	3.5	199.4	205.5	3.1	257.2	264.6	2.9
16	77th Street East	19.3	20.1	4.1	38.6	42.3	9.6	49.1	55.4	12.8
161	84th Street East	15.6	17	9.0	37.2	45.1	21.2	54.8	69.3	26.5
182	East Fork at 90th Street East	15.3	18.1	18.3	46.0	59.4	29.1	74.0	97.6	31.9
18	East Fork at Pipeline Road	5.3	7.8	47.2	14.3	18.1	26.6	20.8	24.4	17.3
17	West Fork at Canyon Road and 90th Street East	21.7	25.6	18.0	41.5	47.1	13.5	51.5	58.0	12.6
15	West Trib. at Canyon Road East	30.8	31.7	2.9	63.5	65.1	2.5	83.8	85.9	2.5

TABLE 6-1
Existing and Future Flood Frequency

HSPF Reach[a]	Location	2-Year Peak Flow (cfs)			25-Year Peak Flow (cfs)			100-Year Peak Flow (cfs)		
		Existing	Future	%Diff	Existing	Future	% Diff.	Existing	Future	% Diff.
Rody Creek										
19	Pioneer Way East	17	18	5.9	34.0	36.1	6.2	43.5	46.3	6.4
20	84th Street East	1.4	1.6	14.3	3.4	4.2	23.5	4.7	6.0	27.7
21	104th Street East	8.7	11	26.4	19.9	22.0	10.6	25.6	27.1	5.9
Diru Creek										
22	Pioneer Way East	28.5	30.5	7.0	72.2	75.8	5.0	102.9	107.1	4.1
23	84th Street East	6.2	7.0	12.9	40.0	42.1	5.3	72.8	74.1	1.8
24	104th Street East	2.3	2.8	21.7	4.5	5.4	20.0	5.4	6.7	24.1
Woodland Creek										
40	Pioneer Way East	14.9	24.4	63.8	43	59	37.2	64.6	80.9	25.2
41	84th Street East	35.1	48.7	38.7	63.7	77.7	22.0	79.1	92	16.3
42	96th Street East	15.6	16.3	4.5	20.2	20.8	3.0	22.1	23.2	5.0
43	SR 512	11.8	12.5	5.9	15	15.7	4.7	16	17.3	8.1
43S[b]	Stage at 112th Street East (feet)	405.3	405.7	0.4	407	407.2	0.2	407.6	407.9	0.3
Clarks Creek										
32	Outfall to Puyallup River	178.1	194.4	9.2	272.5	297.8	9.3	320	351.2	9.8
33	Stewart Avenue East	163.2	176.6	8.2	246.2	265.8	8.0	288.7	313.7	8.7
34	USGS Gage 12102075	160.2	171.7	7.2	244.5	263.1	7.6	289	313.9	8.6
35	7th Avenue SW	115.3	126.4	9.6	177.5	190.4	7.3	208.2	220.8	6.1
36	15th Street SW (Extended)	16.5	29.5	78.8	56.8	75.3	32.6	86.9	102.4	17.8
37	96th Street East	21.5	30.5	41.9	47.8	59.8	25.1	63	76.8	21.9
38-1[c]	Meeker Ditch	63.1	99.8	58.2	128.2	177.9	38.8	161.8	217.4	34.4
38-2[c]	Diversion to Highway Basin	48.9	66.4	35.8	79.4	106	33.5	93.2	126.6	35.8
39	Pioneer Way Storm drain Outfall	40.9	47.5	16.1	78.6	86.4	9.9	100.7	106.9	6.2

[a] See Figure 6-1 for HSPF Reach locations
[b] HSPF Reach 43S values (including Difference) are shown in units of feet.
[c] HSPF Reach 38-1 is the primary discharge point from the subbasin. HSPF reach 38-2 represents the secondary diversion out of the Clear/Clarks Creek Basin

The highest peak flows were predicted for Swan Creek under both existing and future land use conditions. The Swan Creek Subbasin is the second largest subbasin (behind Clarks Creek) and is one of the more developed subbasins with a relatively high (20%) effective impervious area (EIA). Swan Creek, Woodland Creek, and mainstem Clarks Creek (above 15th Avenue SW) have the highest increase in peak flows under future land use conditions.

A small increase in future peak flows will occur in the lower Canyon Creek Subbasin at Pioneer Way. However, peak flow rates in the upper Basin are predicted to be significantly higher. Overall, the Clear Creek Subbasin will likely experience only a slight increase in peak flows under future conditions because only a slight increase in EIA is expected under future land use conditions.

At over 3,000 acres, the subbasin associated with the main stem of Clarks Creek (upstream of 7th Avenue West) is the largest subbasin in the system. However, it generates peak flows on a magnitude similar to much smaller and less developed subbasins. *Table 6-1* shows that the 25-year peak flow for the existing land use condition for Clarks Creek at 7th Avenue West (HSPF Reach 35) is about 180 cubic feet per second (cfs).

This compares with the 25-year peak flow in Clear Creek, which is a much smaller (2,000 acres) and less developed basin. The reasons for this are twofold. First, a significant amount of highly permeable outwash soil exists in this part of the Clarks Creek Subbasin. A large portion of the rainfall infiltrates outwash soils and enters the stream system as groundwater inflow rather than as runoff from the land surface. Secondly, a storm drain diversion exists near 15th Avenue SW and Meridian Avenue South in the City of Puyallup (near SR-512), which transfers a large amount of stormwater out of the Clarks Creek system to the Mid-Puyallup River Basin.

Generally, flow at a point in a watercourse is proportional to the upstream area tributary to that point. However, the HSPF model results suggest that this is not always the case in Canyon, Rody, and Woodland Creeks. Using Canyon Creek as an example, *Table 6-1* shows that the 25-year peak flow for the existing land use condition at 90th Street East (HSPF Reach 182) is approximately seven (7) cfs higher than the 25-year peak flow at 77th Street East (HSPF Reach 16). In the Canyon, Rody, and Woodland Creek systems, the reduction in flow is likely due to a combination of floodplain storage and infiltration in reaches where high stream flow has down cut the channel in the canyon reaches exposing the highly permeable outwash soil layer.

Woodland Creek shows the greatest increase (62%) in effective impervious area and the greatest increase in peak flows at Pioneer Way East (HSPF Reach 40). Flood depths will increase at 112th Street East (HSPF Reach 43) under future land use conditions but the increase in peak flow is predicted to be less than 5%. Only a minimal increase in peak flows is expected in this reach because the increased flooding will further attenuate peak flows. In addition, discharge from this reach is limited to about 15 cfs through the pipe under 104th Street East.

Peak streamflow rates used by FEMA to develop floodplain information were substantially lower than peak flow rates predicted by the hydrologic analysis presented in *Table 6-1*. For instance, the 100-year peak flow rate published in the Unincorporated Pierce County Flood Insurance Study for Swan Creek at Pioneer Way was 244 cfs. The flood insurance study value is 125 cfs lower than the peak 100-year flow rate of 374 cfs (see *Table 6-1*) predicted by the HSPF model.

This difference is probably due to a combination of land development and the availability of a longer hydrologic and precipitation data record. The original flood insurance study was conducted in 1987. Since that time, additional impervious area has been added with new development, which in turn has increased peak flows in Swan Creek. Additionally, analytical techniques used to develop peak flows for the FEMA study were much less sophisticated then the techniques used in the HSPF analysis and likely under predicted peak flows in the Basin.

Flow Duration and Stage Duration Analysis

The amount of time (generally expressed as a percent of total time) in which a given flow, or stage, is equaled or exceeded. Duration analysis provides insight on basin hydrology during non-flood events. For example, extended periods of high-flow can erode streambanks and incise the stream channel, leading to bank failure. Extended periods of high-flow also increase the difficulty of maintaining fish sustaining habitat. Conversely, extended periods of low-flow can adversely affect water quality during the summer months. Water quality effects can include temperature increases, reductions in dissolved oxygen, and concentration of pollutants.

Flow duration was computed for 13 locations in the Clear/Clarks Creek Basin. Flow duration data was used to qualitatively identify water quality and habitat problems due to low streamflow, erosion, and poor habitat function. *Table 6-2* shows the results of this analysis. Flow duration plots are provided in *Appendix "F"*.

The HSPF analysis predicted that the duration of high flows will increase under future conditions for most subbasins (see *Table 6-2*). In this region, flows above the two-year peak flow level typically exceed the capacity of the stream channel and often result in erosion of the channel banks and bottom.

Table 6-3 illustrates that the duration of these potentially damaging flows will increase in most of the streams and will likely worsen erosion in reaches already experiencing incising and down cutting.

TABLE 6-2
Existing and Future Flow Duration

HSPF Reach[a]	Location	Percent Time Exceeded[b]				
		0.1	1	10	50	99
Existing Land Use Condition						
1	Swan Creek - Pioneer Way East	139.8	62.3	13.3	2.7	0.1
2	Swan Creek - 67th Street East (Extended)	110.4	47.9	8.3	0.7	0.01
30	Squally Creek - Pioneer Way East	42.2	18.9	4.0	0.6	0.01
7	Clear Creek - 49th Street East (Extended)	62.9	20.6	1.2	0.4	0.01
8	Clear Creek – West Fork at 64th Street East	18.9	5.8	1.1	0.3	0.00
11	Clear Creek - East Fork at 72nd Street East	39.9	17.3	2.8	0.5	0.01
14	Canyon Creek - Pioneer Way East	69.6	62.3	13.3	2.7	0.10
15	Canyon Creek - W Trib. at Canyon Road East	21.2	47.9	8.3	0.7	0.01
16	Canyon Creek – 77th Street East	13.7	18.9	4.0	0.6	0.01
161	Canyon Creek – 84th Street East	17.2	10.7	2.6	0.5	0.01

TABLE 6-2
Existing and Future Flow Duration

HSPF Reach[a]	Location	Percent Time Exceeded[b]				
		0.1	1	10	50	99
20	Rody Creek - 84th Street East	1.3	0.8	0.4	0.1	0.00
22	Diru Creek - Pioneer Way East	19.5	8.6	2.6	0.9	0.01
41	Woodland Creek - 84th Street East	31.2	19.9	5.1	0.7	0.01
Future Land Use Condition						
1	Swan Creek - Pioneer Way East	151.7	69.2	14.9	2.9	0.2
2	Swan Creek - 67th Street East (Extended)	117.2	52.0	9.2	0.7	0.01
30	Squally Creek - Pioneer Way East	44.0	19.9	4.1	0.6	0.01
7	Clear Creek - 49th Street East (Extended)	63.8	21.2	1.2	0.4	0.01
8	Clear Creek - West Fork at 64th Street East	19.1	5.9	1.1	0.3	0.00
11	Clear Creek – East Fork at 72nd Street East	40.3	17.7	2.8	0.5	0.01
14	Canyon Creek - Pioneer Way East	71.9	33.0	6.9	0.7	0.01
15	Canyon Creek – West Trib. at Canyon Road East	21.6	9.9	1.8	0.4	0.01
16	Canyon Creek – 77th Street East	14.9	7.0	1.8	0.4	0.01
161	Canyon Creek – 84th Street East	18.2	11.5	2.8	0.5	0.01
20	Rody Creek - 84th Street East	1.6	0.8	0.4	0.1	0.00
22	Diru Creek - Pioneer Way East	20.6	9.0	2.6	1.0	0.01
41	Woodland Creek - 84th Street East	36.0	22.5	7.6	0.7	0.01

a See Figure 6-1 for HSPF Reach locations

b Percent time exceeded refers to the percent of time a tabulated flow rate is exceeded. For example, flow in Swan Creek at Pioneer Way East exceeds 13.3 cfs 10% of the time. Similarly, flow in Squally Creek at Pioneer Way East exceeds 0.6 cfs 50% of the time.

TABLE 6-3
Average Number of Hours per Year with Flow Duration Above 2-year Peak Flow Level

HSPF Reach[a]	Location	Existing	Future	Change in Duration
1	Swan Creek - Pioneer Way E	5.8	16.2	10.4
2	Swan Creek - 67th Street (Extended)	11.6	14.0	2.4
30	Squally Creek - Pioneer Way E	6.7	6.6	0.0
7	Clear Creek - 49th Street E (Extended)	8.3	8.3	0.0
8	Clear Creek - West Fork at 64th Street E	6.1	6.0	-0.1
11	Clear Creek - East Fork at 72nd Street E	16.8	17.4	0.6
14	Canyon Creek - Pioneer Way E	3.6	3.8	0.2
15	Canyon Creek - W Trib. at Canyon Road E	2.3	2.3	0.0
16	Canyon Creek - 77th Street E	3.9	6.1	2.2
161	Canyon Creek - 84th Street E	24.5	50.6	26.1
20	Rody Creek - 84th Street E	7.7	12.1	4.4
22	Diru Creek - Pioneer Way E	3.3	3.7	0.4
41	Woodland Creek - 84th Street E	4.5	21.3	16.8

[a] See Figure 6-1 for HSPF Reach locations.

Runoff Volume and Low-Flow Analysis

"Appendix H" presents the results of the runoff volume analysis as the predicted average monthly and annual runoff volume under existing and future land use conditions. The results are used qualitatively in the water quality and habitat analysis in a manner similar to the flow duration analysis.

Table 6-4 shows the months of the year when the model predicted the occurrence of low flows in Clear and Clarks Creek and the tributary drainages. Generally, the model predicted that water is available year-round in the most downstream reaches of each creek, but intermittent flow occurs in the upper reaches when stream flow drops to very low levels in the summer. The volume analysis showed that stream flow occurs in all the reaches from late fall through spring, but drops to nearly zero in all creeks during the summer except for the lowland reaches of Clear Creek and Clarks Creek. These creeks are able to sustain streamflow year-round in the Puyallup Valley reaches due to the presence of springs and seeps in the toe of the plateau.

6.1.2 Hydraulic Analysis

Hydraulic analyses were conducted for many of the major stream channels, tributary drainage systems, and localized flooding problems located within the Clear/Clarks Creek Basin. Hydraulic models were used to evaluate flooding issues resulting from insufficient conveyance capacity, evaluate fish passage conditions through stream culverts, and to develop routing elements for use in the hydrologic model. The models used in this analysis include:

HEC-RAS

Backwater model developed by the US Army Corps of Engineers specifically designed to simulate the hydraulics of open channel systems. This model contains many options for simulating flow through culverts, including a wide variety of culvert shapes to choose from, and accounts for losses through culverts better than many other programs. This model was used for reaches with more than one culvert or where backwater effects were assumed to occur. The problem investigation for RD-7 is an example of an application if this model.

HY8

Culvert analysis program developed by the Federal Highway Administration (FHWA). This model computes barrel velocity and headwater depth and was used to analyze culvert hydraulics at flooding problem locations occurring at a single location with limited downstream backwater effects. The problem investigation for CL-6 is an example of this model.

Inlet control nomographs

A graphical procedure developed by the FHWA that computes headwater for pipe and culvert systems. This technique is used to analyze roadside and driveway culverts. The problem investigation for WO-6 is an example of an application of this model.

Storm drain analytical techniques

Uniform flow analysis was used to simulate the hydraulics of drainage systems consisting mostly of enclosed pipes. Backwater analysis was performed in areas with significant backwater influence. Inlet and catch basin capacity was analyzed in accordance to WSDOT Hydraulics Manual grate inlet design capacity. The problem investigation for SW-5 is an example of an application of this model.

The existing problem areas described in Chapter Five were analyzed using the analysis tools described above. Each problem was analyzed to determine the extent of flooding under existing and future land use conditions. Then the 136 flooding problems were evaluated to determine the cause of flooding.

The first step in this evaluation consisted of a desktop assessment followed by a site visit to gain a better understanding of the problem. During the initial evaluation, over 40 of the flooding problems were determined to either: have been resolved; were outside the jurisdiction of the county; were private property issues; or could be resolved through maintenance activity.

Almost 40 of the remaining problems could be analyzed qualitatively and would likely be considered a "small works project." Small works projects are generally implemented by County Water Programs maintenance crews at a cost of less than $25,000. The remaining 54 problems required hydraulic analysis using the techniques described previously.

Hydraulic analysis results can be found in "Appendix I."

6.2 Existing Problems

6.2.1 Flooding

Repetitive Losses

The Federal Emergency Management Agency (FEMA) has identified Pierce County as a "repetitive loss" community. FEMA defines repetitive loss properties as those where two or more National Flood Insurance Program (NFIP) claims of at least $1,000 each have been paid within any 10-year period since 1978. To participate in the NFIP Community Rating System, Pierce County developed a Repetitive Loss Plan (January 2001).

Lower Canyon Creek is a Repetitive Loss Area

The valley part of the Canyon Creek Basin is one of three areas experiencing repetitive losses from flooding, based on FEMA records. According to the Repetitive Loss Plan, widespread flooding occurs in the vicinity of 47th and 50th Avenues East, and 40th and 55th Streets East. Flooding is due to the backwater effects of the Clear Creek floodgates. The mouth of Canyon Creek is close to the mouth of Clear Creek into the Puyallup River. The floodgate at the mouth of Clear Creek can either prevent, or cause flooding, depending on flow conditions in the Puyallup River and Clear Creek. If river stages are high in the Puyallup River, the gates close preventing river flood waters from entering the Clear Creek system. However, this also prevents Clear Creek from discharging into the river and results in water backing up into Swan Creek, Clear Creek, and Canyon Creek.

A number of homes in this area were identified as repetitive loss properties. Flooding occurred at other properties in the repetitive loss area; however, no insurance claims were filed. According to the Draft Repetitive Loss Plan, residents in this area filed flood insurance claims in seven of the last 20 years. This corresponds to a 33% chance of flooding in any year. The Drainage Issues figure specific to the Clear Creek Basin (*Figure 5-1*) shows the general location of the repetitive loss area.

Causes of Drainage Problems Overview

In general, the drainage problems in the Basin are being compounded by the cumulative effects of historic and ongoing development. The addition of each single-family home results in more impervious surface area and additional surface water runoff. With the increasing development of the Clear/Clarks Creek Basin, there are issues related to the loss of floodplain storage area along the creeks, undersized culverts, and the loss of flow capacity due to invasive vegetation in the roadside channels and streams that are not addressed by development regulations. Development regulations concentrate on not increasing the rate or volume of stormwater coming from a building site, not on runoff, channels or streams passing through. In addition, development is authorized within the 500-year floodplain and many wetland violations occur. *Figure 4-10* shows the location of the 500-year floodplain. *Figure 4-11* shows the location of wetland areas.

Drainage districts continue to operate in some parts of the Clear/Clarks Creek Basin. County maintenance staff generally is not allowed to perform ditch maintenance work within the boundaries of a Drainage District or on private property. County maintenance staff can perform work within a road "Right-of-Way" (ROW) or an easement. In terms of surface water that flows through different jurisdictions, the County maintenance staff can only address problems within unincorporated Pierce County boundaries. In some cases, a ditch in need of maintenance within a Drainage District may be the cause of upstream flooding within the County's jurisdiction.

Access to storm drainage facilities is hindered by encroachment of buildings, outbuildings, fences, and yards into the ROW or drainage easements. In some cases, fences and sheds are built directly over manholes and encroach into the ROW. Unauthorized landscaping in the ROW can also be a problem.

6.2.2 1991 Storm Drainage and Surface Water Management Plan

Culverts

An analysis of culverts in the Clear/Clarks Creek Basin was performed for the 1991 Storm Drainage and Surface Water Management Plan, Volumes I and II (1991 Plan) (James M. Montgomery Consulting Engineers, Inc., 1991).

The 1991 Plan analyzed 96 County-owned culverts. Of these culverts, 70 (73%) did not meet the design criterion (the ability to pass the 25-year design flow with a water depth less than 1.5 times the diameter of the culvert). 47 of these culverts were determined to be sufficiently undersized to warrant their inclusion in the study's Capital Improvement Program.

Culvert upgrades were proposed because it was not feasible to provide enough detention upstream to reduce flood flows. The Clear Creek Basin contained 24 projects and the Clarks Creek Basin contained 23. No culvert projects were proposed within the pothole or Roosevelt Ditch areas. Other culverts in the Clear/Clarks Creek Basin were not selected for improvement because they: 1) had adequate capacity; 2) it was not cost-effective to provide the upgrades; or 3) the culverts functioned as a flow controller and helped to reduce downstream flood peaks.

Undersized Storm Drain Pipelines

12 storm drain lines within the James M. Montgomery, Inc., study area were analyzed. Of these, five pipelines were found to be sufficiently undersized to warrant a recommendation to improve them:

- 24-inch diameter pipeline carrying Woodland Creek from 104th Street East to 100th Street East
- 36-inch diameter pipeline on south side of 97th Street East in the Swan Creek Basin
- 12-inch diameter pipeline along 66th Avenue East carrying Diru Creek from 106th Street East to 104th Street East
- Pipeline connecting along 58th Street East and 112th Street East connecting area east of 58th Street East to Canyon Creek
- 24-inch diameter pipeline along 76th Street Ct. East connecting Portland Avenue East stormdrain system to Roosevelt Ditch

Undersized Private Storm Drainage Facilities

The 1991 Plan also identified three undersized private bridges and 73 private culverts in the Clear/Clarks Creek Basin study area.

No analysis was performed on the bridge passages (assumed that they were adequate); however, the Plan states that approximately 50 (70%) of the private culverts appear to be inadequately sized.

Detention Facilities Recommended

The 1991 Plan identified 36 sites for detention facilities.

The 1991 Plan also recognized the importance detention in protecting streams from excessive erosion. 11 sites were identified in the Clear Creek Basin, four in the Clarks Creek Basin, and 20 sites were in the Potholes Basin.

All but four of the detention projects recommended for the creek drainages were located at roadway embankments. One of the projects recommended siting a sedimentation basin in Swan Creek Park. This project was constructed in 1990 and modified in 1993.

The remaining three projects in the creek drainages and all the projects recommended for the Potholes Basin consisted of flood plain zoning or acquisition.

Implementation of the 1991 Plan

The implementation of the 1991 Plan is as follows:

- 17 of the recommended projects in the 1991 Plan have been constructed.
- 33 projects are included as recommendations in this basin plan. Ten of these projects are currently in various stages of design by Water Programs.
- The updated hydrologic and hydraulic analysis conducted for this plan showed that the culverts at 20 of the project locations were found to have adequate capacity and therefore, did not need to be upgraded.
- 21 of the projects recommended in the 1991 Plan were not recommended in this basin plan. 12 of the projects in the 1991 Plan recommended constructing dams to provide additional instream

detention storage in the system. These storage facilities would be created through the placement of new structures in the stream channel or by converting existing roadway embankments to dams. The 1991 detention CIP projects were not included in this basin plan because these types of structures are barriers to fish passage and would probably not be permitted by the regulatory agency. Also, converting roadway embankments to dams raises a public safety issue, should the embankment fail.

A comparison of the 1991 Plan to this basin plan can be found in Appendix C.

6.2.3 Culvert and Channel Capacity

The hydraulic analysis tools described in the previous section were used to evaluate 54 of the 138 flooding problems presented in Chapter Five. The evaluation included 33 culverts, 13 stormdrain systems, and seven roadside ditch and culvert systems.

The most common flooding problem is roadway overtopping due to insufficient culvert conveyance capacity. In addition, 24 instances of property flooding are documented. The greatest concentration of drainage problems occurs in the Roosevelt Ditch, Canyon Creek, Rody Creek, and Woodland Creek subbasins.

12 of the 33 culverts, eight of the 13 storm drains, and all seven of the ditch and culvert systems analyzed for this basin plan were found to be undersized and flood under existing land use conditions. *Table 6-5* lists the undersized culverts, *Table 6-6* lists the undersized storm drains and *Table 6-7* lists the undersized ditch and culvert systems.

TABLE 6-4
Frequency of Flooding at Undersized Roadway Culverts under Existing Land Use Conditions

Problem ID[a]	Location	Return Period
SW-1	80th Street East	25-yr
CL-5	88th Street East	10-yr
CY-10	104th Street East	10-yr
CY-3	116th Street East	5-yr
CY-30[b]	103rd Street East	25-yr
CY-31	Pipeline Road	50-yr
RY-7	96th Street East at Pipeline Road	25-yr
RY-8	98th Street East	1-yr
DU-7	96th Street East	100-yr
WO-6	72nd Avenue East from 93rd Street East to 96th Street East	2-yr
WO-8	80th Street East	2-yr
RD-17	90th Street East	25-yr

[a] See Figures 5-1, 5-2, and 5-3 for problem locations.
b. Culvert has sufficient capacity, structure flooding occurs at 104th Street East

TABLE 6-5
Frequency of Flooding in Storm Drain Systems under Existing Land Use Conditions

Problem ID[a]	Location	Return Period
SW-5	84th Street East	25-yr
SW-16	24th Avenue East from 84th Street East to 92nd Street East	2-yr
CL-3	North Side of Intersection of 96th Street East and 48th Ave East, 4700, 4800, and 4900 block of 96th Street East	1-yr
CY-5	12400 block of 58th Avenue East and 12100 and 12200 block of 59th Avenue East	10-yr
CK-9	104th Street East (Woodland Elementary School)	10-yr
PH-6	11500 block of 92nd Avenue East	2-yr
PH-9	14600 block of 127th Street East	5-yr
RD-7	7600 block of Portland Avenue East	25-yr

[a] See Figures 5-1, 5-2, and 5-3 for problem location.

TABLE 6-6
Frequency of Flooding in Roadside Ditch & Culvert Systems under Existing Land Use Conditions

Problem ID[a]	Location	Return Period
SQ-2	5600 block Vickery Avenue west side	2-yr
CL-4	104th Street East	1-yr
DU-14	6600 block of Pioneer Way East	100-yr
CK-2	9200 block of 104th Street East	5-yr
CK-6	8400 block of 96th Street East	2-yr
RD-11	7300 block of 20th Avenue East	25-yr
RD-13	1600 block of 85th Street East	1-yr

[a] See Figures 5-1, 5-2, and 5-3 for problem location.

6.2.4 Stream Bank Erosion/Instability

The hydrologic analysis did not include flow prediction under pre-development conditions. However, typically, urbanization leads to an increase in peak flows for all return periods with the largest relative increase occurring for the high-frequency events. These increased peak flows tend to increase the depth and frequency of streambed scour (Booth, 1990). Current detention standards are effective in controlling peak flows from large storm events, but extend the flow duration for intermediate level storm events and provide little benefit for smaller storms (CH2M HILL, 2001).

The increased peak flows have degraded the canyon reaches of streams by incising, or down cutting, the channel. Channel down cutting leads to a widening of the channel when the over-steepened streambanks collapse. Active channel incision and collapsing streambanks are a significant source of sediments in the creek systems.

The most notable example is Swan Creek below 64th Street East, where past episodes of channel down cutting have widened the channel to form nearly vertical banks for more than a mile (8,000 feet) downstream of 64th Street East. Channel down cutting has caused significant damage to the 64th Street East culvert where the concrete outlet apron has detached from the culvert and fallen into the creek. The culvert is now perched about four-feet above the channel, and scour at the culvert outlet is undermining the integrity of the culvert. If left unchecked, continued erosion may ultimately compromise the integrity of the roadway embankment.

Streambank erosion can contribute to flooding when sediment is transported from the canyon reaches and settles in the low-gradient, slow moving, floodplain reaches. Sediment accumulation in these reaches reduces the conveyance capacity of the channels, culverts and bridges and can lead to overbank flooding. Over time, property loss through the streambank erosion will occur as the channel responds to the reduced conveyance capacity.

In the most extreme case, sediment deposition can result in channel avulsion. Channel avulsion occurs when the channel becomes so obstructed with sediment that the stream jumps it banks and cuts a new channel. Channel avulsion has occurred in Woodland Creek upstream of 80th Street East when sediment from an upstream incision event was transported downstream to a more

moderately sloped reach. Sediment deposition occurred which clogged the channel causing the creek to overtop its banks. No new channels were created with this event but a large amount of gravel was deposited in the floodplain of this reach.

Additional discussion on streambank erosion is provided in Section 8.3.

6.2.5 Groundwater Recharge

The conversion of pervious land to impervious land usually results in more stormwater discharge to the stream system and less rainwater available for groundwater recharge to the shallow and deep groundwater aquifers. Recharge to the shallow groundwater is important because it provides base flow to the creeks during the dry summer months. See Chapter Eight for additional discussion on base flow in the creeks. Recharge to the deep groundwater aquifer is an important source of water supply in the Basin, in the most northerly part of a designated Sole Source Aquifer.

Groundwater recharge is affected most in the western part of the Basin overlain by till soils (hydrologic soil types C and D, see *Figure 4-2*). These soils have a very low infiltrative capacity and groundwater recharge rates in this are sensitive to land use conversion. Conversely, the soils on the eastern side of the Basin are overlain by outwash soils (hydrologic soil types A and B, see *Figure 4-2*) which have very high infiltration rates are not likely effected by conversion to impervious land cover.

6.3 Future Problems

6.3.1 Flooding

Hydrologic analysis predicted a significant increase in peak flow rates under future land use conditions in Swan and Woodland Creeks. The largest increases occur for the more frequent events. The creek analysis also predicted that the duration of flow above the two-year peak flow rate (channel shaping flow) will also increase in Swan and Woodland Creeks and in the upland reaches of Canyon Creek. Because stream flow rates in excess of the two-year peak flow rate most heavily influence channel shaping processes, higher peak flows of longer duration will likely increase the rate of erosion in these stream and further degrade habitat.

More frequent flooding will also occur with increased flow rates predicted to occur under future land use conditions. The analysis showed that flooding will occur at one new location and occur more frequently at 11 existing problem areas. *Table 6-8* shows the problems from *Table 6-6* that will increase in frequency under future land use conditions.

Note that the hydrologic analysis of future land-use conditions did not consider the effect of the stormwater detention facilities. If current stormwater management standards are properly applied for all new development then peak flow increases may not be as high as predicted, although, and importantly, cumulative effects would continue. However, there are numerous approved subdivisions in the basin that were approved before adoption of the current stormwater standards. Previous stormwater control regulations were much less stringent, so peak flow will likely increase if these projects are built.

TABLE 6-7
Problem Locations with Increased Frequency of Flooding under Future Land Use Conditions

Problem ID[a]	Location	Return Period
CL-6	76th Street East	100-yr
CY-10	104th Street East	5-yr
CY-3	116th Street East	2-yr
CY-5	12400 block of 58th Avenue East, 12100-12200 block of 59th Avenue East	2-yr
CY-30[b]	103rd Street East	5-yr
RY-7	96th Street E at Pipeline Road	10-yr
WO-6	72nd Avenue East between 93rd Street East-96th Street East	1-yr
WO-8	80th Street East	1-yr
CK-9	104th Street East (Woodland Elementary School)	10-yr
PH-9	14600 block of 127th Street East	2-yr
RD-7	7600 block of Portland Avenue East	10-yr
RD-11	7300 block of 20th Avenue East	10-yr
RD-17	90th Street East	10-yr

a See Figures 5-1, 5-2, and 5-3 for problem location
b Culvert has sufficient capacity, structure flooding occurs at 104th Street East

6.3.2 Stream Bank Erosion/Instability

Table 6-1 showed that streamflow rates in nearly all creeks are likely to increase in the future, which will further increase the rate of channel erosion and streambank instability. Furthermore, *Table 6-3* showed that the duration of flows greater than the two-year peak flow event (channel shaping flow) will increase in most creeks with significant increases in Swan Creek, Canyon Creek, and Woodland Creek. Each of these streams already experience high rates of erosion. Additional discussion on streambank erosion is provided in Section 8.3.

6.3.3 Groundwater Recharge

Groundwater recharge rates will probably decline in the areas with the highest density (and highest impervious area) of future development. *Figure 4-6* shows that shows that the entire Roosevelt Ditch area, and Swan, Canyon, Rody, Diru Creek subbasins south of 112th Street East and the Woodland Creek subbasin are zoned as medium density residential or mixed use districts, which typically have higher levels of impervious area. The Clarks Creek subbasin and the Potholes Basin are zoned for similar land uses, but groundwater recharge rates are not expected to be affected because these areas are underlain by the highly infiltrative outwash soils.

6.4 Potential Solutions

Three types of CIP projects were developed to solve drainage problems. They are:

- Peak flow attenuation through regional detention or retention
- Conveyance improvements (enlarged storm drain pipelines and cross culverts)
- Acquisition (floodplain and headwaters)

Stormwater detention facilities attenuate peak flows by storing stormwater runoff during peak flow events, then slowly releasing the stored water over an extended period of time. Stormwater retention facilities also store stormwater runoff during peak flow events, but they infiltrate the water into the ground rather than discharge to the surface. Stormwater retention is more desirable than detention because groundwater is recharged and base stream flows may be improved as a result. However, stormwater retention has limitations in the Clear/Clarks Creek Basin due to the absence of suitable soils in many of the subbasins. Both regional detention and retention facilities are expensive and sometimes difficult to site.

Conveyance improvements generally involve replacing smaller, undersized pipes or surface conveyance systems with larger more efficient systems. Conveyance improvement projects frequently include measures that retain floodplain storage, such as floodplain excavation or raised roads, so that the flooding problem is not passed downstream.

Property acquisition is an effective strategy when vulnerable property lies within the floodplain or the flooding is so extensive that the solution costs more than the property that is being protected, or to preserve natural functions of floodplains including their flood storage and channel migration functions. Easement or property acquisition is also needed for some projects to provide a dedicated tract for drainage facilities.

Programmatic solutions can be very useful in preventing future flooding problems. These measures include changes to storm water management standards, land acquisition and management programs for preserving floodplain, education, low-impact development, increased maintenance and inspection, monitoring, technical assistance, and floodplain mapping. The capital improvement program (CIP) projects and programmatic solutions recommended to address individual problems identified in this chapter can be found in Chapter Nine.

Over 100 drainage problems were investigated during development of the Clear/Clarks Creek Basin Plan. Each of these problems was evaluated and a determination made about the manner in which each of the problems should be addressed in the Plan. The problem groupings:

- Not directly addressed in the Plan because the drainage problem has been resolved, involves a private storm drain system, or is outside the authority of the County;
- Needs County action, but does not require a major capital cost or program;
- Suitable for a Capital Improvement Program (CIP) project;
- More appropriately solved with an existing county-wide program; or
- Requires additional study to fully understand the problem.

Each of these solution classifications is described in detail in the following sections.

6.4.1 Problems Resolved or Not Addressed in the Basin Plan

Over the course of the investigation, it was found that some of the flooding problems had been resolved with earlier projects or other activity. Others problems were found to be private issues, outside the jurisdiction of the County, or administered by other County departments or agencies.

Some of the flooding problems have been resolved through ongoing activity in the basin by Water Programs or other County agencies. Private property flooding problems not addressed in this Plan were usually due to flooding from adjacent private property or occurred in privately owned drainage systems.

The remaining problems were located outside the jurisdiction of the County. These problems were included in the original list because they were reported to the County. Some of these problems were reported to the County by residents living in incorporated areas and other reported problems occurred in areas that have since been annexed by adjacent communities. A total of 46 drainage problems were not addressed with this Plan: 28 of the drainage problems were found to have been resolved; 12 problems were assumed to be private property issues; and six drainage problems were referred to other jurisdictions.

Tables 6-9 through *6-11* list problems not addressed in the Basin Plan.

TABLE 6-8
Resolved Drainage Issues

Problem ID[a]	Problem Description	Problem Resolution
SW-6	Pond overtopping at 84th Street East during 1997 event.	Hydrologic analysis shows detention pond has sufficient capacity. Event likely exceeded design standard
SW-8	Obstructed field drainage	Obstruction cleared by constructing a ditch
CL-6	Private property flooding	No structure flooding, property is located in floodplain
CY-2	Road flooding at intersection of Canyon Road and 112th Street East	Drainage improved with recent roadway improvement project
CY-6	84th Street East	Hydraulic analysis showed no flooding at this site
CY-7	West Fork at 96th Street East.	Hydraulic analysis showed no flooding at this site
CY-8	West Fork at 104th Street East	Hydraulic analysis showed no flooding at this site
CY-9	East Fork at 96th Street East	Hydraulic analysis showed no flooding at this site
CY-11	East Fork at 112th Street East	Hydraulic analysis showed no flooding at this site
RY-9	Pioneer Way East	Hydraulic analysis showed no flooding at this site
RY-10	90th Street East	Hydraulic analysis showed no flooding at this site
RY-11	104th Street East	Hydraulic analysis showed no flooding at this site
RY-12	112th Street East	Hydraulic analysis showed no flooding at this site
RY-13	128th Street East	Hydraulic analysis showed no flooding at this site
DU-1	Private driveway flooding on 66th Avenue East.	A cross culvert has been installed to convey flow under drive

TABLE 6-8
Resolved Drainage Issues

Problem ID[a]	Problem Description	Problem Resolution
DU-6	90th Street East	Hydraulic model showed no flooding at this site
DU-8	104th Street East	Hydraulic analysis showed no flooding at this site
WO-7	84th Street East	Hydraulic analysis showed no flooding at this
WO-11	Property flooding at 9100 block of Woodland Avenue East.	Berm constructed along driveway to prevent roadway runoff from entering property
WO-13	Road and driveway flooding on 6800 block of 90th Street East	Maintenance activity has resolved this problem
CK-7	Flooding at 10800 block of 82nd Avenue NW	Additional detention ponds constructed in the area
PH-2	Flooding from Meridian Park Place Pond overflow	Detention pond has been expanded
PH-8	Road and property flooding at 145th Street East and 144th Street East.	Maintenance activity has resolved this problem
PH-13	Property flooding in a closed depression	Recent County project has solved this problem
PH-16	Road flooding reported at 99th Avenue East	Maintenance activity has resolved this problem
PH-22	Road and property flooding at 141st Street Ct. and 144th Street East	Recent County project has solved this problem
RD-8	85th Street East	Hydraulic analysis showed no flooding at this site
RD-9	80th Street East	Hydraulic analysis showed no flooding at this site

[a] See *Figure 6-2* for problem location

TABLE 6-9
Private Property Drainage Issues

Problem ID[a]	Problem Description
CL-8	Property flooding at 4500 block of 112th Street East caused by dumping in drainage ditch
CL-9	Yard flooding at 9300 block of 40th Avenue East
CL-13	Stormwater runoff from private road causes property flooding at 4000 block 53rd Ct. Street East
CY-4	Poor maintenance of private system causes private property flooding at 8600 block of Canyon Road
WO-15	Stormwater runoff from private road causes flooding at 6900 block of 81st CT East
PH-3 PH-4	Drainage dispute between adjacent property owners that has been resolved

TABLE 6-9
Private Property Drainage Issues

Problem ID[a]	Problem Description
PH-10	Stormwater runoff from private road causes flooding on private property at 11500 block of 82nd Avenue Court East
PH-11	Restaurant parking lot built in depression is causing private property flooding
PH-19	Runoff from commercial development to the west is causing roadway flooding at 9600 block of 159th Street Court East
PH-20	Private detention pond overflowing at 10700 block of 83rd Avenue East
RD-3	Parkside Village storm drain system needs maintenance

[a] See *Figure 6-2* for problem location

TABLE 6-10
Drainage Issues Referred to Other Jurisdictions

Problem ID[a]	Problem Description	Jurisdiction
SW-15	Field flooding south of Hwy 512 on west side of Waller Road.	Drainage District No. 14
SW-30	Private property flooding on Pioneer Way East	City of Tacoma
CL-8	Property flooding at 4500 block of 112th Street East caused by dumping in drainage ditch	Drainage District No. 14
CY-31	Flooding at Pipeline Road	City of Tacoma
CK-4	Flooding at 1000 block of 16th Street SW (Meeker Ditch), 12th Avenue SW, and 2200 block of Pioneer Way East	City of Puyallup
CK-8	Flooding at 7400 block of Stewart Avenue and 6300 block of 76th Avenue East	City of Puyallup

[a] See *Figure 6-2* for problem location

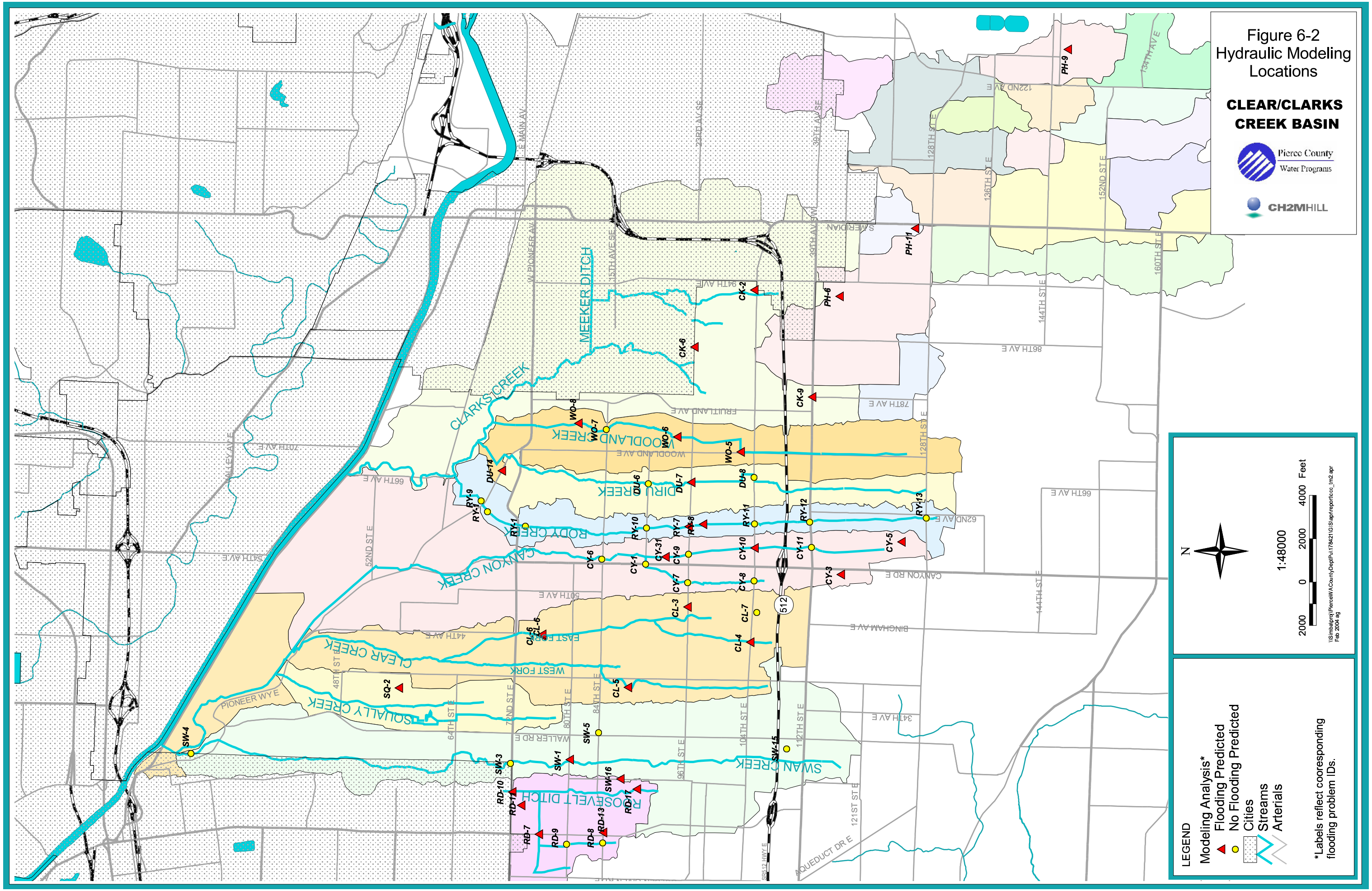
Figure 6-2
Hydraulic Modeling Locations
CLEAR/CLARKS CREEK BASIN
Pierce County Water Programs
CH2MHILL
LEGEND
Modeling Analysis*
Flooding Predicted
No Flooding Predicted
Cities
Streams
Arterials
*Labels reflect cooresponding flooding problem IDs.
N
1:48000
2000 0 2000 4000 Feet
\\Sirius\proj\PierceW\A County\Dept\u178421\GIS\rpt\report\cc_lm2.apr
Feb 2004 ag
CLARKS CREEK
MEEKER DITCH
WOODLAND CREEK
DIRU CREEK
ROBY CREEK
CANYON CREEK
CLEAR CREEK
WEST FORK
EAST FORK
SOUALLY CREEK
SWAN CREEK
ROSEVELT DITCH
PIONEER WY E
W PIONEER AV
E MAIN AV
15TH AV SE
23RD AV SE
39TH AV SE
SMERIDIAN
128TH ST E
136TH ST E
144TH ST E
152ND ST E
160TH ST E
137TH AV E
122ND AV E
94TH AV E
86TH AV E
78TH AV E
FRUITLAND AV E
WOODLAND AV E
66TH AV E
62ND AV E
CANYON RD E
BINGHAM AV E
34TH AV E
44TH AV E
50TH AV E
52ND ST E
48TH ST E
64TH ST E
72ND ST E
80TH ST E
84TH ST E
96TH ST E
104TH ST E
112TH ST E
121ST ST E
144TH ST
WALLER RD E
SR512 HWY E
AQUEDUCT DR E
512
PH-9
PH-11
PH-6
CK-2
CK-6
CK-9
WO-8
WO-7
WO-6
WO-5
DU-14
DU-8
DU-7
DU-6
RY-9
RY-8
RY-1
RY-10
RY-7
RY-6
RY-11
RY-12
RY-13
CY-6
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CY-3
CY-9
CY-7
CY-10
CY-8
CY-11
CY-5
CY-3
CL-6
CL-5
CL-3
CL-7
CL-4
CL-5
SQ-2
SW-4
SW-3
SW-1
SW-5
SW-16
SW-15
RD-14
RD-10
RD-7
RD-9
RD-8
RD-13
RD-17

6.4.2 Small Works Projects, Maintenance, and Enforcement Issues

Fifty-one of the drainage problems identified in the Basin Characterization can be addressed by a small works project at a cost less than $100,000, maintenance activity, or enforcement of County ordinances. This includes 37 small works projects, 20 maintenance projects, and 2 enforcement actions. *Table 6-12* lists these projects and the proposed resolution.

6.4.3 Capital Improvement Program Projects

There were 35 projects developed to solve 34 drainage problems in the Clear/Clarks Creek Basin. These projects are of a mix of conveyance improvements (culvert, pipeline and swales), raising roadways out of the floodplain, property acquisition, and detention expansion. In addition to these projects, the detention projects presented as habitat CIPs (see Section 8.5) will provide additional flood protection in the creek reaches. *Table 6-13* summarizes CIP projects by subbasin in the Clear/Clarks Creek Basin. The project locations for the Roosevelt Ditch, Swan Creek, Squally Creek, Clear Creek and Canyon Creek subbasins are shown in *Figure 9-1*. The project locations for the Rody Creek, Diru Creek, Woodland Creek, and Clarks Creek subbasins are shown in *Figure 9-2*. The project locations for the Potholes subbasin are shown in *Figure 9-3*. Each of the projects listed in *Table 6-13* are discussed in greater detail in Chapter Nine.

6.4.4 Potential Programmatic Measures

Six programmatic measures are recommended that will serve to reduce flood hazard impacts. These include:

- Develop and Implement a Land Management Program for Flood Hazard Reduction and Water Quality and Habitat Impact Mitigation (an acquisition-maintenance program)
- Adopt Updated Stormwater Management Standards
- Develop and Implement an Education, Outreach and Technical Assistance Program
- Develop and Implement a Surface Water Management Monitoring Program
- Require Flood Disclosure Statements on Property Titles

6.5 Sites Requiring More Detailed Data or Analysis

Two additional studies are recommended to fill information gaps in the Clear/Clarks Creek Basin:

CIP03-SW-DS01 Floodplain Analysis-Swan Creek Headwaters South of 112th Street East

This area has experienced groundwater and surface flooding in the past in addition to wetlands, fill, and grade violations. The land use in this area is expected to convert from single-family residential to medium-density residential and mixed-use in the future. A detailed hydrologic and hydraulic analysis should be performed to quantify the extent of the flooding problem. The floodplain should be mapped and the base flood elevation (BFE) established to ensure that existing floodplain storage is retained.

CIP03-CL-DS01 Floodplain Analysis-West Fork Clear Creek, 84th to 88th Street East

Extensive road and property flooding has been reported in this area. Several structures appear to be located in the floodplain, however; accurate structure low-water entry, and culvert elevation information are unavailable. A detailed hydrologic and hydraulic analysis should be performed to quantify the extent of the flooding problem. The floodplain should be mapped and the BFE established to ensure that existing floodplain storage is retained.

TABLE 6-11
Small Works Drainage Issues Identified for Clear Clarks Creek Subbasins

ID No.[a]	Location	Problem Description	Potential Solution	Resolved Through:
SW-2	2400 block of 80th Street East	Obstructed culvert causing roadside flooding.	Maintain obstructed culvert.	Maintenance
SW-4	Swan Creek at Pioneer Road East	Sedimentation buildup at Pioneer Way causing property flooding. Culvert downstream under the BNSF railroad also backs up contributing to flooding.	Maintain sedimentation pond upstream of Pioneer Way and the culvert under the BNSF railroad.	Maintenance
SW-7	Intersection of 24th Avenue East and 90th Street East.	Stormwater ponds at the intersection.	Construct ditch on 90th Street East to drain stormwater to Roosevelt Ditch.	Small Works Project
SW-9	2600 block of 112th Street East	Excessive vegetation in roadside ditch causing roadway flooding 150-feet west of Swan Creek crossing.	Maintain of ditch.	Maintenance
SW-11	9500 block of Portland Avenue East	Roadway runoff causing driveway and garage flooding.	Install raised asphalt lip to prevent road runoff from entering residential driveway.	Small Works Project
SW-12	2800 block of 96th Street East	Roadway runoff causing property flooding and driveway culvert is plugged.	Install berm on south side of road and clear obstructions from driveway culvert.	Small Works Project
SW-13	9900 block of Waller Rd E	Backyard flooding due to filling in of Swan Creek.	Maintain this section of Swan Creek.	Maintenance
SW-14	10600 block of Waller Rd East	Roadway runoff causing property flooding.	Install inlet in driveway and connect with 12-inch-diamter storm drain to drainage structure just south of the home.	Small Works Project
SW-16	24th Avenue E from 84th Street East to 92nd Street East	Insufficient inlet capacity causing road and property flooding.	Provide additional inlet capacity in existing storm drain system. (This problem is also recommended as a candidate Low Impact Development	Small Works Project

TABLE 6-11
Small Works Drainage Issues Identified for Clear Clarks Creek Subbasins

ID No.[a]	Location	Problem Description	Potential Solution	Resolved Through:
			retrofit project).	
SQ-1	7000 block of Waller Rd East	Front yard and house flooding reported in 1990. Low bank on east side of roadside ditch.	Reestablish east bank of roadside ditch.	Small Works Project
SQ-2	5600 block Vickery Avenue west side	Roadway flooding due to undersized roadside ditch and culvert system.	Excavate ditches to provide additional conveyance capacity. Provide grate inlet in driveway between 5600 block of Vickery Avenue	Small Works Project
CL-2	6600 block of 44th Avenue East	Road flooding due to two obstructed driveway culverts.	Clean culverts in 6600 block of 44th Avenue E.	Maintenance
CL-3	Intersection of 96th Street East and 48th Ave East 4700, 4800, and 4900 block of 96th Street East, north side	Road flooding due to obstructed culvert at intersection. Property flooding due to no drainage system on 96th Street E.	Construct new ditch and culvert conveyance system on 96th Street E. Clean blockages in culverts at intersection.	Small Works Project
CL-6	76th Street East	Wire fence installed at downstream end of culvert may be obstructing flow. One-half foot head differential through fence noted during site visit.	Remove fence.	Small Works Project
CL-7	4700 block of 105th Street East	Chronic property flooding reported at 4700 block of 105th Street East in depression area south of roadway Fence posts placed in channel by downstream property owner likely cause a backwater condition at the 105th Street East culvert aggravating the flooding problem.	Encourage downstream landowner to remove obstructions in channel.	Enforcement
CL-11	4700 block of 53rd Street East	Private property flooding.	Install drywell on south side of road.	Small Works Project
CL-12	5400 block of 57th Avenue East	Road runoff causing driveway flooding.	Install inlet to collect stormwater runoff at driveway and discharge to drainage swale located behind house. Requires drainage easement through property.	Small Works Project
CL-28	West Fork Clear Creek at 72nd Street East	Upstream end of culvert is blocked with extensive debris jam.	Remove debris dam	Maintenance
CL-29	East Fork Clear Creek at 72nd Street East	Upstream end of culvert is blocked with extensive debris jam.	Remove debris dam	Maintenance
CY-29	Canyon Creek at 72nd Street East	Upstream end of culvert is blocked with extensive debris jam.	Remove debris dam	Maintenance
CY-36	4700 through 5300 block of Pioneer Way East	Excessive vegetation in roadside ditch causing overtopping of Pioneer Way.	Clear excessive brush from roadway ditches on south side of Pioneer Way East between 44th Street East and 52nd Street East	Maintenance
RY-1	Rody Creek at 72nd Street East	Upstream end of culvert is blocked with extensive debris jam.	Remove debris dam	Maintenance
RY-2	6800 block of Bentley Rd East	Road runoff runs down driveway and washes around home.	Install asphalt berm to prevent road runoff from entering residential driveway.	Small Works Project
RY-4	5700 block of 80th Street East	Roadside ditch flooding driveway.	Install culvert under driveway.	Small Works Project
RY-6	11900 block of 62nd Avenue East	Roadside ditch overtopping.	Maintain ditch and culvert system.	Maintenance
RY-14	Rody Creek at 72nd	Upstream end of culvert is blocked	Remove debris dam	Maintenance

TABLE 6-11
Small Works Drainage Issues Identified for Clear Clarks Creek Subbasins

ID No.[a]	Location	Problem Description	Potential Solution	Resolved Through:
	Street East	with extensive debris jam.		
DU-2	9700 block of 66th Avenue East	Limited capacity of roadside ditch and culvert system causing road flooding.	Increase capacity of roadside ditch.	Small Works Project
DU-3	9800 block of 67th Avenue Ct. East	Stormwater ponding on roadway occurs in depression.	Install catch basin inlet and connect with 12-inch-diamter storm drain to existing storm drain system located on east side of road.	Small Works Project
DU-4	10200 block of 67th Avenue East	Road flooding due to blocked culvert inlet.	Maintain culvert inlet in 10200 block of 67th Avenue East.	Maintenance
DU-5	9900 block of 63rd Avenue Ct. East	Driveway and garage flooding.	Install new inlet on 12-inch-diamter storm drain on west side of 63rd Avenue Ct. East.	Small Works Project
DU-7	96th Street East	Hydraulic analysis predicted flooding for 100-year event under existing and future land use conditions.	Replace existing 18-inch-diamter culvert with a 24-inch-diamter culvert.	Small Works Project
WO-3	East side of Woodland Avenue at 119th Street East	Road and property flooding due to plugged driveway culvert.	Maintain driveway culvert.	Maintenance
WO-4	6900 block of 113th Street Ct. East	Blocked grate inlet.	Maintain grate inlet.	Maintenance
WO-9	6800 block of 128th Street E	Private property flooding due to raised roadway.	Install thickened pavement edge and inlet to capture runoff in storm drain system.	Small Works Project
WO-10	10900 block of Woodland Avenue	Blocked culvert causing road flooding.	Maintain culvert.	Maintenance
WO-12	9100 block of Woodland Avenue East	Roadway runoff causing property flooding.	Install asphalt berm to prevent road runoff from entering residential driveway.	Small Works Project
WO-14	Intersection of Woodland Avenue and 84th Street East	Water ponding at southeast corner of intersection due to no outlet.	Construct ditch at southeast corner and slope toward Woodland Creek.	Small Works Project
WO-16	8700 block of 72nd Avenue East	Water is coming from the south and west side and washing out driveway. Flow is minimal and seasonal.	Owner installed culvert has alleviated his driveway flooding problem. Maintenance of roadside ditch still needed on east side of 8700 block of 72nd Street East.	Maintenance
WO-17	Woodland Creek at 96th Street East	Blocked culvert causing road flooding.	Maintain culvert.	Maintenance
WO-18	Intersection of 96th Street East and 74th Avenue East	Runoff sheet flows from asphalt ditch on west side of 74th Avenue East and floods intersection.	Construct ditch on east side of 74th Avenue East and redefine ditch on south side of 96th Avenue East, west of intersection. Install inlet at southeast corner of intersection and connect to 96th Avenue East ditch.	Small Works Project
WO-19	7200 block of 102nd Street East	Catch basin inlet is full of gravel and causing road flooding.	Maintain catch basin.	Maintenance
WO-20	11500 block of 74th Avenue East	Roadway and adjacent property runoff causes private property flooding.	Extend existing ditch to flooding problem location.	Small Works Project
WO-21	Woodland Avenue from 80th Street East to 76th Street East	According to residents, new development on Woodland Avenue between 80th Street East to 76th Street East altered drainage patterns which have resulted in flooding. Roadway was expanded and roadway runoff is diverted to east side of road.	Improve drainage system on east side of road.	Small Works Project

TABLE 6-11
Small Works Drainage Issues Identified for Clear Clarks Creek Subbasins

ID No.[a]	Location	Problem Description	Potential Solution	Resolved Through:
CK-6	8400 block of 96th Street East	Hydraulic analysis predicted that the roadside ditch in front of 8400 block of 96th Street East is unable to convey the 25-year event without overtopping.	Improve roadside ditch in front of 8400 block of 96th Street East	Small Works Project
PH-9	14600 block of 127th Street East	Road flooding	Install catch basin.	Small Works Project
PH-12	13300 block of 112th Avenue East and 11300 block of 136th Avenue East	Roadway runoff is causing property flooding.	Install berm and inlet structure to direct runoff to storm drain system.	Small Works Project
PH-17	Cascade Park and Firgrove subdivision	Roadway and property flooding reported in subdivision due to obstructed roadside ditch and culvert system.	Install storm drain system or clean out and maintain existing ditch and roadside culvert system.	Small Works Project
PH-20	10700 block of 83rd Avenue East	Private detention pond overflowing	Require detention pond owner to maintain of repair pond.	Enforcement
PH-21	15200 block of 103rd Avenue Ct. East	Dry well is under capacity.	Provide additional drywells.	Small Works Project
RD-1	7700 and 7800 block of Golden Givens Rd East	Stormwater ponding on the road shoulder and in front of driveway.	Install a new catch basin at low point of depression and connect to storm drain system located approximately 100 feet north.	Small Works Project
RD-2	Coventry Court Apartment on 10th Avenue Ct.	Detention pond may be undersized or has a clogged outlet. Pond has been reported to overflow into the apartment yards.	Inspect outlet structure. Provide additional capacity if pond analysis shows pond is undersized.	Maintenance
RD-4	9th Avenue E and 75th Street East	Storm drain system is undersized and cause property flooding.	Replace existing storm drain system with larger diameter pipe.	Small Works Project
RD-5	7200 block of 12th Avenue East	Road and property flooding due to absence of drainage system. A roadside ditch to the north of the house flows south to the house but has no outlet.	Install storm drain system on 12th Avenue E and connect to system on 72nd Street E.	Small Works Project
RD-6	12th Avenue E, just south of 80th Street East	Road flooding due to obstructed roadway ditch and culvert system.	Regrade ditch on 12th Avenue East and reset cross culvert inverts on 12th Avenue East and 80th Street East.	Small Works Project
RD-10	2100 block of 72nd Street East	Road flooding due to lack of grate inlet capacity in a sag.	Install flanking catch basin(s) around existing sag catch basin.	Small Works Project
RD-12	2200 block of 80th Street East	The roadside ditch has an adverse slope causing road and property flooding.	Regrade ditch to provide positive drainage to Roosevelt Ditch.	Small Works Project
RD-14	8700 and 8800 block of Portland Avenue East	Roadway flooding due to depressions in the road.	Install a catch basin at depression and connect to Portland Avenue storm drain system.	Small Works Project
RD-16	2100 block of 91st Street East	Roadway runoff is causing property flooding.	Install inlet catch basin.	Small Works Project

[a] See Figure 6-3 for problem location.

TABLE 6-12
Flooding and Drainage CIP Projects

Project Number	Project Name	Solves Problem
Swan Creek Sub-Basin		
CIP03-SW-AC01	112th Street East Floodplain Storage/Wetland Preservation Project	
CIP03-SW-CR01	80th Street East Culvert Replacement Project	SW-1
CIP03-SW-PL01	84th Street East Pipeline Storm drain Replacement Project	SW-4
CIP03-SW-SBS01[a]	Stream bank Stabilization at 72nd Street East Outfall	SW-3
CIP03-SW-SBS03[a]	Stream bank Stabilization at 64th Street East Outfall	SW-23
Squally Creek Sub-Basin		
No Drainage Projects		
Clear Creek Sub-Basin		
CIP03-CL-VC01	104th Street East Riparian Area Enhancement Project	CL-4
CIP03-CL-CR01	88th Street East Culvert Replacement Project	CL-5
Canyon Creek Sub-Basin		
CIP03-CY-DP02	90th Street East Detention Project	CY-1
CIP03-CY-RD01	116th Street East Roadway Improvement Project - West Fork	CY-3
CIP03-CY-SL01	58th Avenue East Property Acquisition Project with Setback Levee	CY-5
CIP03-CY-RD02	104th Street East Roadway Improvement and Culvert Replacement Problem - East Fork	CY-10
CIP-03-CY-AC01	Property Acquisition at 5600 block of 104th Street East	CY-30
CIP-03-CL-AC02	Canyon Creek Floodplain Repetitive Loss Land Acquisition	CY-33
Rody Creek Sub-Basin		
CIP03-RY-SBS02[a]	Stream bank Stabilization Project at 80th Street East	RY-3
CIP03-RY-SWL01	62nd Avenue East Drainage Swale Project	RY-5
CIP03-RY-CR01	Pipeline Road and 96th Street East Culvert Replacement Project	RY-7
CIP03-RY-CR02	98th Street East Culvert Replacement Project	RY-8
CIP03-RY-DP01	Rody Creek Regional Detention Facility Expansion	RY-7 RY-8
Diru Creek Sub-Basin		
No Drainage Projects		
Woodland Creek Sub-Basin		
CIP03-WO-CR01	72nd Avenue E Culvert Replacement Project - 93rd Street East to 96th Street East	WO-6
CIP03-WO-CR02[a]	80th Street East Culvert Replacement Project	WO-8
CIP03-WO-DP01	Woodland Avenue Flood Control Phase II CIP	WO-2

TABLE 6-12
Flooding and Drainage CIP Projects

Project Number	Project Name	Solves Problem
Clarks Creek Sub-Basin		
CIP03-CK-AC01	Property Acquisition at 9200 Block of 104th Street East	CK-2
CIP03-CK-PL01	112th Street East Drainage Improvement Project (Woodland Elementary School)	CK-9
CIP03-CK-PL02	Fruitland Avenue Drainage Improvement Project - 104th Street East to 96th Street East	CK-10
Potholes Sub-Basin		
CIP03-PH-IP01	128th Street East Infiltration Pond	PH-1
CIP03-PH-PL01	92nd Avenue East Storm Drain Improvement Project	PH-6
CIP03-PH-PL02	156th Street East Regional Drainage Improvements	PH-15
CIP03-PH-PL03	136th Street East Pipeline (D178-003)	PH-18
CIP03-PH-PL04	144th and 94th Avenue East Pipeline (D174-003)	PH-14 PH-15 PH-18
CIP03-PH-PL05	Springfield Pothole Pipeline Project (D136-003)	PH-23
CIP03-PH-PL06	South Hill Pump Station Discharge Pipeline	
Roosevelt Ditch Sub-Basin		
CIP03-RD-DIV01	85th Street East Diversion	RD-13 RD-15
CIP03-RD-DP01	Portland Avenue East Regional Detention Facility	RD-7
CIP03-RD-RD01	90th Street East Roadway Improvement	RD-17
CIP03-RD-SWL01	20th Avenue East Drainage Swale	RD-11

a. Also listed as an Aquatic Habitat CIP project (See Table 8-7).

CHAPTER SEVEN
Water Quality Analysis

7.1 Introduction

Chapter Seven analyzes the water quality information and problems described in Chapter Four, Existing Conditions; Chapter Five, Identification of Problems; and problems uncovered during the "Phase 2" habitat field investigations documented in Chapter Eight.

This chapter begins with a review of water quality problems, followed by a description of existing water quality facilities. It then describes a watershed assessment and treatment model used to establish alternative responses successful in other parts of the United States. It identifies the programs and activities of other agencies that bear on treatment alternatives. The chapter concludes by recommending solutions to the problems.

Solutions range from enhanced water quality monitoring to gain a better understanding of water quality conditions in the Clear/Clarks Creek Basin, to capital improvement projects focused on improving water quality.

7.2 Water Quality Problems Review

Significant water quality problems exist in the Basin including:

High levels of fecal coliform bacteria: Swan Creek, Clear Creek, and Clarks Creek are on the State's 1998-303(d) list of impaired water bodies due to fecal coliform levels. Fecal coliform is an indicator of pathogens. The Clarks Creek TMDL used microbial source tracking to determine the sources of fecal coliform in the Clarks Creek system and found that humans are not the primary source.

High nutrient loading (nitrogen and phosphorus): Although the current water quality standards do not contain maximum levels of nitrogen and phosphorus, the State has adopted nutrient standards and is waiting for EPA approval. High nutrient levels lead to the growth of invasive vegetation including algae growth. As the vegetation decomposes, it uses oxygen, which depletes the supply for fish and other aquatic life. High nutrient levels can also increase acidity (pH). When oxygen is stripped from carbon dioxide, carbonic acid is produced. Clarks Creek is also on the Washington 303(d) list for pH.

Excessive sediment (turbidity and suspended solids): Erosion within open channels and streams is a chronic problem of urban stormwater, especially where land development is occurring. Eroded soil clouds stream water. Then where the stream slows, soil particles precipitate to the channel bottom, covering spawning gravels, taking up flood storage capacity, and providing a medium for algae and invasive vegetation.

Remaining water quality concerns were primarily associated with odor complaints, summertime flows in creeks, erosion and sedimentation, elevated water temperatures, and dumping of garbage into or near streams. *Table 7.1* lists the water quality concerns reported by citizens, County staff, and the project consultant, CH2M Hill.

Table 7-1. Water Quality Problems

Problem ID	Location	Description
	Swan Creek	
SW-17	Swan Creek at 80th Street East	Trash dumped into creek channel
SW-18	Swan Creek north of 64th Street E	Reach on 303d list for fecal coliform
SW-19	Upper Swan Creek	On the 303d list for fecal coliform levels
SW-20	Waller Road East at 92nd Street East	Trash dumped into creek
SW-21	Swan Creek at 72nd Street East	Downstream erosion
SW-22	Swan Creek from 72nd Street East to 64th Street East	Channel erosion is occurring downstream of 72nd Street East to 64th Street East due to high stream flow. Exposed vertical banks are 2 to 3 feet high.
SW-23	Swan Creek downstream of 64th Street East	High stream flows have scoured a four to five-foot hole at the 64th Street East culvert outlet and undermined the culvert headwall and apron.
SW-25	Downstream of 64th Street East	The channel is eroding in the 8,000-foot reach downstream of 64th Street East due to high stream flow. Exposed vertical banks are 10 to 12 foot high.
SW-26	Downstream of Burlington Northern Santa Fe Railroad	Channel down cutting is occurring downstream of railroad culvert due to high stream flow.
SW-27	Upstream of 64th Street East	Intermittent flow occurs in late summer
SW-35	Downstream of Pioneer Way East	Sediment in channel
SW-36	Swan Creek	Excessive nutrients
SW-37	Swan Creek	Low dissolved oxygen/ High pH
	Squally Creek	
SQ-3	Squally Creek at 48th Street East	Trash in the creek from dumping into the creek
SQ-4	Clear Creek confluence	Eroding banks and sedimentation occurs where Squally Creek flows into Clear Creek.
SQ-6	Pioneer Way East	Invasive riparian vegetation in and along the creek
SQ-8	Throughout stream system	No water quality data exists

	Clear Creek	
CL-8	4500 block of 112th Street East	Dumping garbage in drainage ditch
CL-14	Clear Creek from 104th Street East to Vickery Avenue East	Trash in creek channel
CL-15	4500 Block at Pioneer Way East	On the County's Dirty Dozen list as a junk/wrecking yard, plus several occupied recreational vehicles and a large amount of solid waste cover the site
CL-16	Clear Creek below Pioneer Way East	Reach is on the 303d list due to fecal coliform levels.
CL-17	Clear Creek from Pioneer Way East to the Puyallup River.	Erosion upstream has caused sedimentation in channel from Pioneer Way East to the Puyallup River
CL-18	Pioneer Way E to Gay Road East	Invasive aquatic vegetation present in the reach extending from Pioneer Way to Gay Road East
CL-21	Clear Creek between Pioneer Way East and 45th Street East	Stream bank erosion and minor slides
CL-22	Downstream of 64th Street East	The stream bank is eroding and the channel down cutting.
CL-23	West Fork of Clear Creek at 72nd Street East	Intermittent flow occurs upstream of this location
CL-24	Pioneer Way to Gay Road East	The natural channel has been straightened in this reach. The riparian buffer has been significantly reduced.
	Canyon Creek	
CY-15	46th Avenue E and 58th Avenue East	Septic odors present at Quiet Ridge subdivision retention pond.
CY-17	12300 block of 58th Avenue East	Report of failing septic system
CY-18	Canyon Creek at 80th Street East.	Stream bank is eroding.
CY-20	Upstream of second Canyon Road crossing.	Stream bank is eroding
CY-21	Downstream of second Canyon Road crossing	Stream bank is eroding and channel down cutting with 10-foot-high exposed banks in 1,000-foot reach downstream of second Canyon Road crossing due to high stream flow
CY-22	Downstream of 72nd Street East	Channel is down cutting
CY-23	Clear Creek confluence to Pioneer Way East.	Upstream erosion has caused sedimentation in channel from Clear Creek confluence to Pioneer Way East.
CY-24	72nd Street East	Intermittent flow occurs upstream of this location.
CY-25	Clear Creek confluence to Pioneer Way East	Invasive aquatic vegetation is pervasive in the channel.

	Rody Creek	
RY-3	80th Street East	Stream bank is eroding.
RY-8	98th Street East	Road and property flooding of Rody Creek at 98th Street East. According to property owner, 6002 98th Street East, flooding occurs annually due to clogging of the inlet by debris. Water backs up and causes flooding of property and septic tanks. Flooding also reported upstream in the 10100 block of 98th St East and the 10300 block of 61st Ave East (possible reduction with recent maintenance project). The 1991 Plan identified this culvert as "insufficient conveyance capacity."
RY-15	84th Street East	Intermittent flow occurs upstream of this point.
RY-16	Clarks Creek to Pioneer Way East	The natural channel has been straightened with the buffer reduced. Invasive riparian vegetation also is present.
	Diru Creek	
DU-9	Whole stream	Water quality
DU-10	Clarks Creek confluence to Pioneer Way East	Invasive riparian vegetation is present in the 2,200-foot reach from the mouth to Pioneer Way East.
DU-11	Downstream of 72nd Street East	Stream bank is eroding in the 100 foot-long reach downstream of 72nd Street East. Exposed vertical banks are 8-feet-high.
DU-12	84th Street East	Intermittent flow occurs upstream of this location
DU-13	Clarks Creek confluence to Pioneer Way East	The natural channel has been straightened and the buffer reduced in 2,200-foot reach from Clarks Creek confluence to Pioneer Way East
	Woodland Creek	
WO-1	Woodland Creek at 84th Street East	Bank erosion, channel down cutting downstream of 80th Street East due to high stream flow. Three foot deep channel incision. Reduced riparian buffer
WO-23	Upstream of Pioneer Way East	Invasive riparian vegetation is present in this reach.
WO-24	84th Street East	Scour (erosion) is occurring at culvert outlet.
WO-25	Downstream of 84th Street East	Channel is down cutting downstream of 84th Street East due to high stream flow. Channel incision is 5-feet-deep.
WO-26	Upstream of 80th Street East	Upstream erosion has caused sedimentation in channel.
WO-27	Downstream of 80th Street East.	Stream bank erosion and channel down cutting downstream of 80th Street East due to high stream flow. Three foot deep channel incision. Reduced riparian buffer.
WO-28	84th Street East	Intermittent flow occurs upstream of this location.
WO-29	Clarks Creek confluence to Pioneer Way East	The natural channel has been straightened and the buffer reduced.

	Clarks Creek	
CK-11	Tacoma Road	Septic systems reported as failing.
CK-12	Clarks Creek	On 303d list due to fecal coliform levels and pH levels
CK-13	Puyallup River confluence to Puyallup City Limits	Invasive aquatic vegetation in channel
CK-14	Puyallup River to Puyallup City Limits	Upstream erosion has caused sedimentation in channel.
CK-15	Creek at 99th Street East	Stream banks are eroding.
CK-21	Clarks Creek	Excessive nutrients. Connected to CK-13, invasive vegetation and CK-12, pH standard exceeded.
	Potholes	
PH-23	Throughout drainage area	No water quality data exists
	Roosevelt Ditch	
RD-8	Throughout drainage area	No water quality data exists

7.2.1 Existing Stormwater Treatment Facilities

The Clear/Clarks Creek Basin contains 75 ponds: 37 detention facilities; 22 infiltration facilities; one sedimentation pond; and one water quality pond. The majority of ponds serve individual developments. Pre-1997 stormwater drainage systems for developments were designed to handle flow without water quality treatment features. Ponds are larger so suspended solids have more time to precipitate before stormwater is discharged into the regional conveyance system.

Pierce County Water Programs usually designs regional ponds with a presettling basin or other features that remove suspended sediments from the water before it is released from the pond. Sand filters have been used at infiltration ponds. Catch basins in the stormwater conveyance system have chambers that collect sediment. Sediment is periodically removed. Vegetation in drainage ditches also aids in removing sediment by slowing movement of the water in a way that enables suspended solids to settle. Water quality can/should be addressed in the design of upgrades to existing facilities and in new construction.

7.2.2 Water Quality Facilities in Private Development

In 1992, Ecology developed the Stormwater Management Manual for Puget Sound (1992 Stormwater Management Manual) in response to a directive of the Puget Sound Water Quality Management Plan (Ecology, 1992) to address stormwater issues described in the federal National Pollutant Discharge Elimination System, Phase I rules.

The 1992 stormwater manual included water quality treatment standards in the form of structural "Best Management Practices" (BMPs). It called for government agencies to require water quality treatment of stormwater discharges from new and redevelopment projects that create additional impervious surfaces. The manual listed an array of structural BMPs along with design guidelines. Because structural BMP treatment systems (i.e., wet ponds, wet vaults, and bioswales) are typically designed to achieve 80% removal of total suspended solids, an objective of 80% removal was set.

7.2.3 Monitoring Data

No sampling data was available for Roosevelt Ditch, Squally Creek, Canyon Creek, Woodland Creek, or the Potholes drainage area. Lacking results from systematic water quality sampling, Pierce County must rely on data from sporadic sampling, one-time sampling, shifting sampling points, and other methods that are not statistically reliable.

Adequate water quality is critical to the protection of beneficial uses, including salmonid. When water quality is found to not meet standards, monitoring of various chemical and biological parameters in streams helps in the discovery of pollution sources and aids in developing effective remedies.

7.2.4 Temperature

The data indicate general compliance with temperature standards throughout the Basin. Mean temperature values and individual sample values were below the standard of 18 degrees centigrade. All of the sampling locations are in the Puyallup River Valley reaches of the streams, where anadromous fish reside. Low stream temperatures are probably due to the groundwater contributions to stream flow that occur in the canyon and valley reaches of the streams. Groundwater recharge within the aquifers catchment area that maintains the groundwater contributions to stream flow will be important to protect water temperature. A second major influence is tree cover along streams so streams remain shaded.

7.2.5 Dissolved Oxygen

Mean dissolved oxygen concentrations in samples were generally well above the State standard of 8 mg/L; ranging from a low of 10.29 mg/L in Rody Creek, to a high of 12.3 mg/L at the mouth of Swan Creek. A few individual samples for Swan Creek and Clarks Creek also did not meet the standard. Much of the excess biological oxygen demand comes from rotting aquatic and herbaceous invasive vegetation that has filled stream channels where riparian vegetation has been removed.

7.2.6 Nutrients

Nutrients, measured by nitrate, nitrite, and total phosphorus concentrations, are not regulated under Washington's current water quality standards. However, high nutrient levels in surface water can result in excessive aquatic plant growth, eutrophication, and (as aquatic plants and algae decay) depressed dissolved oxygen levels (EPA, 1993).

The mean nutrient concentrations shown in *Table 7-3* range from 0.1 mg/L to 0.26 mg/L for total phosphorus, and 0.53 mg/L for nitrate+nitrite. The federal Environmental Protection Agency's (EPA) Technical Guidance Manual for rivers and streams (EPA-822-B-00-002) published in 2000, states that in general streams should contain less than 21.8 ug/L (0.218 mg/L) of total phosphorus and 0.38 mg/L of total nitrogen.

Values appear to be moderately high in the Basin, although they are consistent with concentrations found in similar developed basins of the region (Minton, 2002). The moderately high nutrient concentrations do not appear to be significantly affecting the dissolved oxygen concentrations. For example, only 5% of the Swan Creek samples exceeded State standards for dissolved oxygen; 8% of the Clarks Creek samples exceeded standards. However, as the Basin

develops further, nutrient concentrations are likely to increase unless preventive measures are undertaken. Nutrients are probably one of the contributing factors for the excessive growth of aquatic plants in the lower reaches of the streams.

7.2.7 Fecal Coliform

Fecal Coliform bacteria concentrations for most the streams sampled did not meet the water quality standard. Swan Creek, Clear Creek, and Clarks Creek are on the State's current (1998) 303(d) list. The listings were based on a limited number of samples and the data are highly sporadic. These factors tend to skew the statistics. Some of the high fecal coliform values may reflect a storm event. Fecal coliform concentrations can temporarily increase by several orders of magnitude in urban stormwater runoff (EPA, 1993).

Fecal coliform bacteria are present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals, and can enter water bodies from human and animal waste. Fecal coliform are indicator organisms, which means they signal the presence of other pathogenic bacteria and are associated with the presence of viruses or other types of pathogens. Swimming in waters with high levels of fecal coliform bacteria increases the chance of developing illness (fever, nausea or stomach cramps) from pathogens entering the body through the mouth, nose, ears, or cuts in the skin. Diseases and illnesses that can be contracted in water with high fecal coliform counts include typhoid fever, hepatitis, gastroenteritis, dysentery, and ear infections.

7.2.8 Turbidity and Suspended Solids

Swan Creek and Diru Creek had mean turbidity values of 28 and 22 Nephelometric Turbidity Units (NTUs), respectively. In this region, values in excess of 10 NTUs represent cloudy conditions and indicate the presence of silt or sediment. Field studies performed for this plan identified excessive sediment buildup in lower Swan Creek, Woodland Creek, Clear Creek, and Canyon Creek. Sediment deposits are evidence of turbid conditions in the past. The deposits also contribute to turbidity during later storm events as faster water and new current directions pick up sediments and transport them further downstream.

High concentrations of suspended solids (measured as "Total Suspended Solids," TSS) can cause many problems for stream health and aquatic life. Suspended solids can block light from reaching submerged vegetation. As the amount of light passing through water is reduced, photosynthesis slows down. Reduced rates of photosynthesis causes less dissolved oxygen to be released into the water by plants. If light is completely blocked from bottom dwelling plants, the plants will stop producing oxygen and will die. As the plants are decomposed, bacteria will use up more oxygen from the water. Low dissolved oxygen can result in fish kills. High suspended solids can also cause an increase in surface water temperature, because the suspended particles absorb heat from sunlight. Higher water temperatures can cause dissolved oxygen levels to fall even further (because warmer waters can hold less DO), and can harm aquatic life in many other ways (Mitchell and Stapp, 1992). High total suspended solids in a water body can often mean higher concentrations of bacteria, nutrients, pesticides, and metals in the water. These pollutants may attach to sediment particles on the land and be carried into water bodies with storm water. In the water, the pollutants may be released from the sediment or travel farther downstream (Federal Interagency Stream Restoration Working Group, 1998).

7.2.9 pH

pH values have been generally good across the Basin, with a few exceptions. Low values detected in Diru Creek could be due to process water from the fish hatchery. The sampling location was immediately downstream of the hatchery. Clarks Creek is on the 303(d) list for pH, as is its tributary Meeker Ditch in the City of Puyallup. The Clarks Creek listing was prompted by three samples taken in 1996; two of which were slightly below the minimum of 6.5. A more recent study (2002-2003) involved 12 rounds of monitoring at five locations on the creek over a 15-month period. Results include three samples with pH slightly below 6.5; two of which occurred during a very large (25-50 year recurrence) on October 21, 2003. None of the Clarks Creek samples exceeded the State maximum pH of 8.5. Based on these results, pH does not appear to be a problem in Clarks Creek at present.

pH measures the acidity or alkalinity of water and other solutions. It is presented on a scale from zero to 14. A pH of 7 is neutral. PH values of 0 – 7 indicate acidity, and values from 7 to 14 indicate alkalinity. A solution with a pH value of 7 is neutral; a solution with a pH value less than 7 is acidic; a solution with a pH value greater than 7 is basic. Natural waters usually have a pH between 6 and 9. The scale is negatively logarithmic, so each whole number (reading downward) is ten times the preceding one (for example, pH 5.5 is 100 times as acidic as pH 7.5). The pH of natural waters can be made acidic or basic by human activities such as heavy automobile traffic. Drainage water from forests and marshes is often slightly acidic, due to the presence of organic acids produced by decaying vegetation.

Very high (greater than 9.5) or very low (less than 4.5) pH values are unsuitable for most aquatic organisms. Young fish and immature stages of aquatic insects are extremely sensitive to pH levels below 5 and may die at these low pH values. High pH levels (9-14) can harm fish by denaturing cellular membranes.

Changes in pH can also affect aquatic life indirectly by altering other aspects of water chemistry. Low pH levels accelerate the release of metals from rocks or sediments in the stream. These metals can affect a fish's metabolism and the fish's ability to take water in through the gills, and can kill fish fry.

7.2.10 Sediment

Severe erosion occurring in the stream channels is causing siltation of the streambeds in the lower reaches. The buildup of sediment in the lower reaches is due primarily to scour of banks and transport of particles downstream during storm events, or due to pollutant wash off of impervious surfaces, and construction sites with inadequate erosion and sedimentation controls.

Sediment accumulations are a significant problem in the valley reaches of all of the creeks. Eroded material from incising stream channels and sediment loads from land clearing, grading, and construction projects deposits in the valleys. The sediment removes the capacity of stream channels to handle stormwater and the capacity of floodplains to store excess runoff. Sediment provides a medium for invasive aquatic plants. Sediment buries food needed by aquatic life.

7.2.11 Excessive Growth of Invasive Aquatic Vegetation

Excessive growth of invasive vegetation occurs in the lower reaches of Clear Creek and Clarks Creek. Both the complaints database and the habitat field surveys identified the excessive growth of invasive aquatic vegetation such as elodea, reed canary grass, and milfoil in the lower, slow moving reaches of the creeks. Two factors in combination contribute to the excessive growth. The large sediment loads in the streams enriches water with nutrients.

Additionally, the reaches receive an overabundance of sunlight because property owners have removed much of the streamside trees and shrubs that provide shade. Excessive vegetation can reduce fish passage and the hydraulic capacity of the stream, contribute to flooding problems, and create an oxygen demanding during plant die-off and decay. See Chapter Eight for additional discussion of this problem.

7.3 Watershed Analysis

The analysis of water quality and identification of treatment options for the Clear/Clarks Creek Basin uses two methods. The first method uses the "Watershed Treatment Model" (WTM) developed by the Center for Watershed Protection under an EPA grant. The model is a simple spreadsheet-based general water quality treatment model that Water Programs staff ran for the Clear Creek Basin and the Clarks Creek Basin. The model factors land use, sources of non-point pollution, the amount of impervious surfaces, the availability of sanitary sewer systems, and other existing information about a basin to identify effective water quality management practices.

The second method consists of finding the source of the water quality problems, be it dumping, loss of tree canopy over streams, or down cutting of stream channels with increasing stormwater peaks flows, etc. For each water quality problem, the analysis identifies factors bearing on future conditions and considers the future condition likely given the development regulations currently in effect, planned growth, and stormwater flows forecast from the results of hydrologic and hydraulic model runs. From this analysis, needs for water quality facilities or programmatic actions were determined.

7.3.1 Watershed Treatment Model

The "Watershed Treatment Model" predicts the mass loading or concentration of certain pollutants found in stormwater based on existing and future land use conditions. The model can also be used to rapidly assess and quantify the general effectiveness of various watershed treatment options to reduce water pollution. Because it is a simple model, it only tracks sediments, nitrogen, phosphorus and bacteria. However, these pollutants are the most significant indicators in water quality in a watershed.

The advantage of using this model lies in its ability to compare treatment options and their relative effectiveness in reducing the quantity of pollutants in surface water. Estimates used in the model are based on certain principles and simple algorithms.

The model has two basic components:

Pollution Sources Component. The pollutant sources component looks at the watershed's pollutant load without treatment measures in place. It takes into account land uses, primary source pollutants (pollutants that enter the water directly from various sources, secondary source pollutants (pollutants formed when primary pollutants react with each other or with other compounds present), and the common loading these factors produce.

Treatment Options Component. The treatment options component uses simplified assumptions to determine how various treatment measures will reduce the uncontrolled load. The model uses a total of 20 different treatment options to evaluate potential pollutant load reductions. These options range from education programs to the treatment of point sources.

7.3.2 Model Development

The model consists of inputs such as the existence of sanitary sewer overflows and whether connections of household wastewater to storm drains occur within the drainage area being analyzed. Clear Creek and Clarks Creek water quality, land use, environmental practices, existing governmental or non-profit agency programs, and similar information was entered into the model. Much of the data used in the model was obtained from the County's "Geographic Information System" (GIS), supplemented with data provided by various County, city, and tribal employees. Where GIS or other data were not available, the experience and expertise of County staff were used; for example, the existence of sanitary sewer overflows in the basins or whether connections of household wastewater to storm drains have been reported.

7.3.3 Model Results – Existing Loads

Table 7-2 presents the estimates of existing primary and secondary pollutant loadings for urban and rural lands and associated land uses given the characteristics of the Basin. It lists estimated loadings for total nitrogen, total phosphorus, total suspended solids, and fecal coliform for both rural and urban sources and shows the larger sources in the Basin. Results suggest that the secondary sources in rural areas account for less than 1% of the total pollutant loading and, therefore, are not significant. In urban areas, the model indicates that the greatest contributors to overall pollutant loadings are channel erosion, active construction, urban land use and illicit connections. Illegal (illicit) connections are non-stormwater discharges to the storm system, such as wash water and direct connections of household wastewater. Note that vacant lots are parcels without a building value and not categorized as forest or agriculture rather than an undeveloped plot of land.

Table 7.2 Predicted Existing Loads for Clear and Clarks Creek basins From Watershed Treatment Model

URBAN SOURCES	Area (acres)	Total Nitrogen (lb/year)	Total Phosphorus (lb/year)	Total Suspended Solids (TSS)	Fecal Coliform (billion colonies/year)
Urban Land	10,565	70,516	11,983	1,687,725	153,465
Active Construction	645	8,318	2,994	1,663,611	0
SSOs	0	17	3	115	13,018
CSOs	0	0	0	0	0
Illicit Connections	0	1,208	486.1	9,863	432,288
Channel Erosion	0	23	4,694.0	2,607,779	0
Marinas	0	0	0	0	0
Road Sanding	0	0	0	65,397	0
Point Sources	0	5,762	1,440	144,049	0
Vacant Lots	2,577	9,019	1,288	257,700	67,002
RURAL SOURCES					
Rural Land	830	3,818	581	83,000	32,370
Forest	340	850	68	34,000	4,080
Livestock	0	0	0	0	0
Open Water	121	1,549	60	18,755	0
TOTAL LOAD		101,081	23,599	6,571,994	702,224
Storm Load		63,815	21,021	6,368,416	268,634
Non-Storm Load		37,266	2,578	203,578	433,590

Source: Pierce County Water Programs

Results approximate actual water quality data. The model somewhat underestimates loadings for nitrogen, phosphorus, and total suspended solids and overestimates loading for fecal coliform. A number of reasons exist for differences between model estimates and water quality samples results. Actual sampling data is limited and tends to be biased to excursions above water quality standards. Actual sample data may not represent the median annual pollutant concentration. Fecal coliform monitoring typically has a high variability.

Additionally, although the model operates with specific information about the Clear/ Clarks Creeks Basin, the model is not specifically calibrated for the Basin and cannot be expected to reproduce actual in-stream loads unless supplemented by more complex models.

Table 7-3. Comparison of Data with Results of the Watershed Treatment Model

Avg Clear/Clarks Water Quality Data			Converted Data		Model Results	
Nitrogen	1.6	mg/l	271,683	lb/year	101,081	lb/year
Phosphorus	0.2	mg/l	33,124	lb/year	23,599	lb/year
TSS	37.3	mg/l	9,552,426	lb/year	6,571994	lb/year
Fecal Coliform	600	col/100ml	460,368	billion colonies/year	702,223	billion col/year

Source: Pierce County Water Programs

Existing load projections form the basis for the next step. The model contains a set of watershed treatment options and estimates of the amount of nitrogen, phosphorus, total suspended solids, and fecal coliform loads that each treatment option removes from the watershed.

According to the model, the most effective overall watershed treatment option is Erosion and Sediment Control particularly at lowering total suspended solids and phosphorus loadings. The most effective treatment option for removing nitrogen would be a Lawn Care Education Program. For lowering fecal coliform levels, an “On-Site Septic System Education Program” was the most effective.

7.3.3 Analysis of the Results

Table 7-4 lists the total net benefit from each management practice for Clear Creek. *Table 7-5*, Watershed Treatment Model Net Benefit of Future Management Practices for Clarks Creek Basin, lists the load reductions for each management practice considered by the model.

Table 7-4 Predicted Load Reduction Benefits of Future Management Practices
Clear Creek Basin

Pollutant	Nitrogen	(Rank)	Phosphorus	(Rank)	TSS	(Rank)	Fecal Coliform	(Rank)	Sum Rank
Units	(lbs/year)		(lbs/year)		(lbs/year)		(billion/year)		
Lawn Care Education	2471	(1)	49	(7)	0	(16)	0	(11)	10
Pet Waste Education	194	(7)	25	(10)	0	(16)	1689	(5)	12
Erosion and Sediment Control	970	(2)	349	(2)	193905	(2)	0	(11)	1
Street Sweeping	262	(5)	70	(4)	12064	(4)	0	(11)	3
Street Sweeping - Sanding	0	(17)	0	(17)	77	(14)	0	(11)	17
Impervious Cover Disconnection	21	(13)	2	(14)	267	(11)	81	(9)	14
Structural Stormwater Management Practices	122	(9)	106	(3)	6757	(6)	611	(6)	3
Riparian Buffers	5	(14)	0	(15)	470	(10)	0	(11)	15
Catch Basin Cleanouts	216	(6)	54	(6)	13352	(3)	0	(11)	6
Marina Pumpouts	0	(17)	0	(17)	0	(16)	0	(11)	18
Septic System Education	378	(4)	29	(9)	1163	(8)	725909	(1)	2
Land Reclamation	0	(17)	0	(17)	0	(16)	0	(11)	18
Impervious Cover Reduction	28	(12)	8	(11)	1066	(9)	101	(8)	13
Stormwater Retrofits	96	(10)	32	(8)	8117	(5)	169	(7)	9
Illicit Connection Removal	146	(8)	63	(5)	1224	(7)	51466	(4)	3
CSO Repair/ Abatement	0	(17)	0	(17)	0	(16)	0	(11)	18
SSO Repair/ Abatement	0	(16)	0	(16)	0	(15)	20	(10)	16
Septic System Inspection/Repair	73	(11)	6	(12)	224	(12)	139598	(2)	11
Septic System Upgrade	445	(3)	6	(12)	224	(12)	139598	(2)	8
Channel Protection	2	(15)	471	(1)	261477	(1)	0	(11)	7
Point Source Reduction	0	(17)	0	(17)	0	(16)	0	(11)	18
Total Reduction	5431		1271		500387		1059241		

Table 7-4 Predicted Load Reduction Benefit of Future Management Practices Clarks Creek Basin

Pollutant	Nitrogen	(Rank)	Phosphorus	(Rank)	TSS	(Rank)	Fecal Coliform	(Rank)	Sum Rank
Units	(lbs/year)		(lbs/year)		(lbs/year)		(billion/year)		
Lawn Care Education	6272	(1)	125	(7)	0	(15)	0	(11)	10
Pet Waste Education	1015	(5)	132	(6)	0	(15)	8822	(6)	7
Erosion and Sediment Control	1194	(3)	430	(1)	238859	(1)	0	(11)	2
Street Sweeping	879	(6)	234	(3)	42163	(5)	0	(11)	6
Street Sweeping - Sanding	0	(17)	0	(17)	0	(15)	0	(11)	17
Impervious Cover Disconnection	35	(12)	2	(15)	282	(12)	76	(9)	15
Structural Stormwater Management Practices	439	(9)	252	(2)	48960	(3)	1300	(7)	3
Riparian Buffers	19	(13)	2	(14)	2150	(8)	0	(11)	13
Catch Basin Cleanouts	54	(11)	16	(11)	999	(10)	0	(11)	12
Marina Pumpouts	0	(17)	0	(17)	0	(15)	0	(11)	17
Septic System Education	1975	(2)	152	(5)	6076	(6)	3792339	(1)	1
Land Reclamation	0	(17)	0	(17)	0	(15)	0	(11)	17
Impervious Cover Reduction	3	(15)	1	(16)	113	(13)	10	(10)	16
Stormwater Retrofits	530	(8)	188	(4)	51503	(2)	953	(8)	5
Illicit Connection Removal	156	(10)	58	(10)	1242	(9)	56606	(4)	8
CSO Repair/ Abatement	0	(17)	0	(17)	0	(15)	0	(11)	17
SSO Repair/ Abatement	15	(14)	2	(13)	97	(14)	11007	(5)	13
Septic System Inspection/Repair	1111	(4)	85	(8)	3418	(7)	2133191	(2)	3
Septic System Upgrade	756	(7)	9	(12)	380	(11)	237021	(3)	8
Channel Protection	0	(16)	78	(9)	43414	(4)	0	(11)	11
Point Source Reduction	0		0		0		0		
Total Reduction	14452		1768		439656		6241327		

7.4 Future Conditions

7.4.1 Upcoming Projects

Several projects are underway or in development that are designed to have a positive effect on water quality in the Clear/Clarks Creek Basin. The projects range from habitat improvements to flood control projects, but they will also improve water quality.

Port of Tacoma Clear Creek Habitat Area. The Port of Tacoma is currently constructing "Phase 2" of their Clear Creek Habitat Project. This project is designed to enhance and restore salmon habitat at the site and mitigate for habitat that was lost as part of implementing the Sitcum/Blair/Milwaukee Waterway Cleanup Project. The 11-acre site is located at the mouth of Clear Creek.

Swan and Clarks Creek were channelized long ago in the 1940-50's. It appears that the Port of Tacoma's newly created wetland incorporates much of the land that Clear and Swan Creeks once meandered through. Once isolated ponds are now connected to Clarks Creek by a weir and an expansive pond system. This system is fed by ground water and water from these ponds. In addition, the wetland is filled twice daily by tidally influenced waters that cause Puyallup River water to flow into Clarks Creek.

A variety of trees – big-leaf maple, dogwood, hazelnut, red alder, vine maple and western red cedar – shade and cool the water for fish and offer nesting places for hundreds of birds. Ducks make their homes among wetland and riparian vegetation (Port of Tacoma: An Environmental Report April 2003).

The Port constructed an outlet channel, tidal mudflat refuge bay, bridge, and sluice gate at the mouth of Clear Creek to ensure that water flows freely into the constructed pond/wetland complex. Now salmon have access to nearly ten miles of streams and creeks (Port of Tacoma: An Environmental Report April 2003). Two sluice gates are located where Clear Creek enters the Puyallup River that are shut when the Puyallup River floods. The gates prevent the river floodwater from flowing up Clear Creek during a large storm event. One gate is manual and operated by Drainage District #10, the other gate was replaced by the Port of Tacoma as part of the wetlands habitat project and is electronically controlled. Neighbors upstream of the project reported faster relief of high waters during significant storm events in the 1999 and 2000 seasons.

The Port of Tacoma does not currently participate in any water quality monitoring; however, they do monitor the salmon that utilize the wetland. The Port also tracks the health of the vegetation and monitors the wetted perimeter of the wetland (Site visit, 10/16/2003).

City of Puyallup Silver Creek Restoration. The City of Puyallup, in cooperation with the Western Washington Fair Association, is restoring Silver Creek. Silver Creek emerges from a spring on South Hill and flows in open ditches and pipelines to Meeker Ditch. The restoration project will replace undersized culverts and considerable length of pipeline to more natural stream channel on land acquired by the City.

The site for the newly restored creek is currently the Silver lot at the Puyallup Fair, which is how the creek got its name. In addition to the new creek bed, a constructed wetland will be created next to the creek. The City of Puyallup expects this project to improve the quality of water flowing into Meeker Ditch, a major tributary of Clarks Creek.

7.4.2 Future Land Use

The Pierce County Comprehensive Plan continues development in the Clear/Clarks Creek Basin. 41% of the Basin (considering the basin including the cities) is designated "Rural"; 59% of the basin is designated "Urban". Part of the area designated "Rural" has been subdivided to lots less than one-half acre in size that will probably be developed.

These characteristics bear on the amount of impervious surfaces likely created during the life of this plan. The effective impervious area is expected to increase as the intensity of land use increases. In the Clear Creek drainage area, the impervious area will increase from 19% to 23%. The impervious area in Clarks Creek drainage area is forecast to increase from 25% to 35% and

the Potholes drainage area is expected to increase from 27% to 45% impervious area. The development envisioned is likely to have substantial effects on the character of stormwater runoff and water quality in the creeks.

7.5 Programmatic Recommendations

Programmatic recommendations are nonstructural actions for solving stormwater drainage problems. Generally they are broad in applicability, having basin-wide or County-wide benefit.

Site development regulations are a type of programmatic action, enforcement of temporary erosion and sedimentation control requirements is another type. Programmatic actions suggest ways of solving stormwater drainage problems by modifying how people do things, when and where.

Ideally, programmatic actions maximize public investment in structural facilities and floodplain acquisition. This section identifies the programmatic actions most likely to have a significant positive effect on water quality.

The recommended actions derive from the "Watershed Treatment Model" and from knowledge of practices that have proven effective for other local governments, Washington State agencies, and private interests.

7.5.1 Water Quality Monitoring Plan

Two types of monitoring are proposed. Both would enable tracking how well the implementation of recommendations in this Basin Plan have stabilized or improved water quality.

The first involves tracking of the implementation of programmatic recommendations of this basin plan (i.e.; retrofits, land acquisitions, educational components).

The second type of monitoring involves a quantitative analysis of instream water quality. A strategic water quality-monitoring plan would be designed to measure water quality and quantity of flow in a way that data can be used to indicate the success of recommended solutions/interventions. Typically, it takes 20 years of data to develop a meaningful understanding of the hydrologic variables of a stream system.

A TMDL for fecal coliform bacteria has been developed for the Clarks Creek Subbasin. The Clarks Creek action plan sets up specific pollution reduction goals. For the Clarks Creek Subbasin streams, Swan Creek, and Clear Creek (stream reaches on the States 303 (d) list of impaired water bodies) a more advanced water quality model capable of probabilistic analysis should be used to develop a specific monitoring plan(s). A minimum monitoring plan should be developed to quantify existing baseline water quality and track pollutant loading reductions as the result of implementation of recommendations of this plan.

As part of the initial analysis for the Basin Plan, three flow gauges and temperature monitoring stations were established on Clear Creek, Canyon Creek, and Swan Creek. In addition, Pierce County Water Programs and the USGS have been operating a flow monitoring station on Clarks

Creek for a number of years. Operation of these flow and temperature stations should be continued indefinitely and be augmented by similar gauges on other streams in the basin planning area.

7.5.2 Adopt Updated Stormwater Management Standards

In 2002, Ecology adopted a new Stormwater Management Manual for Western Washington (Ecology Manual). Terms of the County's Stormwater NPDES Permit require the County to control the quality of stormwater discharged to rivers, streams, marine waters, and groundwater. Programs to control runoff water quality must include minimum requirements and best management practices equivalent to those found in the Ecology Manual.

To comply with the County's NPDES Permit, the County must analyze the Pierce County Stormwater Management and Site Development Manual, 1999 (County Manual) for consistency with the Ecology Manual, must revise the County Manual to achieve equivalency, and must formally adopt the revisions.

Application of the revisions has potential to reduce the need for construction of public stormwater treatment facilities or reduce their size.

7.5.3 Invasive Species Management Program

Pierce County spends approximately $40-60,000 per year to maintain vegetation in the lower reaches of Clarks Creek alone. An invasive species management program would provide a longer-term solution that is more effective at reducing problem vegetation than use of herbicides. The management program would involve the removal of invasive species and the planting of native vegetation in its place.

The program would include monitoring the vegetation planted to ensure its survival and prevent the invasive plants species from returning. When native plants are established, they will provide shade for habitat, create stable stream banks, and out-compete invasive vegetation. Water quality benefits will include higher dissolved oxygen, balanced pH, and lower water temperatures.

An "Invasive Species Management Program" would ultimately shift the costs of invasive vegetation removal to maintaining the healthy riparian vegetation that keeps the invasive species in check. Invasive vegetation removal, while important, is labor intensive, typically requires the use of herbicides, and it is a continuing expense unless long-range objectives are established to reduce or remedy the conditions on which invasive vegetation thrives.

7.5.4 Floodplain/Riparian Corridor Land Management

The 1991 Pierce County Storm Drainage and Surface Water Management Plan (1991 Plan) recommended the acquisition of floodplain lands important as habitat, open space, recreation, or floodwaters storage or conveyance. Policies of the 1991 Plan and the County Comprehensive Plan state that non-structural alternatives are preferable to traditional structural solutions.

In response to these directions, Water Programs began to acquire land as part of a strategy for flood control and for mitigating the adverse environmental effects of storm drainage practices. In some cases, acquisition consisted of purchasing development rights. In other cases, such as

when federal grant funds were used, fee simple purchase was required to protect the public investments and adequately maintain the property.

Riparian buffers within both stream systems in the Basin have been largely destroyed. Riparian cover exists in the canyon reaches of the streams, but otherwise the stream cover was replaced by agricultural fields, residential lawns and landscaping, roads, etc. Intact riparian areas buffer streams by filtering out sediment and other pollutants in runoff, limiting access to streams by waterfowl, moderating temperature fluctuations (providing shade), provide for floodwater storage, and generally protecting water quality. One of the principles of the "Watershed Treatment Model" says that every stream mile of riparian corridor with 50-foot deep buffers on both sides of a stream can reduce loading by 18 pounds of nitrogen, 1.1 pounds of phosphorus, and 471 pounds of sediment annually.

Acquisition of riparian corridors through purchase or conservation easements should be a priority. Wetlands areas in the pothole area should also be protected and managed thru a combination of purchase and conservation easements. Doing so will preserve the water cleansing functions of wetlands and protect groundwater quality. Groundwater is used for human consumption and is an important source of cool base flow for the streams of the Clear/Clarks Creek Basin and other adjacent basin (Mid-Puyallup Basin and Clover Creek Basin).

7.5.5 Stormwater Structure Retrofits

Stormwater structure retrofits are structural "Best Management Practices" implemented after a development or stormwater facility has been constructed. Because of site constraints after development has occurred, retrofits are often smaller than treatment facilities in new developments. Developments built before the adoption of stormwater site development regulations in 1996 will typically be the most likely candidates for retrofit.

Retrofits tend to be expensive to construct and to maintain. In the event that non-structural solutions do not bring about sufficient improvements in (or protection of) water quality, stormwater facility retrofits should be considered.

The first step in developing a program for retrofits will be to conduct an inventory of existing stormwater structures and rank them for retrofit potential. To minimize need to retrofit additional stormwater facilities, design of new stormwater facilities should incorporate water quality components.

7.5.6 Street Sweeping

Conduct a systems analysis of the County's street sweeping program in collaboration with the Pierce County Public Works and Utilities, Transportation Maintenance Division to identify cost-effective ways of augmenting street sweeping in areas where stormwater quality is adversely affected by road runoff.

Include an analysis of the benefit of funding certain street sweeping program expansions with storm drainage and surface water management funds. Street sweeping is an effective way of reducing the concentration value of total suspended solids, nitrogen, and phosphorus from road

runoff. (See *Table 7-3* and *7-4* for the load reduction and effectiveness rank in the Clear Creek and Clarks Creek basins.) The ability of street sweeping to reduce the concentration value of pollutants is primarily limited by the type of equipment used, the frequency of sweeping being performed, and the road type.

7.5.7 Education Programs

Public education programs may help to reduce the concentrations of nutrients, sediments and bacteria in to the streams by making people aware of the consequences of the choices they make. They suggest new ways of doing things that contribute to nonpoint pollution and offer new ways of thinking about these activities.

Public participation, with each person doing his/her part, is a crucial aspect of improving water quality, especially in reducing nonpoint pollution. Approximately 50% of the Basin is residential area, so educating homeowners and residents could have a significant effect on reducing nonpoint pollution-based water quality problems, such as nutrient loading and fecal coliform bacteria.

Success of education programs depends on the media chosen for distributing the message and the intensity of effort. Some of the various media types in order of their effectiveness are: television, radio, newspapers, billboards, brochures/pamphlets, and public meetings.

In a voluntary program, some fraction of people will be unwilling to change their behavior. However, the degree of participation is influenced by the intensity of the education effort. Intensity of effort is a function of the number of educational media employed, the variety of images or illustrations used to convey the message, and how often the message is repeated.

Pet Waste Program. Pet waste can contribute bacteria, pathogens and nutrients to ground and surface water. Educational programs that address nonpolluting ways of disposing of pet waste can be an effective way of reducing these pollutants. The goal of a pet waste program is to change the behavior of pet owners so they properly dispose of their pets' waste.

The "Watershed Treatment Model" estimated potential load reductions for the Clarks Creek sub-basin using two media types as follows:

Media Type	Nitrogen reduction (lbs/year)	Phosphorus reduction (lbs/year)	Sediment reduction (lbs/year)	Fecal coliform reduction (billion colonies/year)
Brochure	202	26	0	1,764
Television Ad	1,014	132	0	8,822

Lawn Care Program. Excessive fertilizer application can contribute nutrients (nitrogen and phosphorus) to surface and ground water. Educational programs that address proper lawn care can help to reduce these pollutants in groundwater and streams. The goal of a lawn care program would be to eliminate all of the excess fertilizer applied to turf.

Potential load reductions for the Clarks Creek Sub-basin according to the "Watershed Treatment Model," using two media types are as follows:

Media Type	Nitrogen reduction (lbs/year)	Phosphorus reduction (lbs/year)	Sediment reduction (lbs/year)	Fecal coliform reduction (billion colonies/year)
Brochure	1,254	25	0	0
Television Ad	6,271	125	0	0

On-Site Sewer Systems Program. The Tacoma-Pierce County Health Department (TPCHD) has an existing education program for on-site sewer system maintenance that use workshops and printed material. TPCHD gives information on the proper use and care of on-site sewer systems to people when they apply for a new on-site sewer system permit or repair.

Free classes are offered to interested people through the Washington On-Site Sewage Association (WOSSA) and are taught by WOSSA members. They are offered at two locations, Puyallup and Purdy. Workshops in the Key Peninsula area are reported to have good turnouts probably due to the inclusion of workshop announcements in Peninsula Light power bills.

Improper on-site sewer system operation and maintenance can contribute bacteria, other pathogens, and nutrient pollution to receiving waters. Educational programs that address proper on-site sewer system operation can be an effective tool to reduce the discharge of these pollutants.

The "Watershed Treatment Model" estimated the following potential load reductions for the Clarks Creek Basin using two media types as follows:

Media Type	Nitrogen reduction (lbs/year)	Phosphorus reduction (lbs/year)	Sediment reduction (lbs/year)	Fecal coliform reduction (billion colonies/year)
Brochure	395	30	1,215	758,467
Television Ad	1,974	151	6,075	3,792,339

7.5.8 Structural Stormwater Management Practices

"Structural Stormwater Management Practices" refers to an agency's commitment to integrating water quality related design features into the design of stormwater facilities, public and private. It includes programs for regular inspection of public and private stormwater treatment related facilities.

Stormwater treatment efficiencies decline without property maintenance. A thorough investigation of relevant factors, policy guidelines, and alternatives should be undertaken to evaluate the County's existing programs and recommend cost-effective solutions.

7.6 Site-Specific Water Quality Recommendations

This section describes the site specific water quality problems in the Clear/Clarks Creek Basin. The section is ordered from west to east as follows:

Roosevelt Ditch Drainage Area

Clear Creek Basin	Swan Creek Squally Creek Clear Creek Canyon Creek
Clarks Creek Basin	Rody Creek Diru Creek Woodland Creek Clears Creek

Potholes Drainage Area

7.6.1 Roosevelt Ditch Drainage Area

Problem Description: RD-18

No water quality data exists for the Roosevelt Ditch drainage area. This precludes a water quality assessment. Although there are speculations about particular sites and sources of nonpoint pollution, no data exists to support or refute the hypotheses.

Recommendation: Incorporate Roosevelt Ditch into the water quality monitoring plan. Sample the ditch to document baseline information on the water quality, including flow volumes. The data obtained can be evaluated to determine the degree to which water quality problems exist. Then alternative solutions to address water quality can be identified.

Problem Description: RD-19

According to the Water Programs Maintenance Division, sediments accumulate in Roosevelt Ditch.

Recommendation: A potential CIP project may alleviate erosion on Roosevelt Ditch. An alternative is to expand the natural detention storage area located next to Portland Avenue between 80th Street E and the Shopping Center. Expanding the storage area by an additional 8 acre-feet would help prevent flooding and water quality concerns associated with high flows such as erosion.

7.6.2 Clear Creek Basin

Swan Creek Subbasin

Problem Descriptions: SW-18 and SW-19

Swan Creek is listed on the 1998 and 2004 303(d) lists for fecal coliform bacteria. The compacted till soil and absence of pore spaces between soil particles prevent wastewater from percolating through the soil.

Recommendation: Prepare a strategic monitoring plan for fecal coliform in Swan Creek. Further monitoring is necessary to determine when high levels of fecal matter are present in the stream and identify patterns in their occurrence.

Maintenance of on-site sewer systems is very important to keep systems operating property. An educational program for homeowners on maintaining their on-site sewer systems is one part of the solution to the fecal contamination problem. Tacoma-Pierce County Health Department regulates on-site sewer systems and also offers educational programs.

Failing on-site sewer systems part of the solution to the fecal problem. To further the goal of repairing on-site sewer systems, the Tacoma-Pierce County Health Department implemented an on-site sewer maintenance program County-wide. However, the cost of repairing or replacing an on-site sewer system can be a financial burden that dissuades homeowners from repairs. A program to assist homeowners with the cost of repair or replacement of failing on-site sewer systems should be investigated.

Problem Description: SW-3, SW-22, SW-23, SW-24, SW-25, SW-26, SW-35

Sediment is a serious problem in Swan Creek below Pioneer Way East. Sediments increase turbidity, reduce aquatic organisms' survival rates, and fill stream bottoms, increasing the chances of flooding and weed growth. The draft results of the Limiting Factors Analysis of the Ecosystem Diagnosis and Treatment (EDT) Model for Pierce County lists erosion as the factor most limiting salmonid habitat in Swan Creek. Evidence of erosion includes a severely incised channel downstream of 64th Street East with ten-to-twelve-foot vertical stream banks and an undermined culvert inlet at 64th Street East.

Recommendation: Eliminate the sources of sediments as much as possible. (a) Enforce use of Best Management Practices to control erosion at public and private construction sites. (b) Reduce the volume, velocity, and duration of peak flows by storing stormwater in detention facilities as ponds or wetlands and metering discharges to Swan Creek. Eight (80)-acre feet of detention storage and the purchase of a wetland for preservation adjacent to Swan Creek will reduce peak flows as the sub-basin's land use changes. (c) Stabilize stream banks and restore riparian corridor vegetation through a combination of bio-stabilization and armoring techniques.

Problem Description: SW-36

Excess nutrients are present in Swan Creek. Nutrients are naturally present in water; however, when nutrient levels increase, they stimulate growth of aquatic vegetation. Nitrogen and phosphorus levels are present in the groundwater, a major source of base flow to the streams in the Clear/Clarks Basin. Other nutrient sources include human and animal wastes, soil erosion and fertilizers.

Recommendation: Alternatives discussed above to address fecal contamination and sedimentation would also lower potential nutrient sources. Further investigation of the sources of nitrogen and phosphorus in the ground water.

Problem Description: SW-37

Dissolved oxygen (DO) and pH were measured below acceptable levels on a few occasions on Swan Creek. The occurrences were probably a result of the other problems listed above. pH levels tend to decrease when rapid aquatic vegetation growth occurs. Levels of DO tend to fall when there is an excess of organic materials in the stream system; as the organic materials decay, they consume oxygen, depleting the oxygen supply. Sources of organic materials include on-site sewer effluent, urban runoff, aquatic vegetation, and agriculture runoff.

Recommendation: Addressing the sedimentation problem and the high nutrient loadings may prevent the pH from dropping to an acidic level below the states criterion. Dissolved oxygen levels will improve as nutrient levels drop and invasive aquatic vegetation is brought under control. The alternatives discussed above to reduce sediment and fecal coliform bacteria should also improve conditions and reduce DO and pH problems.

Squally Creek Subbasin

Problem Description: SQ-6

Invasive species are present in Squally Creek above Pioneer Way.

Recommendation: Remove invasive the reed canary grass and nightshade and restore native vegetation along this reach of the stream. Implement an invasive species management program to keep the invasives in control until native riparian trees and plants are established.

Problem Description: SQ-7

Squally Creek detention pond was designed for a 25-year storm so it does not have capacity for peak flows from larger events. The creek channel downstream of the detention pond is incising.

Recommendation: Expand the pond to handle a 100-year flood and include certain water quality features such as providing shade to control water temperatures and features that limit the number of birds attracted to the pond.

Problem Description: SQ-8

No water quality water quality data was found for Squally Creek.

Recommendation: Incorporate Squally Creek into the water quality monitoring plan so there is data to assess whether the stream meets the State water quality standards and identify water quality problems.

7.6.3 Clear Creek

Problem Description: CL-16

Clear Creek is on the state 303(d) list of impaired water bodies due to the presence of fecal coliform bacteria levels in excess of state standards. Fecal coliform bacteria are an indicator of pathogens. Decomposition of fecal waste can also lower dissolved oxygen levels in the water, which harms aquatic life.

Recommendation: Incorporate Clear Creek into the monitoring plan to be tested regularly for fecal coliform.

Determine the sources of fecal contamination. Incorporate Clear Creek into the water quality monitoring plan to be tested regularly for fecal coliform to determine if fecal contamination is a seasonal problem or if high values only occur after storm events. Perform microbial source tracking analysis to determine the sources of the fecal bacteria. If the main source is human waste, the solution should focus on the repair failing on-site septic systems. If the problem is pet waste, a program to encourage responsible pet owner behavior would be implemented.

Problem Description: CL-17, 18, 19, 20, 21, 22, 33

Erosion over time is a natural process. However, the rate of down cutting has increased due to increased runoff in the basin, particularly peak storm flows. Many of the areas where down cutting has occurred are associated with undersized culverts. The high flows forced into an inadequately sized culvert increase the water velocity in the culvert. This powerful flow then causes erosion and down cutting below the culvert.

Recommendation: Replace the undersized culverts to slow the rate of channel incision and streambank instability. Undersized culverts are located at 88th Street East and at Gay Road East. To ease the high flows that contribute to down cutting, construct a detention pond/wetland to store stormwater. Rebuilding streams beds to have more sinuosity will also decrease the velocity of high flows.

Canyon Creek Subbasin

Problem Description:

Water quality data is very limited for Canyon Creek.

Recommendation: Incorporate Canyon Creek into a water quality monitoring plan. Use the data collected to determine if there are additional water quality concerns for Canyon Creek.

Problem Description: CY-18, CY-19, CY-20, CY-21, CY-22, CY-23

Excessive down cutting occurs on Canyon Creek with sediment from the erosion accumulating in the Puyallup Valley. During storm events, peak flows scour around undersized culverts and create high velocity flows that increase incising of the channel at the culvert outlet.

Recommendation: (1) Replace undersized culverts at 84th Street East, 88th Street East, 104th Street East, 112th Street East, and 116th Street East to alleviate the scour around existing culverts. (2) Undertake the stream stabilization projects for Canyon Creek such as installing weirs and drop structures. Stabilization projects are needed downstream of 80th Street East, downstream of 72nd Street East, upstream of Canyon Road East, and downstream of Canyon Road East.

7.6.4 Clarks Creek Basin

Rody Creek

Problem Description: RY-19

Microbial Source Tracking for Rody Creek was undertaken as part of the TMDL study for Clarks Creek as described in Chapter Four. According to tracking results, the greatest contributors to fecal contamination are birds (29%), rodents (29%), canines (21%), and humans (13%).

Recommendations: Decrease the primary sources of fecal material to lower the nutrient loading and fecal contamination in Rody Creek. Address bird and rodent contamination by planting native vegetation along the riparian corridor. Doing so deters waterfowl from over using the

stream and should lower the concentration of fecal matter from bird populations. Lower the amount of fecal coliform bacteria from rodents by implementing a strong rodent-control program. Rodent control starts with public education, followed by community action in the form of litter and rubbish pick up. A public education programmatic measure should include the subjects of rodent control, pet waste disposal, and effective maintenance of on-site sewer systems. Add Rody Creek to the water quality-monitoring program for the basin.

Problem Description: RY-14

Like the other streams in the Clear/Clarks Creek Basin, Rody Creek is experiencing erosion and down cutting. The erosion leads to sediment accumulation in low gradient reaches of the stream, especially downstream of Pioneer Way East.

Recommendation: Construction of a detention pond will help to reduce down cutting on Rody Creek. Detention facilities are designed to decrease peak flows by providing storage of stormwater and gradually release the stormwater to minimize erosive energy of the water. Replace the undersized culverts and install streambank stabilization projects to reduce the down cutting. All three alternatives are listed under recommended capital improvement projects.

Diru Creek Subbasin

Problem Description: DU-9

Microbial Source Tracking for Diru Creek was undertaken as part of the TMDL study for the Clarks Creek TMDL for fecal contamination as described in Chapter Four. According to tracking results, the greatest contributors of fecal coliform bacteria in Diru Creek are rodents (38%), unknown (38%), and canines/dogs (12%). No reported human fecal contamination was reported on Diru Creek unlike other subbasins discussed in the chapter.

Recommendation: Further investigation of the unknown factor in fecal coliform bacteria counts will be needed to identify the unknown sources and enable an effective response. Lower the amount of fecal coliform bacteria from rodents by implementing a strong rodent-control program. Rodent control starts with public education, followed by community action in the form of litter and rubbish pick up. The public education measures for this drainage area should include how to control rodents and dispose of pet waste.

Problem Description: DU-10, DU-11

Diru Creek streambanks are eroding in a 100-foot long reach downstream of 72nd Street East. Exposed vertical banks are eight feet high. The culvert that conveys Diru Creek under 72nd Street East is perched three feet above the stream bank. The resulting sediment provides a medium for invasive riparian vegetation that occurs in a 2,200-foot reach from the confluence with Clarks Creek to Pioneer Way East.

Recommendation: Undertake the streambank/channel stabilization project at 72nd Street East as recommended in Chapter Eight.

Problem Description: DU-12

Diru Creek flows intermittently upstream of 84th Street East.

Recommendation: Monitor the volume of flow in the reach above 84th Street East over time to determine whether the intermittent flow is correlated with development in the basin and identify a rate of change.

Woodland Creek Subbasin

Problem Description: WO-30

According to the Microbial Source Tracking performed for Woodland Creek as part of the Clarks Creek fecal coliform study, the largest contributors of fecal material in Woodland Creek are birds (52%), canines (26%), humans and rodents (both 11%).

Recommendations: Address bird and rodent contamination by replanting native vegetation and reestablishing the riparian corridor where it is missing. Doing so will deter waterfowl from over using the stream and lower the amount of fecal matter in the stream from birds. Lower the amount of fecal coliform bacteria from rodents by implementing a strong rodent-control program. Rodent control starts with public education, followed by community action in the form of litter and rubbish pick up. A public education programmatic measure should include the subjects of rodent control, pet waste disposal, and effective operation and maintenance of on-site sewer systems. Add Woodland Creek to the water quality-monitoring program for the basin so the extent of any contribution to the Clarks Creek fecal contamination problem is known.

Problem Description: WO-23

Sedimentation is a problem on Woodland Creek upstream of Pioneer Way East and upstream of 80th Street east. The sediment comes from channel erosion upstream of these locations. Sediment impairs water quality by providing a medium for invasive vegetation, clouding water as it is held in suspension before being deposited. When the invasive plants die, they consume oxygen needed for other aquatic life.

Recommendation: Stream restoration between Pioneer Way East and Clarks Creek would improve the water quality of the stream by providing shade, stream meanders, planting of riparian vegetation, removing invasive vegetation, and widening the floodplain. Erosion control is the most effective means of reducing the amount of sediment that accumulates. Implement the CIP projects related to stream and channel stabilization.

Problem Description: WO-24, WO-25, WO-26

Out of all the creeks in the Clear/Clarks basin, channel incising is most severe on Woodland Creek. The most severe erosion was found at 84th Street East. These are sources of sediment that are a problem in the Puyallup Valley reaches of the creek.

Recommendation: Projects to replace culverts and stabilize stream banks would help to ease this problem. Culvert replacements are needed from 93rd Street East to 96th Street East, at 72nd Street East and 80th Street East. Streambank stabilization such as porous weirs and drop structures at 84th and 80th Streets East would help to direct the energy of flowing water to the center of the stream rather than the eroding streambanks.

Clarks Creek

Problem Description: CK-12

Clarks Creek is listed on the State's 303(d) list for fecal coliform bacteria. Microbial Source Tracking results reported that 44% of the fecal material in a sample at 56th Street East came from birds. DeCoursey Park is an attractive resting spot for migrating birds. Long reaches of Clarks Creek have lawns extending down to the stream bank or pastures extend up to the stream channel that attracts birds. Other sources of fecal material listed were canines (13%), unknown (13%), and felines (9%). Sewage, raw sewage, and humans combined were (12%). See Chapter Four, *Figure 4-13*.

Recommendation: The single most effective way of reducing the fecal contributions from birds is to restore a riparian corridor and plant native plants along the water's edge. Geese and other waterfowl do not land in an area where they cannot easily access the land or see possible predators.

Help pet owners dispose of pet waste in a sanitary way through an education program that targets homeowners and places where people frequently walk their dogs. The City of Puyallup posts signs and distributes waste disposal bags at the parks in the City.

Implement the public education programmatic measure. Tailor program offerings in the Clarks Creek Basin to emphasize stewardship of riparian areas, proper disposal of pet waste, and the care and feeding of on-site sewer systems.

Problem Description: CK-21

Clarks Creek is also on the State 303(d) list for pH. Clarks Creek is overly acidic, a condition brought about by excess nutrients. Three major sources of nutrients have been postulated. (a) The first is the groundwater sources of base flow for Clarks Creek. (b) The second is the WDFW Puyallup Hatchery. (c) The third is the decay of aquatic vegetation.

(a) Perennial flow in Clarks Creek starts where groundwater from Maplewood Springs joins the creek. The spring is artesian and rises from an aquifer that is typically high in nitrate-nitrite nitrogen (2.03ug/L NO_{2+3}-N measured at Maplewood Springs from 1988-1993, (KCM, 1996)). Another large spring rises between the dam for the hatchery pond and the confluence of the WDFW hatchery outfall to Clarks Creek. At times, when the hatchery has essentially dewatered the spring, there is still a 10-20 cubic feet per second flow at the outfall (Michael, personal communication, 2003). No sampling has occurred to determine the source or composition of this water, but it is presumed to be another spring.

(b) The WDFW Puyallup Hatchery operates under a NPDES hatchery permit issued by the Washington State Department of Ecology. It has been identified as a source of nutrients to Clarks Creek (KCM 1993, 1996). It is located just below Maplewood Springs in the City of Puyallup. The hatchery site includes a constructed intake pond to provide the hatchery with water. The intake pond has acted as a sedimentation pond for flows coming from the upper drainage area (South Hill), with the consequence that it is full of sediment. Department of Fish and Wildlife representatives stated that the pond has only been cleaned out one time in recent years and that the permitting issues related to cleaning it out again or on a regular basis are prohibitive. This is potentially an area where the County could help by referring this site to the

Washington Department of Ecology, which is responsible for ensuring compliance with the hatchery NPDES permit.

Wastes from the rearing process are transported to settling ponds on the lower hatchery site, where the solids are quiescently settled out, and the water discharged back to the creek. These ponds were previously used as rearing ponds, and some incidental trout do get vacuumed out of the rearing area and make it to the settling ponds. Fish and Wildlife staff indicates that creating artificial wetlands in this area of the hatchery would probably be very beneficial in removing nutrients and polishing the water that is then released back into the creek. A current paper (Michael, 2003) details the success of a constructed wetland at the Issaquah Hatchery.

Medications such as antibiotics, formalin, and potassium permanganate are used in hatchery operations. Because source water for the Puyallup hatchery originates at a spring with no anadromous fish, this facility probably uses less of these compounds than hatcheries that take rearing water from a stream. Most of the compounds could be attenuated by wetlands before reaching the creek.

(c) The sediments passing through and nutrients from the fish hatchery coupled with long open reaches of the creek that are missing riparian vegetation ads to the growth of invasive aquatic vegetation. The decay of vegetation depletes the creek of dissolved oxygen and changes its pH.

7.6.5 Potholes Drainage Areas

Problem Description:

No water quality data exists for the Potholes drainage area. Water quality data will be instrumental in securing the necessary permits to construct the recommended pipeline from Hemlock Pond to the Puyallup River in the Mid-Puyallup Basin.

Recommendation: Include Hemlock Pond in the water quality-monitoring program.

CHAPTER EIGHT
Stream Habitat and Riparian Areas Analysis

This chapter documents the habitat analysis and summarizes potential solutions to improve and restore habitat conditions in the future.

The aquatic habitat analysis performed for the Clear/Clarks Creek Basin was primarily qualitative. Qualitative factors considered in the analysis included barriers to fish passage, increased peak stream flow rates and availability of perennial streamflows in the basin, streambank erosion and instability, and other conditions that adversely affect aquatic habitat conditions.

The aquatic habitat analysis of the Clear/Clarks Creek Basin included an assessment of stream reaches using the "Urban Stream Baseline Evaluation Method" (USBEM) (R2 Resource Consultants, 1999). The USBEM contains a rating table for characterizing habitat into "good," "fair," and "poor" categories. These categories are used in the project prioritization process presented in Chapter Nine.

Chapter 4 documented the extent of degraded riparian and aquatic habitat in the Clear/Clarks Creek Basin. *Appendix "E"* documents the habitat field investigation conducted for this study. There are a number of interrelated causes for loss of salmonid habitat.

8.1 Summary of Aquatic Habitat Field Investigation

The USBEM in the Tri-County Urban Issues Study was used to classify salmon habitat quality in the Clear/Clarks Creek Basin. The analysis was a two-phase process consisting of a pre-classification screening phase and a field observation phase.

"Phase I" prescreening was performed as part of basin characterization as documented in Chapter Four. "Phase II," field observation, provided a quantitative assessment of habitat characteristics including riparian condition, substrate composition, embeddedness (presence of fine sediments), bank condition, passage barriers, pool frequency, channel pattern and bedform, and large woody debris (LWD).

In addition to field habitat assessment, local residents were interviewed for information on fish use, habitat alteration, land use, water flow fluctuation, and any other factor that might influence habitat condition. Selection of the appropriate recovery options for the species of concern used the results from the USBEM analysis. *Table 8-1* summarizes the USBEM habitat evaluation for each planning unit (subbasin) in the Clear/Clarks Creek Basin. *Appendix "E"* documents the USBEM analysis.

TABLE 8-1
USBEM Phase II Habitat Condition Assessment

Subbasin	Study Reach[a]	Subbasin	Location	USBEM Rating
Swan Creek	A	SW-1	Confluence with Clear Creek to BNSF Railroad	Poor
Swan Creek	B	SW-1	BNSF Railroad to Pioneer Way	Fair
Swan Creek	C	SW-1	Pioneer Way to 41st Street E	Fair
Swan Creek	D	SW-2	41st Street E to 48th Street E	Fair
Swan Creek	E	SW-2	48th Street E to 1500' upstream of 48th Street E	Good
Swan Creek	F	SW-2	Approx. 1500' upstream of 48th Street E to 64th Street E	Poor
Squally Creek	A	SQ-1	Pioneer Way to 48th Street E	Poor
Clear Creek	A	CL-1	River Road to 100' upstream of confluence with Swan Creek	Poor
Clear Creek	B	CL-2	Gay Road to 300' downstream of BNSF Railroad	Poor
Clear Creek	C	CL-2	300' downstream of BNSF Railroad	Poor
Clear Creek	D	CL-2	BNSF Railroad to Pioneer Way	Fair
Clear Creek	E1	CL-4	1800' upstream of Pioneer Way to 49th Street E	Poor
Clear Creek	E2	CL-4	49th Street E to 60th Street E	Poor
Clear Creek	F	CL-5 CL-6	60th Street E to 765' upstream of 72nd Street E	Poor
Canyon Creek	A	CY-1	Confluence with Clear Creek to 44th Street E	Poor
Canyon Creek	B	CY-1	44th Street E to 52nd Street E	Poor
Canyon Creek	C	CY-1	600' reach downstream of Pioneer Road	Poor
Canyon Creek	D1	CY-2	Pioneer Road to first Canyon Road crossing	Poor
Canyon Creek	D2	CY-2	1000' Reach upstream of first Canyon Road crossing	Poor
Canyon Creek	D3	CY-2	650' reach downstream of second Canyon Road crossing	Poor
Canyon Creek	E	CY-2	500' reach upstream of second Canyon Road crossing	Poor
Canyon Creek	F	CY-2	1400' reach downstream of 72nd Street E	Poor
Canyon Creek	G	CY-3	72nd Street E to 80th Street E	Poor
Rody Creek	A	RY-1	Stewart Road to Pioneer Road	Poor
Diru Creek	A	DU-1	72nd Street E to 78th Street extended	Fair
Woodland Creek	A	WO-1	Pioneer Way to 80th Street E	Fair
Woodland Creek	B	WO-2	150' reach upstream of 80th Street E	Poor

TABLE 8-1
USBEM Phase II Habitat Condition Assessment

Subbasin	Study Reach[a]	Subbasin	Location	USBEM Rating
Woodland Creek	C	WO-2	900' reach downstream of 84th Street E	Poor
Woodland Creek	D2	WO-2	1500' reach upstream of 84th Street E	Poor
Clarks Creek	A	CK-2	W end Tacoma Road to 7th Avenue E	Poor
Clarks Creek	B	CK-3	7th Avenue E to 15th Avenue E	Fair
Clarks Creek	C	CK-3	150' upstream of 15th Avenue E	Fair

[a] See Figure F-1 in Appendix "E"

8.2 Limiting Factors

Limiting factors to fish production were characterized from the results of the USBEM "Phase II" analysis. *Table 8-2* shows the limiting factors in relative order of importance for each of the creeks in the Clear/Clarks Creek Basin. The table shows that low base flow, channel size, and erosion are the most important limiting factors in all streams but Clarks Creek. This table also shows that the benthic invertebrate community and water temperature are generally the least important limiting factors. Section 8.3 presents a comprehensive discussion of the limiting factors is in the Basin.

TABLE 8-2
Limiting Factors[a] in the Clear/Clarks Creek Basin

Stream	Limiting Factors Most Limiting									Least Limiting	
Swan Creek	Erosion	LWD	Low Flow	Pool Frequency	Bank Condition	Channel Size	Substrate Composition	Benthic Inv. Comm.	Water Temp.	Passage Barriers	Riparian Condition
Squally Creek	Low Flow	Channel Size	Erosion	Substrate Composition	Pool Frequency	LWD	Bank Condition	Riparian Condition	Passage Barriers	Benthic Inv. Comm.	Water Temp.
Clear Creek[b]	Erosion	Passage Barriers	Low Flow	LWD	Substrate Composition	Pool Frequency	Bank Condition	Channel Size	Riparian Condition	Water Temp.	
Canyon Creek	Low Flow	Channel Size	Erosion	LWD	Pool Frequency	Substrate Composition	Bank Condition	Benthic Inv. Comm.	Passage Barriers	Riparian Condition	Water Temp.
Rody Creek	Low Flow	Channel Size	Erosion	Pool Frequency	LWD	Substrate Composition	Bank Condition	Benthic Inv. Comm.	Riparian Condition	Passage Barriers	Water Temp.
Diru Creek	Low Flow	Channel Size	Erosion	Bank Condition	Pool Frequency	LWD	Substrate Composition	Benthic Inv. Comm.	Riparian Condition	Passage Barriers	Water Temp.
Woodland Creek[a]	Low Flow	Channel Size	Erosion	Bank Condition	LWD	Substrate Composition	Pool Frequency	Riparian Condition	Passage Barriers	Water Temp.	
Clarks Creek	Pool Frequency	LWD	Bank Condition	Riparian Condition	Substrate Composition	Benthic Inv. Comm.	Passage Barriers	Water Temp.	Channel Size	Low Flow	Erosion

[a] Limiting factors from USBEM analysis, see Appendix "E"

[b] Only 10 limiting factors assessed. B-IBI sampling not performed in this reach so the condition of the benthic invertebrate community is not known.

8.3 Existing Aquatic Habitat Problems

8.3.1 Fish Passage Barriers

Maintaining fish passage is particularly important for salmonids. During migration periods to and from the ocean, salmonids frequently encounter instream manmade blockages such as culverts and diversion weirs, or natural barriers, such as beaver dams or overly steepened channels (i.e., cascades). Culvert openings too high above the stream channel for fish to jump into, and culverts too long or positioned at a grade too steep for fish to ascend, can be barriers to fish migration. Fish passage barriers are present in all streams of the Clear/Clarks Creek Basin. All streams in the Basin have total blockages at street crossings at the upstream ends of their canyon reaches. Blockages are present at:

- 64th Street East for Swan Creek
- 58th Street East for Squally Creek
- 72nd Street East for Clear, Rody, and Diru Creeks
- 84th Street East for Woodland Creek
- 96th Street East for Clarks Creek
- Partial blockage at Pioneer Way East on Rody Creek.
- A dam just upstream of the WDFW hatchery on Clarks Creek at Maplewood Springs is a total barrier. The dam, which impounds water for use at the hatchery, is approximately ten feet high and does not have a fish ladder.
- A weir structure on Clear Creek just above Pioneer Way East, operated by Trout Lodge, forms a barrier to salmon migration. According to the WDFW area habitat biologist, the Trout Lodge hatchery has operated the weir under permit from the State since the 1930s.

Fish passage barriers were identified during the field investigation and from the Pierce Conservation District (PCD) database. Field observation and the hydrologic analysis showed that most of the creeks run dry during the summer months. For this reason, the fish passage analysis for culverts was limited to the lower canyon and floodplain areas where year-round base flow is present.

Culverts were assessed during the field investigation using the WDFW "Level A" Criteria (WDFW, 2000). *Tables 4-23, 5-1* and *5-2* list the locations of barriers to fish passage in the Clear/Clarks Creek Basin. Location of the barriers to fish passage identified during "Phase I" are shown on *Figures 5-1* and *5-2*.

A "Level B" analysis was performed using the culvert analysis model HY-8 on publicly owned culverts with barrier status of "unknown" but with known fish use. *Table 8-3* presents the results of the "Level B" analysis. The table reports that the culverts at Clear Creek and Pioneer Way East, Clear Creek and Gay Road East, and Rody Creek at Pioneer Way East are not barriers to fish passage. However, the velocity of Woodland Creek through a culvert on the Washington State University (WSU) Experimental Farm is a barrier.

TABLE 8-3
"Level B" Fish Passage Barrier Analysis

Problem ID[a]	Location	Design Discharge (cfs)	Culvert Length (feet)	Hydraulic Drop (feet)	Depth of Flow (feet)	Average Velocity (fps)	Barrier Status
CL-30	Clear Creek at Gay Road	24.5	45	0.08	3.25	1.9	No
CL-31	Clear Creek at Pioneer Way E	15.5	80	0.2	1.9	1.0	No
RY-20	Rody Creek at Pioneer Way E	4.5	113	0.7	1.4	3.9	No
WO-30	Woodland Creek - WSU Experimental Farm	13.1	1,115	3.2	1.4	5.5	Yes, Velocity

[a] See Figures 5-1 and 5-2
[b] Existing and future conditions design discharge are approximately equal
Source: CH2M HILL Habitat Analysis

Low flow conditions in the summer prevent passage of fish in all streams low in their watersheds. Swan Creek was dry at a point about halfway between 64th Street East and Pioneer Way East when surveyed in July 2001. Squally, Diru, Woodland, and Rody Creeks are very small streams and prevent adult salmon passage at low flow. When chinook salmon return to the Puyallup Tribal Hatchery in September and October, Diru Creek is too small for the fish to get up to the hatchery. Even if no dam existed on Clarks Creek at Maplewood Springs, the flow above Maplewood Springs is very low during the dry season.

8.3.2 Altered Stream Flows

Many of the habitat problems in the Clear/Clarks Creek Basin result from the altered hydrologic regime caused by the conversion of forested land to agricultural, residential and commercial uses. The relationship between urbanization in a watershed and the resulting impacts on stream flows is well documented.

Before development, rain falls on forested areas, is retained in the layer of forest duff, and is slowly released to the stream system. The natural retention ability of the forest reduces peak stream flows and provides a base flow during the dry summer months.

As development occurs, pervious areas are paved or hardened, and stormwater runs off into constructed drainage systems that quickly convey rainwater to a receiving stream or wetland. As a result, less rainwater is able to infiltrate and peak stream flows have increased significantly in the Clear/Clarks Creek system.

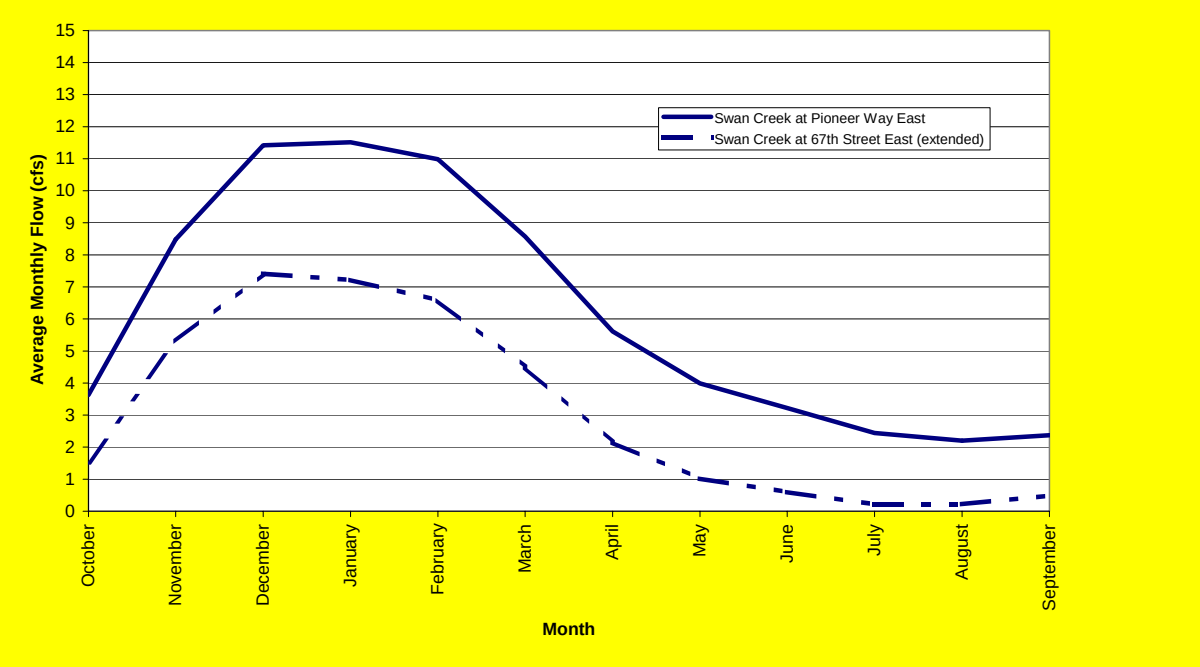
Low Summer Base Flow

During the summer months, intermittent low flow conditions exist in all streams low in the watersheds, as discussed above in terms of fish passage. In their mid-canyon reaches, Swan, Clear, Canyon, and Clarks Creek receive considerable groundwater and gain in flow as they proceed down into the Puyallup River Valley. Above these points, the streams are essentially dry during the late summer. Even if blocking culverts did not exist at 64th Street East, 72nd

Street East, 84th Street East, and 96th Street East, fish habitat would not be available due to an absence of perennial flow. Low flows in the canyons prevent the canyon reaches from providing high-quality spawning habitat. Due to the absence of historic flow data, it is not possible to quantify the effects of land development on base flow in the creeks.

The hydrologic analysis in Chapter Six predicted that nearly all the canyon reaches of the creeks dry up during the late spring and summer months. *Figure 8-1* illustrates the results from the analysis of Swan Creek. The figure shows the average monthly flow for a canyon and lowland reach in Swan Creek. The canyon reach is located above 67th Street East and the lowland reach is located at Pioneer Way East. *Figure 8-1* shows that perennial stream flow occurs in the lowland reach of Swan Creek year round. In comparison, stream flow occurs in the canyon reach only during the winter months and essentially disappears during the summer months. *Figures 5-1* and *5-2* in Chapter Five show the approximate location in each stream where perennial flow starts.

FIGURE 8-1
Average Monthly Flow at Swan Creek (from HSPF analysis)



Increased Peak Discharge Rates

Urbanization typically results in increase of peak stream flows, with the largest relative increase occurring for more frequent flow events. These increased peak flows tend to increase the depth and frequency of streambed scour (Booth, 1990). Land development removes trees, understory and groundcover plants, and top soil. It increases impervious surfaces. Consequently, peak stream flow rates increase, and erosive flows increase in their frequency and duration. The high velocity flows pick up and transport sediment to less steep stream reaches and pools where sediment settles, and buries sources of fish food.

Higher peak flows also negatively affect fish habitat by causing channel erosion and stream bank instability. Direct impacts to salmon can occur when bed scour depth during the egg incubation period exceeds the nest (redd) depth.

Field observation of bank instability provides evidence that peak flow rates are increasing in the subbasins. The banks of the Swan Creek channel downstream of 64th Street East have eroded to nearly vertical, 12-foot high walls. This erosion pattern is typical of a lower gradient stream where increased flow rates create lateral erosive forces that cut into channel walls and cause the channel to widen into a rectangular shaped channel section with steeply sloped channel walls.

The near-vertical walls indicate that the Swan Creek channel has not yet reached equilibrium (Booth, 1990). Vertical channel downcutting, or incision, usually occurs rapidly in response to increased peak flow rates in relatively higher gradient streams. In steep terrain, peak flows scour and incise stream channels, sometimes to the point of creating barriers to fish passage and creating landslides. The steep reach of Woodland Creek downstream of 84th Street East exhibits significant incision to accommodate increased peak flows resulting from urbanization.

8.3.3 Riparian Corridors

Riparian corridors play an important role in supporting aquatic habitat conditions in a stream system. Streamside vegetation contributes large woody debris for pool habitat and complexity, shades streams to maintain cool temperatures, stabilizes streambanks and reduces fine sediment, supports wildlife, provides food and food-generating leaf litter, and provides floodplain storage of stormwater.

Vegetated buffers also help reduce or eliminate impacts to streams from nearby land uses. The effectiveness of riparian buffers generally increases with buffer width and presence of streamside conifers. Generally, riparian corridors need to be as wide as the streamside trees are tall; maximum height of trees in the Basin is 150 feet, and resource agencies recommend 150-foot buffer width.

Riparian function in the upper areas of all the watersheds is severely impaired. When the upper watersheds were cleared for pasture, riparian vegetation did not reestablish in either large or contiguous corridors. Cattle and other livestock probably cropped the sapling trees, except in areas where livestock were excluded.

In addition, riparian vegetation was removed when ditch channels were dug for stormwater flow conveyance improvements to solve local flooding problems. The upper watersheds contain many ditch channels. Homeowners along the creeks have encroached on riparian buffers by clearing vegetation to the edge of the creek and planting lawns. The sparse, patchy, narrow, or absent riparian vegetation has a wide range of adverse effects on salmonid communities.

The loss of trees and other streamside vegetation affects the recruitment of large woody debris and the frequency of pools in streams. Large woody debris and pools in streams are important to salmonid habitat. The general lack of streamside tree cover and shade also limits terrestrial insect and leaf litter inputs to the food chain.

The canyon reaches of the tributaries generally have good riparian characteristics. The canyon reaches extend up to: 64th Street East for Swan Creek; 58th Street East for Squally Creek; 72nd Street East for Clear, Rody, and Diru Creeks; 84th Street East for Woodland Creek; and 96th Street East for Clarks Creek. Woodland Creek does not have much of a canyon reach or a

contiguous riparian area associated with it. Despite the generally good riparian buffer width in the canyon reaches of the streams, many of the desirable benefits of riparian growth are absent. Shade is generally good, but the trees are too young to contribute much LWD to the channels.

Channel down cutting is another factor diminishing the benefit of riparian function in the canyon reaches. Any large woody debris that falls into the creeks is swept downstream by high peak flows. Streambank erosion contributes to this problem by creating smooth-walled channels that are unable to hold trees in place.

Deciduous trees dominate the forest community in canyon reaches. In streamside areas, conifer trees typically provide a higher benefit to habitat than deciduous trees because conifers provide more durable, longer lasting wood when submerged in streams. Conifers are more resistant to rot compared to deciduous trees. Conifers LWD can last up to 50 to 80 years in wet conditions whereas deciduous LWD may last no more than 20 years. Some conifers, such as cedars, can last up to 100 years or more. Deciduous trees provide leaf litter, but it comes as one big dump in the fall. Conifers provide leaf litter year-round. Conifer trees also provide year-round shade, which is helpful in shading out undesirable or invasive understory vegetation, such as Himalayan blackberries, purple nightshade, and reed canary grass.

The floodplain reaches of all the streams have been adversely affected by practices that have removed the native riparian cover. This has allowed invasive species such as Himalayan blackberry, elodea, and reed canary grass to encroach on the streams. Nearly all of the creeks in this area have been channelized (straightened and rerouted from their original courses). Stream channelization limits the complexity of the riparian community and eliminates fish refuge areas by removing meander bends and disconnecting the stream from the floodplain.

8.3.4 Instream Habitat

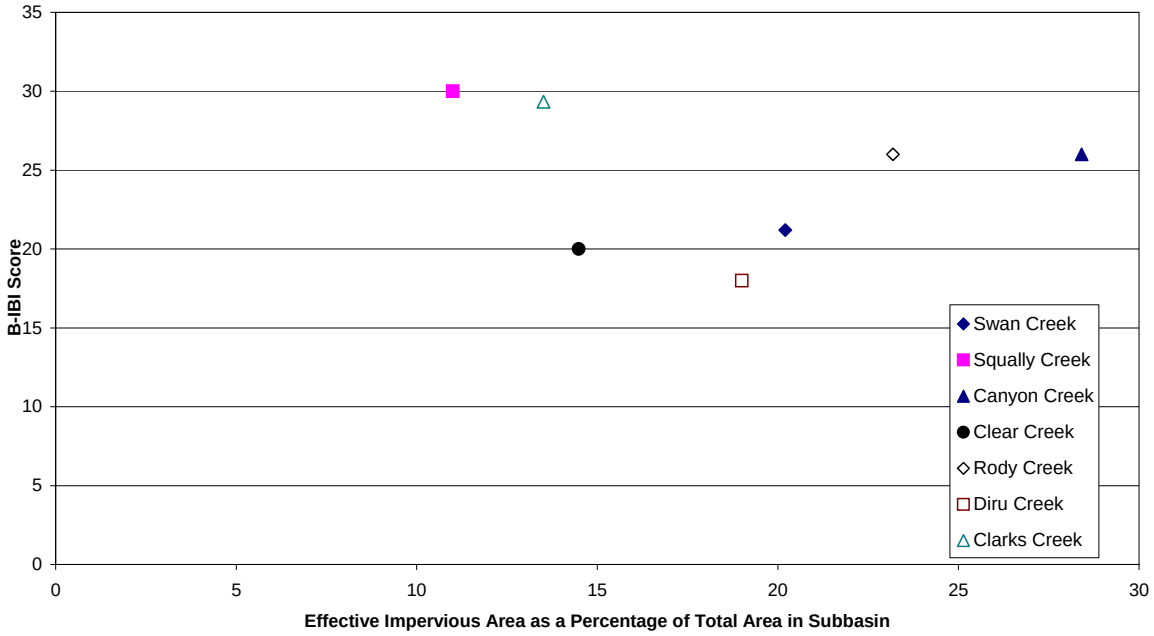
The diversity and abundance of aquatic insects that live in or near the stream bottom is a good indicator of the overall ability of the stream to support healthy salmon populations. Factors, such as water quality, sedimentation and bed load movement, affect the benthic[1] community and salmon production in a similar manner.

The Benthic Index of Biotic Integrity (B-IBI) was assessed for Swan, Squally, Clear, Canyon, Rody, Diru and Clarks Creeks. B-IBI is a measure of the degree to which the quality of stream habitat deviates from that expected at a relatively undisturbed site. It is based upon the numbers and diversity of species of benthic invertebrates obtained from samples taken from the stream substrate. Based on this assessment, the condition of the benthic community in the creeks was rated “Fair” for all but Swan Creek, which was rated “Poor”.

Increasing urbanization has been correlated to a rapid decline in stream biological health (May, 1997). Total impervious area as low as 10% of the total basin area has been linked to degradation of the instream habitat. *Figure 8-2* plots the B-IBI scores and the existing effective impervious area (EIA). The figure shows that streams in the Clear/Clarks Creek Basin generally follow expected relationships with the highest B-IBI scores occurring in the subbasins with the lowest EIA. Conversely, subbasins with the lowest scores contain the highest percentage EIA.

[1] Benthic means organisms living in or on bottom substrates in aquatic habitats

FIGURE 8-2
B-IBI Scores and EIA for Clear/Clarks Creek Streams
Source: Habitat investigation, see Section 4.4.2 and Appendix "E"



8.3.5 Stream Bank Erosion & Instability

Normal bank erosion processes are necessary for the maintenance of productive salmon habitat. Bank erosion introduces large woody debris for pool creation and sediment retention, and provides gravel used for spawning. However, erosion at high levels can be detrimental to a stream system by degrading fish habitat and water quality, increasing the frequency of overbank flooding, and inducing mass wasting (land slides). Fine sediments entering the stream negatively affect habitat by burying spawning gravels. Excessive scouring and downcutting can disturb salmon spawning nests and causes salmon eggs to wash out of spawning nests.

Habitat field evaluation identified unstable and eroding streambanks in the canyon and floodplain reaches of nearly all streams within the Basin. Erosion problems in canyon reaches are generally characterized by unstable banks cut by high peak streamflow rates. Channel widening and downcutting (as described in the previous section) were observed throughout the stream systems. Channel widening due to sedimentation is the main erosion problem in the floodplain reaches. High stream flows in the canyons transport eroded sediments downstream into the floodplain reaches, where sediments settle out in low-gradient backwater reaches. Typically, a depositional channel will widen in order to re-establish the conveyance capacity of the stream.

Stream bank and stream bed erosion is a serious problem in all watersheds in the Clear/Clarks Creek Basin. For example, Swan Creek has sections where the channel has downcut as much as 12-feet with vertical banks. There was one area of serious slumping located on Swan Creek about 1,500 feet below 64th Street East.

The tremendous hydraulic power of peak flows and the associated bedload movement of cobble and gravel are demonstrated by the condition of a recent bed stabilization project in the 0.5-mile-long reach below 64th Street East. A series of log "V" weirs were installed in the mid-1990s. When observed in 2001, about half of these weirs had washed away (they were sequentially numbered and marked) and the other half were not functioning. Most of the remaining weirs were almost completely buried with gravel on both the upstream and downstream side of the weir. This reach was dry in July 2001.

The significance of high peak flows and the associated erosion and bedload movement, is that pools cannot be maintained and spawning success can be greatly diminished. Salmonid eggs in spawning nests (redds) might be lost if the scour depth extends into the spawning depth. It is almost certain that this occurs, but the extent to which it happens is not known. LWD is washed downstream where it is piled up against road culverts and, thus, is not available to create and maintain pools.

Lack of pools is a serious limiting factor in all watersheds. Excessive sands and fine particles, which are part of the till soil being eroded upstream, fill in the void spaces between spawning gravels and limit water irrigation over developing eggs. The loss of water movement around salmonid eggs can lead to death of the developing embryos.

In Clear Creek, altered hydrology from impervious surfaces in the upper watershed has led to an erosion and bedload situation similar to that in Swan Creek, albeit less serious. In Clear Creek, the channel has down cut as much as 10-feet with vertical exposed banks below the 72nd Avenue East culvert. The most severe erosion observed in the Clear Creek Basin was below this culvert, with exposed banks continuous on both sides of the creek for 150-feet downstream of the culvert. A private homeowner, interviewed on 72nd Avenue East, described how his backyard fence has required rebuilding due to the slumping land below. Exposed banks and slides of shorter length were also observed between the 45th Street East cul-de-sac and Pioneer Way East on Clear Creek.

In Canyon, Rody, and Woodland Creeks, channel down cutting is common. The most severe down cutting occurs in Woodland Creek, above and below the 84th Street East crossing. Along Woodland Creek, the exposed soil layers appear to have a higher clay content, and have subsequently resisted sloughing and slumping. However, down cutting in Woodland Creek was observed at depths of as much as eight feet, often in places with a channel width of only two or three feet. In Canyon and Rody Creeks, down cut banks were present, but were not as severe as those in Woodland Creek. Exposed banks of up to three-feet were encountered only occasionally.

Serious erosion was not observed in Clarks Creek. This was because the short canyon reach in Clarks Creek within the City of Puyallup was not surveyed. Stream bed substrate in the reach of Clarks Creek adjacent to DeCoursey Park is composed almost entirely of sand and organic muck, which suggests that there is a significant sediment source somewhere upstream. According to a local resident, sediment deposition in Clarks Creek near Puyallup has raised the bottom of the channel three feet in the past 30 years.

8.3.6 Channel Morphology

As described in Chapter Four, channel morphology in all streams (except Clarks Creek) differs dramatically above and below Pioneer Way East. In Clarks Creek, the change occurs at Meeker Ditch. Downstream of Pioneer Way East (downstream of Meeker Ditch in the case of Clarks Creek), the stream channels have been straightened into ditch-like conveyance channels. The nearly flat topography, tidal backwatering, flooding from the Puyallup River, and manmade excavation are all influences that have shaped channel morphology in this area. Additionally, the Puyallup River levee system effectively disconnects the lowland, floodplain area of the Clear/Clarks Creek drainage from the Puyallup River.

The low-gradient channelized reaches serve as depositional areas due to low stream energy and high bed load and fine sediment inputs from upper reaches. The mouths of the channels additionally experience sediment deposition from the Puyallup River. Several channels appear to have been rerouted from their original course and have been reformed as channelized, uniform drainage ditches with little, or no habitat complexity.

The stream channels below Pioneer Way East are currently confined to the minimum channel width required for base flows, presumably to maximize agricultural acreage. Channel sizing of this type promotes flooding problems during high-flow events. Widening the channels would allow for sufficient containment during high-flows and could allow normal channel morphology to develop.

Above Pioneer Way East in all creeks except Clarks Creek and Woodland Creek, channel morphology is dramatically different. All the streams surveyed contained reaches with steep, confined, and erosional channels with long high-gradient riffles and very few pools. In Clarks and Woodland Creeks, these reaches did not begin for several hundred yards upstream of Pioneer Way East. For Swan, Squally, Clear, Canyon, Rody, and Diru Creeks the channel processes transition between floodplain and alluvial fan at Pioneer Way East. The low pool/riffle ratio found in the stream reaches above and below Pioneer Way is unfavorable for salmonids other than chum salmon. Chum salmon do not need pool habitat because juveniles move downstream to the estuary shortly after emergence from the nests.

8.4 Future Habitat Conditions

8.4.1 Fish Passage Barriers

Several factors will probably improve fish passage over time. Creation of new fish passage barriers is not likely due to the ESA listings of Puget Sound chinook salmon and bull trout (Dolly Varden).

A Hydraulic Project Approval (HPA) permit is required for projects with construction activity in, or near state waters (RCW 75.20.100-160) that affect the bed or flow of a stream. Fish passage and protection will be a condition of new HPA permits or permits issued by the Army Corp of Engineers. As existing culverts or other manmade barriers are repaired or replaced, removal of the barriers to fish passage will probably be required.

Three recommended CIP projects involve removing a barrier to fish passage: one on Canyon Creek; and two on Woodland Creek.

8.4.2 Stream Flows and Stream Bank Erosion

Hydrologic analysis predicted a significant increase in peak stream flow rates under future land use conditions in Swan and Woodland Creeks, with the largest increases occurring for the more frequent storm events. The analysis predicted that flow durations above the two-year peak flow rate (channel shaping flow) will increase in Swan and Woodland Creeks and in the upland reaches of Canyon Creek. Because streamflow rates in excess of the two-year peak flow rate most heavily influence channel shaping processes, higher peak flows of longer duration increase erosion rates and will further degrade habitat in these streams unless mitigation measures (such as stormwater detention) are constructed.

Current County stormwater standards require stormwater detention or infiltration for all new developments to mitigate peak flows. Current detention standards are effective in controlling peak flows from large storm events, but extend the flow duration for intermediate levels and provide little benefit for smaller storms (CH2M HILL, 2001). Data on stream flow are presented in Chapter Six.

The County is updating its stormwater regulations to be equivalent to recent flow control standards published in the updated Stormwater Management Manual for Western Washington (Ecology, 2001). The new Ecology standard requires peak flows from a building site to match those of forested conditions, with an optional flow duration standard. Adopting the new Ecology flow control standard in its entirety would minimize future flow impacts and help to prevent an increase in erosion.

A significant number of residential subdivisions in the Clear/Clarks Creek Basin were approved before adoption of the current stormwater regulations. Because previous stormwater control regulations were much less stringent than the current standards, peak flows will increase as these projects are built.

8.4.3 Riparian, Instream Habitat, and Channel Morphology

The condition of riparian areas will likely remain at current levels. As described earlier, much of the riparian function in the upper reaches and floodplain areas of the watershed is seriously impaired. Much of the intact riparian area in the canyon reaches will likely remain intact, due to either the inaccessibility of the ravines or because these reaches flow through public property.

The increase in stream bank erosion rates described in the previous section will probably result in continued impairment of instream habitat. Future development in the basin is forecast to further degrade instream habitat and degrade water quality. More significant levels of instream habitat degradation are expected in Swan Creek and Woodland Creek than in the other streams because of higher levels of future development in these basins.

8.5 Potential Solutions

Because the aquatic habitat problems have multiple causes, the solutions will have to involve a range of activities; from non-structural programmatic actions to structural solutions. The capital improvement program (CIP) projects developed to solve habitat problems are a mix of:

- Structural solutions
- Wetland and riparian habitat restoration
- Floodplain preservation through property acquisition

Structural solutions consist primarily of the replacement of culverts to remove fish passage barriers. Typically, these projects replace culverts with channel-spanning bridges or large embedded culverts. Structural solutions also include channel stabilization projects to prevent erosion and sediment transport. Detention and infiltration facilities are structural solutions that also play important roles in reducing peak flows.

The field habitat investigation and the PCD identified numerous culverts as actual or potential fish passage barriers above the canyon reaches of the creeks. No projects were developed for these culverts because the low-flow condition described in Section 8.3 would limit the usefulness of these structures. Should suitable low-flow mitigation measures be developed then these structures should be replaced.

Habitat restoration projects restore wetlands, stream habitat and/or riparian areas generally in floodplains. Many restoration projects also benefit water quality because they reduce erosion (turbidity) and provide shade (temperature).

CIP projects involving riparian or wetland revegetation/restoration will require substantial maintenance during the first two to five years after planting. Irrigation may be required for the first year or two to establish some of the tree and brush species. In addition, annual weed removal or suppression will be needed until plants are well established. This is particularly critical in areas where reed canary grass is being eliminated.

Programmatic solutions can benefit existing aquatic habitat and prevent future degradation. For instance, programs can identify and preserve high quality habitat areas, enhancement programs can prioritize and facilitate habitat restoration, and monitoring programs can track water quality, erosion and channel incision, and other measures of the health of natural systems.

8.5.1 Special Considerations in Solution Development

Channel Stabilization and Enhancement

The erosion sites listed in Chapter Five, *Tables 5-1* and *5-2* were evaluated using the streambank protection process described in the Integrated Streambank Protection Guidelines (ISPG) developed by the Washington Department of Fish and Wildlife (WDFW, 2003).

The ISPG methodology provides three screening matrices that help to select the appropriate stream bank protection technique. Screening is based on an assessment of site conditions (mechanism of failure), reach conditions (cause of failure), habitat considerations and a risk analysis.

The ISPG analysis was applied to each of the four failure mechanisms (cause pairings) described in *Appendix "E"* to identify appropriate streambank protection techniques. The analysis only considered protection measures rated "Fair" or "Good" and did not consider protection measures rated "Poor" or "Inappropriate." The results of this analysis are shown in *Appendix "E."*

The highest ranked streambank protection techniques should be considered first when selecting techniques for CIP projects. There may be cases where unique site conditions prevent the use of the highest ranked technique. In that case, CIP projects should consider using the next highest ranked technique.

Stormwater Retention/Detention

Many of the erosion problems described in the previous section are caused primarily by an increase in peak flow rates resulting from land development in the basin. Additional stormwater detention to control peak flow rates in the basin will help to prevent failure of stream bank protection techniques presented.

Previous stream bank stabilization efforts in Swan Creek have been only partially successful due to design and construction problems, and no corresponding means to control peak flow rates and duration. Peak flow reduction is also needed to reduce or eliminate stream bank erosion in the future.

Detention volume estimates in this Plan are based on the need to obtain 50% reduction of the 2-year peak flood (channel shaping flow) under future landuse conditions. The 50% reduction target is based on an assumption that peak flood events in a stream increase by a factor of two or more as a basin develops (Hollis, 1975). The type of stream bank stabilization measures downstream should be a factor when establishing the target release rate.

8.5.2 Problems Resolved or Not Addressed in the Basin Plan

Three culverts identified by the Pierce Conservation District as having unknown barrier status were found to meet fish passage design criteria for adult chum salmon. Nine habitat problems were located outside the authority of the Pierce County Public Works and Utilities.

Tables 8-5 and *8-6* list aquatic habitat problems not addressed by the recommendations forwarded to Chapter Nine. *Figures 5-1* and *5-2* in Chapter Five show the problem locations referred to in these tables.

TABLE 8-4
Resolved Aquatic Habitat Issues

Problem ID[a]	Problem Description	Problem Resolution
Clear Creek		
CL-30	Unknown fish passage barrier status at Pioneer Way E	Hydraulic analysis showed this culvert is not a barrier to fish passage.
CL-32	Unknown fish passage barrier status at Gay Road E	Hydraulic analysis showed this culvert is not a barrier to fish passage.
Rody Creek		
RY-20	Unknown fish passage barrier status at Pioneer Way E	Hydraulic analysis showed this culvert is not a barrier to fish passage.

[a] See Figures 5-1 and 5-2 for site locations.

TABLE 8-5
Aquatic Habitat Issues Referred to Other Parties

Problem ID[a]	Problem Description	Jurisdiction/ Responsible Party
Swan Creek		
SW-3	72nd Street E culvert is a barrier to fish passage	City of Tacoma
SW-31	Pipeline Road culvert is a barrier to fish passage.	City of Tacoma
Squally Creek		
SQ-7	Fish passage barrier at railroad culvert	BNSF RR
Clarks Creek		
CK-5	Poor habitat and water quality in Clarks Creek north of 15th Avenue SW.	City of Puyallup
CK-17	Meeker Ditch at 11th Street SW (City of Puyallup) culvert is a possible barrier to fish passage	City of Puyallup
CK-18	Roadside ditch tributary to Meeker Ditch - 11th Street SW (City of Puyallup) culvert is a barrier to fish passage	City of Puyallup
CK-19	Unnamed tributary to Meeker Ditch – 12th Avenue SW (City of Puyallup) culvert is a possible barrier to fish passage	City of Puyallup
CK-20	WDFW Fish Hatchery dam is a barrier to fish passage.	WDFW

[a] See Figure 5-1 and 5-2 for problem locations

8.5.3 Small Works Projects, Maintenance, and Enforcement Issues

One habitat-related drainage problem (RY-18) identified in the basin characterization qualifies as a small works project. Rather than including the project in the list of CIP projects, the Basin Plan refers the low cost aquatic habitat related project to the Facilities Maintenance section of Water Programs for implementation.

Rody Creek Weir

RY-18 is located on Rody Creek upstream of Pioneer Way East. An instream weir is installed across the channel that is a barrier to fish passage. The weir needs to be redesigned and constructed in a manner that removes the barrier.

8.5.4 Capital Improvement Program Projects

Thirty-four CIP projects were developed to help solve the aquatic habitat problems related to storm drainage. The projects are a mix of projects to stabilize stream banks, floodplain (aquatic habitat) restoration projects, and projects to improve fish passage. In addition, nine regional detention projects are recommended to reduce peak streamflow rates and corresponding erosion of stream banks. The detention projects extend the effective life of the stream bank protection measures. Regional detention projects also protect against flooding when located upstream of areas prone to flooding (see Chapters Five and Six).

Chapter Nine describes each of the projects listed in *Table 8-6* in detail. *Figures 9-1* through *9-3* identify CIP project locations.

TABLE 8-6
Aquatic Habitat CIP Projects

ID Number	Project Name	Solves Problem
Swan Creek Sub-Basin		
CIP03-SW-DP01	Swan Creek Regional Detention Project: 80 acre-feet of storage to reduce peak stormwater flows upstream of 72nd Street East	SW-22 SW-23 SW-25 SW-26
CIP03-SW-SBS01[a]	Stream Bank Stabilization at 72nd Street East Outfall	SW-3
CIP03-SW-SBS02	Stream Bank Stabilization from 72nd Street East to 64th Street East: roughened rock toes, porous weirs and drop structures direct energy away from stream banks	SW-22
CIP03-SW-SBS03[a]	64th Street East Culvert Outfall Repair Project: repair culvert headwall & install boulder clusters at the mouth of the culvert to dissipate energy	SW-23
CIP03-SW-SBS04	Stream Bank Stabilization Downstream of 64th Street East:	SW-24
Squally Creek Sub-Basin		
CIP03-SQ-VC01	Pioneer Way East Riparian Area Enhancement and Restoration: remove invasive vegetation and replant to provide shade	SQ-6
Clear Creek Sub-Basin		
CIP03-CL-RST01	Clear Creek Stream Restoration Project	CL-1 CL-17 CL–18 CL-24
CIP03-CL-SBS01	Stream bank Stabilization on West Fork Downstream of 72nd Street East	CL-19
CIP03-CL-SBS02	Stream bank Stabilization on East Fork Downstream of 72nd Street East	CL-20
CIP03-CL-SBS03	Stream bank Stabilization in vicinity of 49th Street East	CL-21
CIP03-CL-SBS04	Stream bank Stabilization on West Fork Downstream of 64th Street East	CL-22
CIP03-CL-SBS05	Stream bank Stabilization 5000 Block of Vickery Avenue East	CL-33
CIP03-CL-DP01	West Fork Clear Creek Regional Detention Project	CL-17 CL-19 CL–21 CL-22
CIP03-CL-DP02	East Fork Clear Creek Regional Detention Project	CL-17 CL-20 CL–21 CL-22

TABLE 8-6
Aquatic Habitat CIP Projects

ID Number	Project Name	Solves Problem
Canyon Creek Sub-Basin		
CIP03-CY-SBS01	Stream bank Stabilization on Reach Downstream of 80th Street East	CL-18
CIP03-CY-SBS02	Stream bank Stabilization on Reach Downstream of 72nd Street East	CY-22
CIP03-CY-SBS03	Stream bank Stabilization on Reach Upstream of Second Canyon Road Crossing	CY-20
CIP03-CY-SBC04	Stream bank Stabilization Downstream of Second Canyon Road Crossing	CY-21
CIP03-CY-RST01	Canyon Creek Stream Restoration Project	CY-23 CY-25 CY–26
CIP03-CY-FP01	Private Driveway Culvert Replacement Project	CY-28
CIP03-CY-DP01	Canyon Creek Regional Detention	CY-18 CY-20 CY–22 CY-23
Rody Creek Sub-Basin		
CIP03-RY-SBS01	Stream bank Stabilization Project at 72nd Street East	RY-14
CIP03-RY-SBS02[a]	Stream bank Stabilization Project at 80th Street East	RY-3
CIP03-RY-RST01	Rody Creek Stream Restoration Project	RY-16
CIP03-RY-DP01	Rody Creek Regional Detention Facility Expansion	RY-14
Diru Creek Sub-Basin		
CIP03-DU-RST01	Diru Creek Stream Restoration Project Downstream of Pioneer Way East	DU-10 DU–13 DU-14
CIP03-DU-SBS01	Stream bank stabilization at 72nd St East	DU-11
CIP03-DU-DP01	Diru Creek Regional Detention	DU-11
Woodland Creek Sub-Basin		
CIP03-WO-RST01	Woodland Creek Stream Restoration Project	WO-27
CIP03-WO-CR02[a]	80th Street East Culvert Replacement Project	WO-8
CIP03-WO-SBS01	84th Street East High Flow Bypass Pipeline Project	WO-24 WO–25 WO-26
CIP03-WO-SBS02	Stream bank Stabilization at 80th Street East	WO-27

TABLE 8-6
Aquatic Habitat CIP Projects

ID Number	Project Name	Solves Problem
Clarks Creek Sub-Basin		
CIP03-CK-RST01	Clarks Creek Stream Restoration Project	CK-1 CK-13 CK–14 CK-16
CIP03-CK-SP01	State Hatchery Sedimentation Basin Retrofit Project	CK-14
Potholes Sub-Basin		
No aquatic habitat projects at this time		
Roosevelt Ditch Sub-Basin		
No aquatic habitat projects at this time		

a Also listed as an Flooding and Drainage CIP project (See Table 6-12)

8.5.5 Problems Requiring More Detailed Data or Analysis

One study is recommended to fill information gaps as described below:

ST03-02 Identify Significant Sediment Sources in the Basin

Perform a comprehensive survey of basin creeks to identify additional locations of eroding stream banks and other significant sources of fine sediment. The stream survey performed to support the habitat analysis did not cover every reach in the stream system; therefore, it is unlikely that all significant sources of fine sediment were identified during the development of this plan. The study should provide an estimate of the amount of sediment, identify alternatives to solve the problems and recommend control measures.

CHAPTER NINE
Basin Plan

Chapter Nine contains the Clear/Clarks Creek Basin Plan (Basin Plan). The chapter contains a set of recommended capital improvement projects[1] (CIP), programmatic measures[2], and studies that if implemented, will address the storm drainage and surface water management related problems identified in previous chapters.

The Basin Plan establishes the direction that the Water Programs Division will take within the Clear/Clarks Creek Basin over the next five to ten years. All of the recommendations are feasible solutions to achieve the goals of basin plans; i.e., reduce flood and storm drainage hazards, improve water quality, improve aquatic habitat potentially affected by surface water management methods, ensure coordinated and responsible use of public resources, and guide new development.

Chapter Nine is organized as follows:

9.1 Summary of Plan recommendations.

9.2 Plan Approach to Basin needs; a description of key assumptions and thinking behind the recommendations.

9.3 Specific Basin Plan Recommendations; descriptions of individual capital improvement projects, programmatic measures, and studies to close data gaps.

9.4 Plan Implementation Strategy and Considerations.

9.5 Problems and Solutions

9.1 Summary of Plan Recommendations

The Clear/Clarks Creek Basin Plan contains 65 capital improvement projects, 12 programmatic measures, and four studies to remedy flooding, erosion, water quality, and stream habitat problems resulting from surface water runoff in the Basin.

Capital improvement projects and programmatic measures have been divided into "High-Priority," "Medium-Priority," and "Low-Priority"[3] groups. Priorities were not established for studies. Estimated costs of recommendations by priority group are as follows:

"High-Priority" Recommendations:	**$33,152,000**
"Medium-Priority" Recommendations:	**$27,612,000**
"Low-Priority" Recommendations:	**$4,607,000**

[1] A capital improvement project has a cost of $25,000 or more and improves the physical plant of the drainage system, the performance of the system, and/or reduces site-specific or cumulative adverse stormwater impacts.

[2] Programmatic measures are nonstructural solutions, such as changing particular Pierce County procedures, providing technical assistance, enforcing regulations, and offering public information.

[3] "Low-Priority" does not mean "not a priority." "No Priority" actions have already been excluded from this Basin Plan. Rather, "Low-Priority" means the project rated lower than other needs in the Basin. Examples of these include projects with only a single-benefit; the rating system is weighted toward multiple benefits.

In addition, further studies to fill information gaps totaling $224,000 have been identified, but not prioritized.

Table 9.1 presents the estimated cost of the Clear/Clarks Creek Basin Plan recommendations by project type and priority group.

Table 9.1 Estimated Costs of Plan Recommendations

Project Type	*High Priority*	*Medium-Priority*	*Low-Priority*
Capital Improvement Projects	$30,474,000	$27,591,000	$4,585,000
Programmatic Measures	$2,716,000	$21,000	$22,000
Studies	$224,000		
Total Estimated Cost	**$65,595,000**		

Most of the actions provide multiple benefits; for example, a stormwater infiltration pond reduces downstream flooding; reduces erosion, and thus protects water quality; and helps protect base flow by groundwater recharge.

Priority Ranking. The recommended CIPs and programmatic measures have been sorted into high-priority, medium-priority, and low-priority groups based on scores from prioritization worksheets common to all of the basin plans. Worksheets document the project's or program's potential for various aspects of flood reduction, improvement of water quality, aquatic habitat protection, and other benefits using approximately 40 criteria. The top 25% of the projects are designated high-priority, 50% become medium-priority, and the remaining 25% are assigned low-priority. The order within each priority group reflects project cost, from least costly to most costly.

Appendix "H" documents the ranking system and its application to each recommended project. It contains a spreadsheet summarizing the scores assigned to each CIP and individual scoring worksheets for each CIP and programmatic measure.

Table 9.2 contains the list of High-Priority projects, rating scores, and estimated costs. *Table 9.3* presents the Medium-Priority projects. *Table 9.4* shows the Low-Priority projects. Shaded rows indicate programmatic measures.

Table 9.2 High-Priority Recommended Projects

ID Code	Project Title	Rating Score	Estimated Cost
PRG00-02	Update Stormwater Management Standards (Manual)	380	$6,200 *
PRG00-01	Low-Impact Development	346	27,600 *
PRG00-11	Enhanced Cooperative Arrangements with Cities & Other Jurisdictions	315	38,000*
PRG00-08	Establish a BMP Manual for Surface Water Maintenance Activities	427	43,600 *
PRG00-09	Invasive Species Management Program	420	43,600 *
PRG00-04	Land Management Program for Flood Hazard Reduction & Storm Drainage Practices Impact Mitigation	389	56,000 *
PRG00-06	Create an Education, Outreach, & Technical Assistance Program	325	212,000 *
PH-IP01	128th Street East Infiltration Pond	346	469,000
PRG00-05	Riparian & Wetland Restoration Program to Restore Flood Storage and Maintain Water Quality	325	692,000 *
PRG00-07	Surface Water Monitoring Program Basin Specific	244	985,000 * 422,000
CL-RST01	Clear Creek Stream Corridor Restoration	261	Segment 1: 402,000 Segment 2: 402,000 Segment 3: 402,000 TOTAL: 1,207,000
RY-RST01	Rody Creek Stream Corridor Restoration	303	Segment 1: 410,000 Segment 2: 410,000 Segment 3: 410,000 TOTAL: 1,231,000
PRG00-03	Increase Enforcement Inspections	398	1,272,000 *
PH-PL04	144th and 94th Avenue Pipeline	252	1,282,000
SW-AC01	Swan Creek at 112th Street Floodplain Storage/Headwaters Preservation	302	Segment 1: 343,000 Segment 2: 442,000 Segment 3: 442,000 TOTAL: 1,306,000
WO-RST01	Woodland Creek Stream Corridor Restoration	265	Segment 1: 490,000 Segment 2: 490,000 Segment 3: 490,000 TOTAL: 1,470,000

Table 9.2 High-Priority Recommended Projects - *continued*			
ID Code	**Project Title**	**Rating Score**	**Estimated Cost**
CY-RST01	Canyon Creek Stream Corridor Restoration	238	Segment 1: 472,000 Segment 2: 472,000 Segment 3: 472,000 Segment 4: 472,000 Segment 5: 472,000 Segment 6: 472,000 TOTAL: 2,834,000
CK-RST01	Clarks Creek Stream Corridor Restoration	231	Segment 1: 470,000 Segment 2: 470,000 Segment 3: 470,000 Segment 4: 470,000 Segment 5: 470,000 Segment 6: 470,000 Segment 7: 470,000 TOTAL: 3,287,000
RD-DP01	Portland Avenue Regional Detention Facility, Roosevelt Ditch Area	276	3,884,000
CL-AC01	Clear Creek Floodplain Repetitive Loss Land Acquisition	345	6,455,000
SW-DP01	Swan Creek Regional Detention Facility	259	6,455,000
	Total Estimated Cost		**$33,152,200**

***** indicates the Clear/Clarks Creek Basin share (21.2%) of the estimated cost of a program of County-wide applicability

Table 9.3 Medium-Priority Recommended Projects

ID Code	Project Title	Rating Score	Estimated Cost
PRG00-12	Stormwater Facility Design Process	206	21,200 *
SW-SBS03	Swan Creek 64th Street East Culvert Outfall Repair .	152	24,000
RD-SWL01	20th Avenue East Drainage Swale, Roosevelt Ditch	214	29,000
CL-SBS03	Clear Creek Streambank Stabilization in vicinity of 49th Street	194	35,000
CL-SBS04	Clear Creek Streambank Stabilization on West Fork Clear Creek Downstream of 64th Street E	194	35,000
DU-SBS01	Diru Creek Streambank Stabilization at 72nd St East	164	35,000
RY-SBS01	Rody Creek Streambank Stabilization at 72nd Street East	155	35,000
CL-CR01	Clear Creek 88th Street E Culvert Replacement	161	53,000
CL-VC01	Clear Creek at 104th Street E Vegetation Control	203	54,000
RY-SBS02	Rody Creek Streambank Stabilization at 80th Street East	160	66,000
CK-SP01	Clarks Creek State Hatchery Sedimentation Basin Retrofit	174	73,000
CL-SBS05	Clear Creek Streambank Stabilization 5000 block of Vickery Avenue East	153	92,000
SW-SBS01	Swan Creek Streambank/Channel Stabilization at 72nd Street E Outfall	157	100,000
SQ-VC01	Squally Creek at Pioneer Way E Vegetation Control	165	150,000
CL-SBS02	Clear Creek Streambank Stabilization on East Fork Downstream of 72nd Street E	194	161,000
CY-SBS03	Canyon Creek Streambank Stabilization on Reach Upstream of Second Canyon Road Crossing	163	161,000
CY-SBS01	Canyon Creek Streambank Stabilization on Reach Downstream of 80th Street East	158	161,000
CY-SBS02	Canyon Creek Streambank Stabilization on Reach Downstream of 72nd Street East	153	161,000
CK-PL01	112th Street East Drainage Improvement (Woodland Elementary School)	133	180,000
CL-SBS01	Clear Creek Streambank Stabilization on West Fork Downstream of 72nd Street E	194	187,000
CK-AC01	Clarks Creek Property Acquisition at 104th Street East	168	188,000
SW-SBS02	Swan Creek Streambank/Channel Stabilization from 72nd Street E to 64th St E	203	283,000
WO-SBS01	Woodland Creek Streambank/Channel Stabilization at 84th Street East	150	305,000

Table 9.3 Medium-Priority Recommended Projects

ID Code	Project Title	Rating Score	Estimated Cost
CY-SBS04	Canyon Creek Streambank Stabilization Downstream of Second Canyon Road Crossing	163	322,000
WO-SBS02	Woodland Creek Streambank Stabilization at 80th Street E	142	357,000
PH-PL05	Springfield Pothole Pipeline	124	379,000
CK-PL02	Fruitland Avenue Drainage Improvement - 104th Street E to 96th Street E, Clarks Creek	164	399,000
PH-PL03	136th Street Pipeline, 135th Street Pothole	190	509,000
CY-SL01	Canyon Creek 58th Avenue East Setback Levee	165	552,000
SW-SBS04	Swan Creek Streambank Stabilization Downstream of 64th Street East	222	Segment 1: 380,000 Segment 2: 380,000 Segment 3: 380,000 TOTAL: 1,140,000
DU-RST01	Diru Creek Stream Corridor Restoration Downstream of Pioneer Way East	226	Segment 1: 410,000 Segment 2: 410,000 Segment 3: 410,000 TOTAL: 1,231,000
RY-DP01	Rody Creek Regional Detention Facility Expansion	123	1,313,000
CY-DP02	Canyon Creek 90th Street East Detention (D138-003)	184	1,586,000
PH-PL06	South Hill Pump Station Pipeline to Puyallup River	181	2,466,000
WO-DP01	Woodland Avenue Flood Control Phase II CIP	155	2,960,000
CL-DP01	West Fork Clear Creek Regional Detention	163	3,021,000
CY-DP01	Canyon Creek Regional Detention	174	3,930,000
CL-DP02	East Fork Clear Creek Regional Detention	163	4,858,000
	Total Estimated Cost		**$27,612,200**

* indicates the Clear/Clarks Creek Basin share (21.2%) of the estimated cost of a program of County-wide applicability

Table 9.4 Low-Priority Recommended Projects

ID Code	Project Title	Rating Score	Estimated Cost
RY-SWL01	62nd Avenue East Drainage Swale, Rody Creek	32	17,000
RY-CR01	Rody Creek at Pipeline Road & 96th Street East Culvert Replacement	65	19,000
PRG00-10	Flood Disclosure Statements on Property Titles	128	22,400 *
WO-CR02	Woodland Creek at 80th Street East Culvert Replacement	88	27,000
RY-CR02	Rody Creek at 98th Street East Culvert Replacement	89	31,000
PH-PL01	92nd Ave East Storm Drainage Pipeline, Black Swamp Pothole	115	34,000
SW-PL01	84th Street East Pipeline Storm Drain Replacement, Swan Creek	99	74,000
RY-RD01	90th Street East at Rody Creek Raise Roadway	84	75,000
CY-FP01	Canyon Creek Driveway Culvert Replacement	108	89,000
WO-CR01	Woodland Creek & 72nd Avenue East Culvert Replacement - 93rd Street East to 96th Street East	105	102,000
SW-CR01	Swan Creek 80th Street E Culvert Replacement	82	110,000
CY-RD02	104th Street East Road Raising & Culvert Replacement - East Fork of Canyon Creek	99	113,000
CY-RD01	116th Street East Road Raising - West Fork of Canyon Creek	97	137,000
CY-AC01	Canyon Creek Property Acquisition at 5600 block of 104th Street E	73	204,000
PH-PL02	156th Street East Regional Pipeline	120	288,000
RY-DIV01	85th Street East Diversion, Rody Creek	120	288,000
DU-DP01	Diru Creek Regional Detention	105	2,977,000
	Total Estimated Cost		**$4,607,400**

* indicates the Clear/Clarks Creek Basin share of the estimated cost of a program of County-wide applicability

9.1.1 Capital Improvement Projects

The Clear/Clarks Creek Basin Plan proposes an array of capital improvement projects distributed by type of problem addressed as follows:

- Road and Property Flooding - 29
- Erosion Control & Streambank Stabilization - 18
- Other Drainage Problems - 5
- Water Quality (including applicable erosion control projects, aquatic habitat restoration projects, and other types of projects with significant water quality benefits) - 42
- Aquatic Habitat Restoration - 4.6 miles

TABLE 9-5. Summary of CIP Projects for Clear/Clarks Creek Basin

Subbasin	Acquisition	Streambank/Channel Stabilization	Culvert Replacement/ Repair	Detention Pond	Diversion	Infiltration Pond	Fish Passage	Raise Roadway	Pipeline	Setback Levee	Sedimentation Pond	Stream Corridor Restoration	Swale	Vegetation Control	Total Number of Projects	Est. Cost
Swan Creek	1	3	2	1					1						8	$ 10,086,000
Squally Creek														1	1	$ 150,000
Clear Creek	1	5	1	2								1		1	11	$ 16,158,000
Canyon Creek	1	4		2			1	2		1		1			12	$ 10,250,000
Rody Creek		2	2	1				1				1	1		8	$ 2,787,000
Diru Creek		1		1								1			3	$ 4,243,000
Woodland Crk		2	2	1								1			6	$ 5,221,000
Clarks Creek	1								2		1	1			5	$ 4,127,000
Potholes						1			6						7	$ 5,427,000
Roosevelt Ditch				1	1			1					1		4	$ 4,276,000
Basin Total	**4**	**17**	**7**	**9**	**1**	**1**	**1**	**4**	**9**	**1**	**1**	**6**	**2**	**2**	**65**	**$ 65,595,000**

Recommended CIP projects usually fall into several categories. This reflects the interrelationship of environmental factors. For example, habitat problems tend to be a secondary effect of surface water and storm drainage and water quality problems. Culverts that are a barrier to fish passage are frequently too narrow in diameter to convey the surface water volumes generated during storms, so they create backwater flooding or culverts are perched far enough above the stream channel to scour holes and destabilize adjacent areas.

Figures 9-1, *9-2*, and *9-3* show the generalized locations of recommended projects. Basin plans present general locations of projects to promote a focus on project concepts and the bigger picture and agreement at this stage before investing considerable funds in detailed analyses of project sites and design details.

CIPs involving riparian or wetland revegetation or restoration will require substantial maintenance during the first two to five years after planting. Irrigation may be required for the first year or two to establish some of the tree and brush species. In addition, annual weed removal or suppression will be needed until the plants are well established. This is particularly critical where reed canary grass and Himalayan blackberry currently predominate. As soon as trees are large enough to create shade and eliminate the conditions that these invasive plants thrive on, weed suppression is generally not necessary.

Section 9.3, Specific Recommendations, contains descriptions of each of capital projects, estimated cost, and how well each capital project measures against the basin plan objectives and key Pierce County Comprehensive Plan policies.

9.1.2 Programmatic Measures

The Basin Plan recommends twelve programmatic (non-structural) measures. The term "programmatic" relates to a plan of action or procedure for addressing a drainage need or problem. Programmatic measures include such actions as regulations, policy guidelines, site design standards, operational policies, technical assistance, enforcement, public outreach, and educational programs. Some of the programmatic recommendations are specific to the Clear/Clarks Creek Basin. Other programmatic activities would be undertaken with countywide applicability in mind with the Basin paying its share of program costs. The Clear/Clarks Creek Basin contributes 21.2% of the revenue from storm drainage and surface water management fees.

The number of programmatic measures and the high-priority reflects a policy in the Pierce County Comprehensive Plan that advocates use of nonstructural solutions to storm drainage problems before committing to hard-engineered solutions. Pierce County Code 19A.30.220.B.2 states, "Nonstructural measures should be preferred over structural measures."

Recommended programmatic measures are as follows:

High-Priority Programmatic Measures

- Update the Pierce County Stormwater Management and Site Development Manual
- Develop and implement a "Best Management Practices" (BMP) Manual for Pierce County Water Programs Facilities Maintenance Activities
- Develop and implement an "Invasive Species Management Program"

- Develop and implement a "Land Management Program" for Multiple Use, including.
- Develop and implement a "Low Impact Development Program"
- Develop and implement an "Education, Outreach, and Technical Assistance Program"
- Develop and implement a "Restore Degraded Aquatic Habitat and Protect Water Quality and Attenuate Flood Hazards Program"
- Develop and implement a "Surface Water Monitoring Program"
- Increase inspections for compliance with storm drainage and surface water management regulations
- Enhance cooperative arrangements with cities and other jurisdictions

Medium-Priority Programmatic Measures

- Develop and implement a stormwater facility design process

Low-Priority Programmatic Measures

- Require flood disclosure statements on property titles

The estimated cost for the Clear/Clarks Creek Basin of implementing recommended programmatic measures over the ten-year implementation period is $2,722,000.

9.1.3 Additional Studies

The Basin Plan recommends four basin-specific studies. Priorities were not established for studies.

- **ST03-01 – West Fork Clear Creek Floodplain Analysis**
- **ST03-02 – Upland Sediment Sources Identification**
- **ST03-03 – Roosevelt Ditch Channelization Study**
- **ST03-04 – Swan Creek Upland Riparian Restoration**

The estimated cost of the studies is $224,000. Study results will provide information needed to address current Basin issues that cannot be resolved without additional data collection and analysis. Study results will assist in the next update of the Basin Plan and implementation of recommended projects with an improved understanding of basin characteristics.

9.1.4 Implementation Strategy

Order of Implementation. In theory, implementation starts with "High-Priority" projects and activities, then "Medium-Priority," followed by "Low-Priority" projects and activities. In practice, the order of project implementation varies to reflect such factors as availability of funds: availability of staff and professional service resources; links to projects with different

priorities; cooperation with private landowners; projects completed by agencies other than Pierce County Public Works and Utilities; and new information, new regulations, or new public concerns.

The annual Capital Facilities Element of the Comprehensive Plan for Pierce County, Washington reflects the specific annual strategy for CIP's. Programmatic measures and CIP's also appear in the annual budget for Water Programs.

Pierce County Water Programs is primarily the implementer responsible for the recommendations contained in this Basin Plan. Funding of the recommendations is mainly through Pierce County's surface water management fees collected within the Basin, but may also include state and federal grants and other local fund sources. The Clear/Clarks Creek Basin Plan anticipates full implementation over a ten-year period beginning in 2005. Actual duration of full implementation and the timing of specific projects and programs are determined through annual budget decisions of the County Council and County Executive, first in the yearly update of the Capital Facilities Element of the County Comprehensive Plan, and secondly in the operating budget for Pierce County Water Programs.

9.2 Plan Approach to Basin Needs

9.2.1 Preference for Non-Structural Solutions

The 1991 Pierce County Storm Drainage and Surface Water Management Plan and the Capital Facilities Element of the Comprehensive Plan for Pierce County contain the following policy: "Nonstructural measures should be preferred over structural measures". Examples of non-structural solutions and programmatic measures include:

- Adopting an updated Stormwater Management and Site Development Manual
- Increasing inspections for compliance with stormwater requirements and NPDES permits
- Requiring flood disclosure statements on property titles
- Upgrading and administering the county's floodplain regulations to address groundwater and pothole flooding

9.2.2 Low Impact Development

The hydrologic analysis in Chapter 6 described how urbanization alters the hydrologic regime to generate more stormwater runoff, higher velocity runoff, and less infiltration. A way of addressing these adverse effects is through Low Impact Development (LID) practices. LID can substantially reduce the rate of flow and the volume of stormwater runoff from medium and high-density areas. LID emphasizes protection and use of natural on-site features, reduction of impervious surfaces, and small-scale stormwater controls to minimize stormwater runoff and retain pre-development watershed hydrologic functions. LID combines site planning with individual best management practices to preserve natural drainage characteristics (such as soils and vegetation) and to retain and infiltrate stormwater on-site.

LID can reduce development infrastructure and related costs in many settings. LID strategies focus on evaporating, transpiring and infiltrating stormwater on site through native soils, vegetation and bioengineering applications, rather than conveying stormwater through large stormwater facilities, pipes, and other costly, traditionally hard structural drainage systems. In addition to reduced infrastructure costs, LID practices have other economic benefits that can increase a development project's marketability, such as a community's perceived quality of life. LID stormwater facilities can be easier and less costly to maintain over time. Public and private use of LID concepts can also reduce the size of stormwater ponds, resulting in more developable land.

A sample of LID site design applications and BMPs (Wulkan, 2001) follows:

- Developers set aside all sensitive areas and natural drainage, such as streams and wetlands. Portions of a site's trees and native vegetation are integrated into the site design.
- Specially designed bio-retention areas (or landscaped rain gardens) capture, filter and infiltrate stormwater.
- Narrower roads and use of permeable pavements on parking lots and driveways reduces impervious areas. Pervious pavements help to infiltrate stormwater at the site.
- Runoff from remaining impervious surfaces, such as rooftops, can be directed onto landscaped areas with porous soils.
- Rooftop designs can include roof gardens, which retain and slowly release stormwater.
- Soils compacted during construction are amended with compost or other organic soil conditioner that restores their capacity to hold moisture, infiltrate runoff and grow healthy plants.

The Washington Department of Ecology Stormwater Management Manual for Western Washington (Ecology, 2002) emphasizes the use of LID strategies wherever practicable.

LID practices can be used in parts of the Basin zoned for residential and higher density land uses. Seattle and other Puget Sound communities have demonstrated how LID principles can be successfully applied to the retrofit of existing neighborhoods. Public infrastructure improvements such as road and road drainage projects can also embody LID principles.

Programmatic Measure PRG00-01 (Section 9.4.2) calls for the establishment of a Low Impact Development Program that could provide LID outreach services, collaborate with the development industry and citizens to identify and solve problems and impediments to LID implementation, and coordinate LID public and private pilot projects.

9.2.3 Economic Development

Pierce County as a government and provider of public facilities and services works toward the economic health of the County and the region. Sound management of storm drainage facilities, flood hazard reduction, and protection of surface water quality makes Pierce County a more desirable place to live and work, acts as an incentive for new business to locate here, and

encourages existing businesses to stay and expand. Basin plans lay out the surface water management needs of the basins given existing and planned development. These are the facilities and services needed to support planned levels of growth laid out in the County Comprehensive Plan. Facilities bring predictability to businesses. Public funds build facilities and programs that serve economic growth consistent with adopted land use plans and regulations.

9.2.4 Critical Areas Conservation

As described in chapters six and eight, stormwater drainage, flooding, streambank erosion, and loss of aquatic habitat are ongoing surface water management problems in the Clear/Clarks Creek Basin. These problems can be partially addressed through conservation of critical areas, including preservation of lands that are prone to flooding, riparian corridors, wetlands, and associated buffer areas. The basin plans presume that conservation for general public benefit is best achieved through acquisition; either fee-simple or another legal instrument such as a conservation easement. The purchase prices of both are almost the same.

The Clear/Clarks Creek Basin Plan recommends property acquisitions for conservation of critical areas or mitigation of adverse effects of urban development in eight different parts of the Basin. In addition to preventing or removing a flood threat, several of these sites would preserve wetlands. Riparian buffer acquisitions along six creeks are recommended as part of a series of stream corridor restoration CIPs (refer to Section 9.2.8).

9.2.5 Public Involvement and Education

A goal of public involvement is to improve public understanding of the various surface water management issues in the Clear/Clarks Creek Basin, including erosion and sedimentation control, flood hazard reduction, rodent control (and its relationship to water quality), and aquatic habitat restoration and protection. Individual recommendations of this Basin Plan should be incorporated into a comprehensive public education program that informs Clear/Clarks Creek Basin residents about conditions of the creeks and its watersheds, any planned capital improvement projects, and the actions of individual residents that can contribute to restoration and protection of the surface and ground water resources of the Clear/Clarks Creek Basin.

A County-wide watershed education program would help to educate watershed citizens about the consequences of actions and encourage them to change their habits to protect the creeks and watersheds. Specific activities would be targeted to both young and adult audiences and would be related to existing community programs. The publicly-owned parts of creeks lend themselves to citizen involvement in stream and riparian restoration projects and can call attention to watershed activities and events in the Clear/Clarks Creek Basin.

Programmatic measure PRG00-06, Develop and Implement and Education, Outreach and Technical Assistance Program, could include some of the components and recommendations of this Basin Plan and could provide for public involvement and information in the Clear/Clarks Creek Basin as part of the countywide program.

9.2.6 Compliance with Storm Drainage and Flood Hazard Regulations

Compliance with existing storm drainage and critical areas regulations will help to mitigate the adverse effects of future development. For example, filling of floodplain and wetland areas was identified in Chapter Four as a continuing problem in the Clear/Clarks Creek Basin. In addition, existing Washington State, federal and local regulations provide for water quality, habitat, critical areas and land use protection. However, compliance with regulations typically required formal and informal enforcement, inspections, technical assistance, public information, and education.

This Basin Plan reflects Pierce County's commitment to compliance with local regulations related to flooding and water quality management, in addition to the requirements of federal and State regulations such as the federal "Clean Water Act" and Code of Federal Regulations, State water quality standards, "Endangered Species Act," FEMA floodplain regulations and "Community Rating System," State Hydraulic Code, "Shoreline Management Act," and "Growth Management Act." A compliance assurance program, implemented in a fair and consistent manner, would improve natural resource and surface water management within the Clear/Clarks Creek Basin Programmatic measure PRG00-03, Increase Inspections for Compliance with Stormwater Requirements and NPDES Permit, is a measure that addresses compliance assurance.

Protection of stream channels from encroachment by uses with adverse effects can also be addressed through compliance with environmental regulations. The County has development regulations intended to protect critical habitat areas (Title 18E, Pierce County Code) and requirements to control erosion and sedimentation during land clearing, grading, construction and in the long-term. As an NPDES municipal stormwater permit holder, the County is required to have a program that includes the legal authority to investigate drainage problems and inspect development sites to ensure that practices in the County conform to NPDES terms and protect water quality. When administering the regulations is not enough to protect water quality, capital facilities to treat stormwater is required.

Local critical areas rules, NPDES requirements, and other federal and state rules define certain uses and activities that are prohibited within surface waters, stream, and or their buffers. Use and activity regulations prohibit new development and existing landowners from undertaking new activities that could degrade water quality, increase erosion, cause riparian damage, or lead to flooding. Some examples of prohibited activities include: destroying or altering riparian vegetation through clearing, harvesting, cutting, intentional burning, shading, or planting; application of pesticides, fertilizers, and/or other chemicals; constructing, reconstructing, demolishing, or altering the size of any structure; or activities which alter water temperature.

9.2.7 Drainage and Flood Hazard Management

Chapter Six described existing and future drainage and flood hazard problem areas throughout the Clear/Clarks Creek Basin. The Basin Plan identifies projects and programs that will reduce flood hazards.

The Plan contains a range of approaches to meet that goal. Pierce County participates in the National Flood Insurance Program administered by the Federal Emergency Management Agency (FEMA). FEMA also offers communities the opportunity to receive additional benefits through

the "Community Rating System" (CRS). This program makes subsidized flood insurance available to citizens in communities that voluntarily take actions to reduce flood hazards. A community's rating affects the flood insurance rates its citizens pay. Pierce County has one of the lowest flood insurance rates available. Pierce County was the first county in the nation to achieve a "Class 5" rating" through implementation of programs that reduced flood risks. This Basin Plan includes all the necessary program elements for the County to achieve a "Class 4" or better rating.

Flood Hazards

Mapping of flood hazard areas should be improved. Over 100 individual flooding and drainage problems were identified in the Clear/Clarks Creek Basin. *Figure 5-1* shows the distribution of problems is widespread and occur in all parts of the Basin.

According to the current Pierce County Flood Hazard area maps (see *Figure 4-10*), approximately 940 acres (4.5%) of the Clear/Clarks Creek Basin are located within an unnumbered Flood Zone A, the area that statistically is anticipated to be flooded once every 100 years. Flood Hazard maps also show more than 1,300 acres (approximately 6.3%) within the Flood Zone B, the area that statistically is flooded once every 500 years (see Figure 4-10).

Unnumbered Zone A and Flood Zone B floodplain designations do not provide sufficient information (in the form of base flood elevations) to ensure appropriate protection. These mapped floodplains do not always reflect the actual topographic and hydrologic conditions in the Basin.

Recent two-foot contour interval mapping shows that the mapped floodplain in many areas does not align with the topography. The hydrologic analysis also showed that peak flow rates were substantially higher than rates used by FEMA to develop the original floodplain maps.

Programmatic Measures for Flood Hazard Reduction

The Basin Plan supports programmatic measures that will serve to reduce flood hazard impacts. These include:

- **PRG00-02**, Adopt Updated Stormwater Management Standards.
- **PRG00-04**, Develop and Implement a Land Acquisition Program for Riparian and Wetland Habitat Protection and Flood Hazard Reduction.
- **PRG00-01**, Develop and Implement a Low Impact Development Program.
- **PRG00-06,** Develop and Implement an Education, Outreach and Technical Assistance Program.
- **PRG00-07,** Develop and Implement a Surface Water Management Monitoring Program.
- **PRG00-10**, Require Flood Disclosure Statements on Property Titles.
- **PRG00-11**, Enhanced Coordination with Cities and Other Agencies

Studies Benefiting Flood Hazard Reduction

Several studies could lead to additional capital improvement projects that reduce flood hazards. The studies recommended include:

- **ST03-01**, Floodplain analysis for West Fork Clear Creek from 88th Street East to 84th Street East
- **ST03-02**, Sediment Sources Identification
- **ST03-03**, Roosevelt Ditch Channelization Study
- **ST03-04**, Swan Creek Upland Riparian Restoration Program

In addition, a number of CIP projects have been proposed in the Clear/Clarks Creek Basin to alleviate localized flooding problems through stormwater facility improvements. Other CIP projects involve the acquisition of ponding or flood-prone areas.

Major Drainage Systems

Most of the creeks in the Clear/Clarks Creek Basin show signs of channel erosion in the steeper portions as they flow north into the Puyallup Valley. This is especially the case for Swan and Woodland Creeks, where long reaches of the stream channel have suffered from down-cutting. CIP projects are recommended along portions of most of the creeks to stabilize eroding stream channels and restore aquatic habitat. A number of the studies and programmatic measures in the previous sub-section would also alleviate stream channel erosion. In the plateau area in the southern portion of the Basin, there are several locations where stream channels are undersized and channel overflows cause property flooding. Numerous road culverts have been identified which are undersized and where high flows can overtop the road. The CIP improvements in this Plan address these flooding problems.

Minor Drainage Systems

Many of the roadway drainage systems in older developments were installed before current stormwater management standards were implemented. In some neighborhoods, the ditch and culvert system is undersized, or has been filled with sediment and no longer works as designed. As a result, there are many locations where extended stormwater inundation occurs after heavy periods of rain. Some of these areas are widespread and documented in Chapter Five, but others are more localized and may only affect one or two properties. In addition, the topography across much of the southern portion of the Basin is flat and frequently forms shallow depressions. CIP projects are recommended to alleviate flooding in some neighborhoods. However, most of these problems are assumed to be small and better addressed through maintenance activity or as a "Small Works Project."

Homes with an existing stormwater inundation problem have limited options. The home may be physically raised in place or moved. Both are expensive approaches for a homeowner.

Proposals for major new development in the County require, among other things, that an assessment be made of the drainage conditions downstream from the development. For the Clear/Clarks Creek Basin, this downstream assessment should explicitly review whether the project will be impacted by, or drain to, a depression. If this is the case, the hydrologic analysis provided by the project proponent should demonstrate that the project would not be impacted by

onsite flooding nor contribute substantially to an offsite flooding problem. In addition to site-specific flooding information provided by the County, information regarding past flooding incidents should be sought from the local residents.

9.2.8 Water Quality

The Washington State Department of Ecology has issued Pierce County a "Phase 1" Municipal Stormwater NPDES Permit, conditioned to required Pierce County administer and enforce water quality standards adopted by the State of Washington and the federal government. One condition of the permit requires Pierce County to adopt standards equivalent to the State's Stormwater Manual. Pierce County adopted the 1997 Stormwater Management and Site Development Manual as a step in demonstrating the County's intent to comply with State and federal requirements. The manual sets standards for public and private activities that affect the quality of stormwater runoff. Adoption of the manual assumes effective administration and enforcement. Failing this, other methods such as costly stormwater treatment facilities and restoration projects become necessary. The permit also requires the County to update the manual to be equivalent with the State's most recent (2001) manual.

9.2.9 Aquatic (Floodplain) Habitat Protection

Channel erosion and associated reduction of aquatic habitat is common in the Clear/Clarks Creek Basin. This is due to large increases in both the frequency and magnitude of high-volume flows, resulting from development within the Basin. Reduced infiltration due to increases in impervious area may also result in reduced stream base flows and intermittent flow conditions in the upper portions of some streams. The altered hydrologic regimes of the creeks in the Clear/Clarks Creek Basin are a major reason for habitat degradation. Another important reason for degraded stream conditions is a lack of riparian buffer along many of the upper reaches of the streams. The hydrologic changes combined with a lack of riparian buffers have resulted in generally poor fish habitat within the Basin. The Basin Plan addresses these problems, recommending 17 stream channel stabilization CIPs to prevent further serious channel erosion. A Stream Corridor Restoration CIP is recommended in each of six creeks: Clear, Canyon, Rody, Diru, Woodland and Clarks creeks. Finally, the eight detention ponds CIPs recommended by the Plan would reduce peak flows in the streams. These ponds may also be able to mitigate the impacts of the altered hydrology in the basin due to development if streamflow duration is considered when setting the target release rate from the facility. Some of these ponds can also improve base flow in the creeks if designed to encourage infiltration.

Degraded riparian areas that would benefit from enhancement were selected based on field investigation and aerial photography. Primary riparian enhancement sites were defined as those reaches that directly benefit salmonid habitat. These sites are generally located on the lower canyon and floodplain reaches where salmonids are known to be present. Enhancement measures at these sites could include, alone or in combination, instream habitat improvements, riparian zone planting, and control of invasive aquatic vegetation. Secondary riparian enhancement sites were defined as those reaches that indirectly benefit salmonid habitat. These sites are generally located on the plateau upstream of the known fish habitat locations, and benefit salmonid production by providing food-generating leaf litter and water quality treatment. Riparian enhancement in these reaches would mainly consist of riparian zone planting.

9.3 Specific Recommendations

The CIP and programmatic measures have been individually ranked according to a common ranking system used by all the basin plans for Pierce County. Each of the potential capital improvement projects and programmatic recommendations were evaluated using a spreadsheet that assigned points for the project/program's potential for various aspects of flood reduction (approximately 35% of the total score), water quality protection or improvement (30%), natural resource improvement (30%), and other factors such as multiple use, education, and recreation (5%). Each project and program was reviewed and scored using approximately 40 specific criteria. This ranking system is documented in *Appendix "H"*. The appendix also contains a spreadsheet summarizing the scores assigned to each CIP and project estimating spreadsheet. An individual score sheet is included for each programmatic measure.

Recommended projects and programs were then put in rank order, based on their numeric benefit score (project score). Then, high, medium, or low status was assigned as follows:

- High-Priority: 25% of total number of recommendations
- Medium-Priority: 50% of total number of recommendations
- Low-Priority[4]: 25% of total number of recommendations

Within each priority category, projects and programs were ranked from lowest cost to highest cost. This directs County financial resources to where they do the most good for the financial resources invested. *Tables 9-2, 9-3,* and *9-4* present the recommended capital improvement projects and programmatic measures.

9.3.1 Project Identification Codes

Each recommendation has a unique project identification code. The code contains the following information:

Project Category	Basin No.	Project Type	Order Number
CIP	03	RST	01
PRG	03	-----	01
ST	03	-----	01

Basin No.: This is a County designated number for identifying major divisions of drainage basins. The basin number for the Clear/Clarks Creek Basin is 03. Measures of Countywide applicability are 00.

Subbasin: The reach or subbasin identified within the Basin Plan.

[4] Note: "Low-Priority" does not mean "no benefit" for flood control, water quality protection, or natural resource protection. All of the recommendations in the Basin Plan .benefit the objectives. "No benefit" proposals were screened out prior to writing the Plan. "Low-Priority" means that the proposed project or program scored lower than other projects and programs, based on the net environmental benefits that would occur from the project or program as determined by the score sheet criteria. Some projects that are ranked "Medium-Priority" or "Low-Priority" may be built before high-priority projects to ensure the optimal benefit from other projects, such as upstream fish habitat improvements synchronized with downstream barrier removal.

Project Type: The general category of project that best fits the project's activities.

Progect Category Codes:

AC	Property Acquisition	OUT	Outfall
C	Culvert	RD	Raised Road
CHN	Channelization	REF	Retrofit
CP	Culvert/Pipe	RP	Retention Pond
DP	Detention Pond	SBS	Streambank/Channel Stabilization
DS	Drainage Study	SP	Sedimentation Pond
FP	Fish Passage	ST	Study
IP	Infiltration Pond	SWL	Swale
PL	Pipeline	VC	Vegetation Control
PRG	Programmatic	WL	Wetland
PS	Pump Station	WQ	Water Quality

9.3.2 Capital Improvement Projects

The Basin Plan contains more than 60 capital improvement projects to solve the flooding, storm drainage, water quality, and related habitat problems in the Clear/Clarks Creek Basin. This section presents CIP projects by subbasin, moving from the westerly subbasin of Roosevelt Ditch to the Clear Creek drainage system to the Clarks Creek drainage system and concluding with the Potholes area in the east. *Appendix "H"* contains the Project Analysis sheets for each of the projects listed below. Maps showing the general location of recommended projects are distributed in this section proximal to the project descriptions associated with the projects.

Roosevelt Ditch Subbasin Projects

Four projects were developed for the Roosevelt Ditch Subbasin. These projects will solve five flooding problems. *Figure 9-1* shows the location of the projects outlined below.

Table 9.6 ROOSEVELT DITCH Recommended CIPs

ID	*Project Name*	*Project Score*	*Estimated Cost*	*Priority*
RD-DP01	Portland Avenue (Swan Creek) Regional Detention, Roosevelt Ditch	276	3,884,000	High
RD-SWL01	20th Avenue East Drainage Swale, Roosevelt Ditch	214	29,000	Medium
RD-DIV01	85th Street East Diversion	120	288,000	Low
RD-RD01	90th Street East Road Surface Raising	84	75,000	Low
	Total Estimated Cost for Roosevelt Ditch CIPs		**$4,276,000**	

Project Number: **CIP03-RD-DP01**

Project Name: **Portland Avenue (Swan Creek) Regional Detention Facility**

Cost Estimate: **$3,884,000**

Project Score: **276** **High-Priority**

Problem: The hydraulic analysis showed that roadway and property flooding occur in 7600 block of Portland Avenue during the 1-year peak flood event for existing and future land use conditions. The existing 24-inch-diameter storm drain system is undersized and overtops Portland Avenue causing roadway and property flooding.

Solution: Acquire properties on east (upstream) side of Portland Avenue between 80th Street East and Shopping Center property to preserve and expand floodplain storage. The existing topographic mapping shows that this area currently has 36 acre-feet of natural detention storage. The project would excavate an additional 8 acre-feet of storage in this area.

Benefit: This project eliminates roadway and private property flooding at Portland Avenue East. The project preserves also preserves wetland and floodplain in the Roosevelt Ditch Subbasin. This project solves flooding problem RD-7.

Project Number: **CIP03-RD-SWL01**

Project Name: **20th Avenue East Drainage Swale**

Cost Estimate: **$29,000**

Project Score: **214** **Medium-Priority**

Problem: Road and property flooding occur in the 7300 and 7400 block of 20th Avenue East due to an obstructed outfall from the 20th Avenue East storm drain system. The receiving ditch for this system is filled in downstream of the road. Fill has also been placed in the roadside ditch near 7403 20th Avenue East.

Solution: Excavate a 650-foot-long trapezoidal channel along the natural drainage alignment to connect 20th Avenue storm drain system to Roosevelt Ditch. Clean culvert near 7400 block of 20th Avenue East. Purchase 20-foot-wide easement from adjacent landowners.

Benefit: This project restores the drainage system on 20th Avenue East and eliminates roadway and private property flooding at this location. The project solves flooding problem RD-11.

Project Number: **CIP03-RD-DIV01**

Project Name: **85th Street East Diversion**

Cost Estimate: **$311,000**

Project Score: **86** **Low-Priority**

Problem: The hydraulic analysis predicted roadway and property flooding in the 1600 block of 85th Street East during the 10-year peak flood event under existing and future land use conditions. The culvert crossing 85th Street East diverts high flows from the south to the north side of the street. The roadside ditch and culvert system on the north side does not have the capacity to carry the diverted flow. Private property and roadway flooding also occurs on the west side of 18th Avenue East in the 8700 block of 18th Avenue East due to the undersized ditch and culvert system. Stormwater from this area is currently routed through the Portland Avenue drainage system and discharges to Roosevelt Ditch immediately downstream of 80th Street East.

Solution: Divert stormwater from downstream of 80th Street East to downstream of 85th Street East. Construct a 2,000-foot-long, 18-inch-diamter diversion pipeline from the northeast corner of Portland Avenue and 85th Street East to Roosevelt Ditch downstream of 85th Street East. A 40-foot-long, 18-inch-diameter cross culvert would also be installed to connect 18th Avenue ditch and culvert system to new storm drain at intersection of 18th Avenue East and 85th Street East. A flood easement would be acquired upstream of 80th Street East because the 100-year peak flood stage would increase by 0.2 feet at this location. There is an unclassified, unverified wetland present at this location.

Benefit: This project eliminates flooding on 80th Street East and also preserves wetland floodplain. The project solves flooding problems RD-13 and RD-15.

Project Number: **CIP03-RD-RD01**

Project Name: **90th Street East Roadway Improvement**

Cost Estimate: **$75,000**

Project Score: **84** **Low-Priority**

Problem: The hydraulic analysis showed roadway overtopping at 90th Street East during the 25-year peak flood event under existing land use conditions and increasing to the 10-year peak flood event under future land use conditions.

Solution: Raise 165 lineal feet of roadway 2.0 feet to elevation 416.0 NGVD and purchase floodplain easement. There is an unclassified, verified wetland present at this location.

Benefit: This project eliminates flooding at 90th Street East and also preserves wetland floodplain. This project solves flooding problem RD-17.

Swan Creek Subbasin CIP Projects

Eight projects were developed for Swan Creek and the area that drains to the creek. The projects will solve two flooding, four erosion, and five aquatic habitat problems. Figure 9-1 shows the location of the projects described below.

Table 9.7 SWAN CREEK Recommended CIP Projects

ID	*Project Name*	*Project Score*	*Estimated Cost*	*Priority*
SW-AC01	Swan Creek at 112th Street Floodplain Storage/Headwaters Preservation	302	1,306,000	High
SW-DP01	Swan Creek Regional Detention	259	7,049,000	High
SW-SBS03	Swan Creek 64th Street East Culvert Outfall Repair	152	24,000	Medium
SW-SBS01	Swan Creek Streambank Stabilization at 72nd Street E Outfall	157	100,000	Medium
SW-SBS02	Swan Creek Stream Bank/Channel Stabilization from 72nd Street E to 64th Street E	203	283,000	Medium
SW-SBS04	Swan Creek Streambank Stabilization Downstream of 64th Street East	222	Segment 1: 380,000 Segment 2: 380,000 Segment 3: 380,000 TOTAL: 1,140,000	Medium
SW-PL01	84th Street East Pipeline Replacement, Swan Creek	99	74,000	Low
SW-CR01	Swan Creek 80th Street E Culvert Replacement	82	110,000	Low
	Total Estimated Cost for Swan Creek CIPs		**$10,086,000**	

Project Number: **CIP03-SW-AC01**

Project Name: **112th Street Floodplain Storage/Headwaters Preservation**

Cost Estimate: **$1,306,000**

Project Score: **302** **High-Priority**

Problem: The hydrologic analysis predicted that peak flows from this area will increase by 10 to 20 % under future land use conditions. A Class III wetland is located in headwaters of Swan Creek above 112th Street East. The flat topography and saturated soils found in this area result in excessive stormwater inundation and overall poor drainage condition. This condition is problematic for urban development but ideally suited for floodwater storage and riparian habitat. The area is zoned for Mixed-Use District and High Density Residential. Conversion to these types of land uses permitted in these zones usually results in filling of floodplain and a large increase in effective impervious area.

Solution: Purchase 34 acres of floodplain and wetland to preserve the existing floodwater storage, base stream flow, and wetland values.

Acquisition of the full 34 acres will be broken down by segments divided as follows:

Segment 1: Class III, delineated wetland located between SR 512 and 112th Street East	$343,000
Segment 2: Unclassified, delineated wetland located primarily on vacant land north of 116th Street East	$442,000
Segment 3: Unclassified, delineated wetland located south of 116th Street East	$442,000

Benefit: This project preserves floodplain and wetland storage in this flat sloped, poorly drained area helping to prevent further alteration of Swan Creek hydrology.

Project Number: **CIP03-SW-DP01**

Project Name: **Swan Creek Regional Detention**

Cost Estimate: **$7,049,000**

Project Score: **259** **High-Priority**

Problem: The streambank stabilization projects at the 72nd Street East culvert (CIP03-SW-SBS02) and between CIP03-SW–SBS04 will require peak flow reduction if they are to maintain viability over the long-term. This is demonstrated by the fact that high stream flow rates have damaged some of the log weirs installed with previous stabilization efforts. Peak flow reduction is also needed to reduce or eliminate streambank erosion in the streams in the future.

Solution: Construct 80 acre-feet of detention storage (at one or more locations) in Swan Creek Subbasin upstream or near 72nd Street East. Additional hydrologic analysis and a geotechnical investigation prior to project design is needed to accurately define detention volume and the target release rate. The type of streambank stabilization measures should also be considered when establishing the target release rate.

Benefit: Reduces peak stream flow rates in the Swan Creek Subbasin that reduces erosion and helps to maintain the long-term viability of the channel stabilization projects. With proper design of the outlet structure, it may be possible to provide a mitigate some of the impacts of the altered hydrology of the system. This project solves erosion and riparian/aquatic habitat problems SW-3, SW-22, SW-23, SW-25, SW-26. This project has the potential to provide a flood control benefit and solve flooding problem SW-1 if the facility is located upstream 80th Street East.

Project Number: **CIP03-SW-SBS03**

Project Name: **64th Street East Culvert Outfall Repair**

Cost Estimate: **$24,000**

Project Score: **152** **Medium-Priority**

Problem: High stream flows have scoured a 4- to 5-foot-deep scour hole at 64th Street East culvert outlet and undermined the culvert apron so that the apron has completely separated from the culvert. If left unchecked, the culvert will continue to be undermined, which may cause failure to the roadway embankment. This culvert is also a barrier to fish passage.

Solution: Repair the culvert headwall and install boulder clusters at the culvert outfall for energy dissipation.

Benefit: Provides a public safety benefit by maintaining structural stability of the culvert and roadway embankment. Stabilizes the stream channel by preventing further scour erosion. This project solves erosion and riparian/aquatic habitat problem SW-23.

Project Number: **CIP03-SW-SBS01**

Project Name: **Streambank Stabilization at 72nd Street East Outfall**

Cost Estimate: **$100,000**

Project Score: **157** **Medium-Priority**

Problem: High flow velocity at the 72nd Street East culvert outfall has eroded the west bank and is compromising bank stability. A house is located less than 50 feet from the eroded bank.

Solution: Stabilize 200 feet of west bank below home with log cribwall, barbs or other energy deflecting technique. Place boulder cluster in scour hole at culvert outlet to provide energy dissipation.

Benefit: Provides a public safety benefit by maintaining stability of the west streambank protecting the adjacent structure. This project solves erosion and riparian/aquatic habitat problem SW-3.

Project Number: **CIP03-SW-SBS02**

Project Name: **Streambank Stabilization from 72nd Street East to 64th Street East**

Cost Estimate: **$283,000**

Project Score: **203** **Medium-Priority**

Problem: Channel erosion downstream of 72nd Street East to 64th Street East due to high streamflow. Exposed vertical banks 2- to 3-feet high.

Solution: Install streambank stabilization measures such as porous rock weirs or drop structures every 50 feet in 3,000 foot reach from 72nd Street East to 64th Street East. Purchase 40-foot-wide easement from adjacent landowners.

Benefit: Stabilizes streambank and reduces erosion in Swan Creek. This project in conjunction with downstream projects will protect instream habitat in lower Swan Creek. This project will also help to eliminate a source of fine sediments to Clear Creek. This project solves problem erosion and riparian/aquatic habitat SW-22.

Project Number: **CIP03-SW-SBS04**

Project Name: **Streambank Stabilization Downstream of 64th Street East**

Cost Estimate: **$1,141,000**

Project Score: **222** **Medium-Priority**

Problem: High streamflow in Swan Creek has caused significant erosion in the 8,000 foot-long reach downstream of 64th Street East. In some locations, exposed vertical banks in the channel were observed to be greater than 10-feet high.

Solution: Install streambank stabilization measures such as porous rock weirs and drop structures every 50 feet. These types of structures direct the energy of the flowing water away from the streambanks and towards the center of the stream. Because much of the area is steep, inaccessible ravine, use of a helicopter for construction may be necessary. The reach flows through public land so no easement acquisition required.

Stabilization of the full 8,000 foot reach can be broken down by segments divided as follows:

Segment 1:	64th Street East to 57th Street Ct. East (extended)	$380,000
Segment 2:	57th Street Ct. East to 48th Street East	$380,000
Segment 3:	48th Street East to 40th Street East (extended)	$380,000

Benefit: Stabilizes streambanks and reduces erosion along Swan Creek. This project in conjunction with upstream projects will improve instream habitat in lower Swan Creek. The project will also help to eliminate a source of fine sediment to Clear Creek. The project solves erosion and riparian/aquatic habitat problem SW-23.

Project Number: **CIP03-SW-PL01**

Project Name: **84th Street East Storm Drain Replacement**

Cost Estimate: **$74,000**

Project Score: **99** **Low-Priority**

Problem: Hydraulic analysis predicted road and property flooding on 84th Street East, from Waller Road East to 400 feet east of Waller Road East, during the 25-year peak flood event under existing and future land use conditions. Flooding is due to insufficient conveyance capacity and backwater conditions in the 84th Street East storm drain system that connects this area to Waller Road Pond #4.

Solution: Replace existing 24-inch diameter concrete pipe with 350-feet of 36-inch diameter concrete pipe from Waller Road East to catch basin east of Waller Road East. Replace existing 12-inch inlet culvert to catch basin with 50-feet of 24-inch diameter concrete pipe. Field survey and detailed hydraulic analysis should be performed before project implementation.

Benefit: This project eliminates flooding on 84th Street East west of Waller Road East. This project solves flooding problem SW-4.

Project Number: **CIP03-SW-CR01**

Project Name: **80th Street East Culvert Replacement**

Cost Estimate: **$110,000**

Project Score: **82** **Low-Priority**

Problem: Hydraulic analysis predicted roadway overtopping of Swan Creek at 80th Street East during 25-year peak flood event under existing and future land use conditions. Roadway runoff causes property flooding at 2600 block of 80th Street East. This culvert has also been identified by the PCD as a barrier to fish passage; however, it is unknown if fish are present in this reach.

Solution: Raise low-chord of existing structure 1.5 feet. Lower Invert by 0.3 feet. Raise 375 feet of road 0.8 feet to elevation 400.8 feet NGVD[5]. Install thickened pavement edge on north side to contain runoff on roadway. Field survey and detailed hydraulic analysis should be preformed before project implementation.

Benefit: This project lowers the peak water surface elevation at the 80th Street East bridge by about 0.2 feet and eliminates flooding at this location. The water surface elevation upstream of this culvert is controlled by channel conditions so floodplain storage is essentially unchanged. This project also provides for limited fish passage however, the benefit is likely reduced due to downstream fish passage barriers and the lack of base flow during the summer months. This project solves flooding problem SW-1.

Insert Figure 9-1

Squally Creek Subbasin Project

One project was developed for the Squally Creek Subbasin to solve one habitat problem. *Figure 9-1* shows the location of the projects described below.

Table 9.8 SQUALLY CREEK Recommended CIP Projects

ID	*Project Name*	*Project Score*	*Estimated Cost*	*Priority*
SQ-VC01	Squally Creek at Pioneer Way E Vegetation Control	165	$150,000	Medium
Total Estimated Cost for Squally Creek CIPs			**$150,000**	

Project Number: **CIP03-SQ-VC01**

Project Name: **Pioneer Way East Riparian Area Enhancement and Restoration**

Cost Estimate: **$150,000**

Project Score: **165** **Medium-Priority**

Problem: The riparian area of the 1,000-foot-long reach above Pioneer Way East has become overgrown with reed canary grass, creeping purple nightshade, and other invasive species. This reach flows through verified but unclassified wetland. The USBEM Phase II habitat condition assessment rated this reach as having "Poor" habitat conditions.

Solution: Remove reed canary grass and other invasive aquatic vegetation and plant conifers to provide shade. May also want to provide large woody debris. Implementation of this project should be coordinated with a programmatic measure to develop a long-term invasive species management program. Purchase 200-foot-wide easement from adjacent landowners.

Benefit: Improves floodplain habitat of this impaired reach. The project solves problem water quality and aquatic habitat problem SQ-6.

Clear Creek Subbasin Projects

Eleven projects were developed for the Clear Creek Subbasin. The projects will solve two flooding, five erosion, and nine habitat problems. Figure 9-1 shows the location of the projects described below.

Table 9.9 CLEAR CREEK Recommended CIP Projects

ID	*Project Name*	*Project Score*	*Estimated Cost*	*Priority*
CL-RST01	Clear Creek Stream Channel Restoration		Segment 1: 402,000 Segment 2: 402,000 Segment 3: 402,000	
		261	TOTAL: 1,206,000	High
CL-AC01	Clear Creek Floodplain Repetitive Loss Acquisitions	345	6,455,000	High
CL-SBS03	Clear Creek Streambank Stabilization in vicinity of 49th Street E	194	35,000	Medium
CL-SBS04	Clear Creek Streambank Stabilization on West Fork Clear Creek Downstream of 64th Street E	194	35,000	Medium
CL-CR01	Clear Creek at 88th Street E Culvert Replacement	161	53,000	Medium
CL-VC01	Clear Creek at 104th Street E Vegetation Control	203	54,000	Medium
CL-SBS05	Clear Creek Streambank Stabilization 5000 block of Vickery Avenue East	153	92,000	Medium
CL-SBS02	Clear Creek Streambank Stabilization, East Fork Downstream of 72nd Street E	194	161,000	Medium
CL-SBS01	Clear Creek Streambank Stabilization, West Fork Downstream of 72nd Street E	194	187,000	Medium
CL-DP01	West Fork Clear Creek Regional Detention	163	3,021,000	Medium
CL-DP02	East Fork Clear Creek Regional Detention	163	4,858,000	Medium
	Total Estimated Cost for Clear Creek CIPs		**$16,158,000**	

Project Number: **CIP03-CL-RST01**

Project Name: **Clear Creek Stream Corridor Restoration**

Cost Estimate: **$1,206,000**

Project Score: **261** **High-Priority**

Problem: This 3,000-foot reach of Clear Creek between Pioneer Way East and Gay Road has been channelized and disconnected from the floodplain. The reach has a reduced buffer and invasive riparian and aquatic vegetation has replaced the native species. The channel has filled with fine sediment due to upstream erosion activity. Most of this reach is glide aquatic habitat with very few pools and a complete absence of large woody-debris. A large unclassified wetland area abuts the stream at this location. The Port of Tacoma (POT) has purchased property for a future restoration project in the 1,400 foot-long reach upstream of Gay Road.

Solution: Restore 3,000-foot reach between Port of Tacoma property and Pioneer Way. Remove invasive vegetation and enhance riparian community with conifer plantings to provide shade. Install large woody-debris in channel to form pool aquatic habitat. Purchase 300-foot-wide easement from adjacent landowners where practical. The proposed corridor is adjacent to several vacant parcels. This project should be coordinated with the Port of Tacoma project restoration project planned for the reach downstream of this location.

Restoration of the full 3,000 foot reach will be broken down by segments divided as follows:

Segment 1: Pioneer Way East to 400 feet east of Squally Creek confluence	$402,000
Segment 2: 400 feet east to 600 feet west of Squally Creek confluence	$402,000
Segment 3: 600 feet west of Squally Creek confluence to POT property	$402,000

Benefit: This project provides high quality floodplain habitat in lower Clear Creek. The project solves riparian/aquatic habitat problems CL-1, CL-17, CL-18 and CL-24.

Project Number: **CIP03-CL-AC01**

Project Name: **Clear Creek Floodplain Repetitive Loss Land Acquisition**

Cost Estimate: **$6,455,000**

Project Score: **345** **High-Priority**

Problem: Widespread flooding occurs in the area of 47th Avenue East, 50th Avenue East, 40th Street East, and 55th Street East. Sixty-five (65) properties are located within the 100-year floodplain. Federal funds have already been used to purchase 17 properties to be held for their floodplain value. The remaining 48 properties have flooded several times. Several of the properties abut Canyon Creek.

Solution: Purchase 48 properties (61 acres) that experience frequent flooding in the Clear Creek floodplain.

Benefit: This project eliminates the flood hazard by removing structures in the floodplain and may also benefit floodplain habitat if the acquired property is restored to its natural function. The project solves flooding problem CL-33.

Project Number: **CIP03-CL-SBS03**

Project Name: **Streambank Stabilization in vicinity of 49th Street East**

Cost Estimate: **$35,000**

Project Score: **194** **Medium-Priority**

Problem: Streambank erosion due to high stream flow in 100-foot-long reach in vicinity of 49th Street East (extended).

Solution: Install streambank stabilization measures such as roughened rock toes, porous weirs or drop structures in a 100-foot reach in vicinity of 49th Street East. The site is located in a steeply sloped ravine and may be difficult to access. Purchase 100-foot-wide easement from adjacent landowners.

Benefit: Stabilizes streambanks and reduces erosion in Clear Creek. This project in conjunction with upstream other Clear Creek streambank stabilization projects will protect instream habitat in lower Clear Creek. This project will also help to eliminate a source of fine sediment to Clear Creek. The project solves problem erosion and riparian/aquatic habitat CL-21.

Project Number: **CIP03-CL-SBS04**

Project Name: **Streambank Stabilization on West Fork Clear Creek Downstream of 64th Street East**

Cost Estimate: **$35,000**

Project Score: **194** **Medium-Priority**

Problem: Streambank erosion in West Fork due to high stream flow in 100-foot-long reach downstream of 64th Street East.

Solution: Install streambank stabilization measures such as roughened rock toes, porous weirs or drop structures in 100-foot reach in vicinity of 64th Street East. The site is located in a steeply sloped ravine and may be difficult to access. Pierce County has existing easement on 64th Street East.

Benefit: Stabilizes streambanks and reduces erosion in Clear Creek. This project in conjunction with other upstream Clear Creek streambank stabilization projects will protect instream habitat in lower Clear Creek. The project will also help to eliminate a source of fine sediment to Clear Creek. It solves erosion and riparian/aquatic habitat problem CL-22.

Project Number: **CIP03-CL-CR01**

Project Name: **88th Street East Culvert Replacement**

Cost Estimate: **$53,000**

Project Score: **161** **Medium-Priority**

Problem: Hydraulic analysis showed that flooding occurs at 88th Street East during the 5-year peak flood event under existing and future land use conditions.

Solution: Replace the existing twin 18-inch diameter culverts under 88th Street East with 6.5' span x 2' rise box culvert.

Benefit: This project eliminates roadway flooding at 88th Street East. The project solves flooding problem CL-5.

Project Number: **CIP03-CL-VC01**

Project Name: **104th Street East Riparian Area Enhancement**

Cost Estimate: **$54,000**

Project Score: **203** **Medium-Priority**

Problem: The East Fork reach below 104th Street East is overgrown with reed canary grass, which causes chronic road and property flooding on an annual basis. The length of impaired reach is about 400 feet.

Solution: Remove reed canary grass and other invasive aquatic vegetation and plant conifers to provide shade. Purchase 40-foot-wide easement from adjacent landowners.

Benefit: This project eliminates roadway flooding at this location and improves floodplain habitat of this impaired reach. This project solves flooding problem CL-4.

Project Number: **CIP03-CL-SBS05**

Project Name: **Streambank Stabilization 5000 block of Vickery Avenue East**

Cost Estimate: **$92,000**

Project Score: **153** **Medium-Priority**

Problem: Streambank erosion in the West Fork in a 100-foot-long reach in vicinity of 5000 block of Vickery Avenue East. Uncontrolled saturated fill caused mass wasting of the hillside on west bank with 200-foot-long landslide chute to Clear Creek. Approximately 100 feet of the west bank of Clear Creek was damaged.

Solution: Install woody plantings (willow and conifer) in landslide chute to permanently stabilize hill slopes. Also install woody plantings on west bank of Clear Creek to stabilize streambank. Cut back over steepened slope at top of ravine near slide. Temporary construction easement will be needed from landowner.

Benefit: Stabilizes streambanks and reduces source of fine sediment to Clear Creek. This project in conjunction with other Clear Creek streambank stabilization projects will protect instream habitat in lower Clear Creek. This project solves erosion and riparian/aquatic habitat problem CL-33.

Project Number: **CIP03-CL-SBS02**

Project Name: **Streambank Stabilization on East Fork Downstream of 72nd Street East**

Cost Estimate: **$161,000**

Project Score: **194** **Medium-Priority**

Problem: Streambank erosion due to high stream flow in 500-foot-long reach downstream of 72nd Street East. A 3-foot deep scour hole is present downstream at culvert outlet. .

Solution: Acquire 100-feet-wide easement from adjacent landowners. Place boulder clusters in scour hole at culvert outlet to provide energy dissipation. Install streambank stabilization measures such as roughened rock toes, porous weirs or drop structures in 500-foot reach downstream of 72nd Street East.

Benefit: Stabilizes streambanks and reduces erosion in Clear Creek. This project in conjunction with upstream other Clear Creek streambank stabilization projects will protect instream habitat in lower Clear Creek. This project will also help to eliminate a source of fine sediment to Clear Creek. The project solves erosion and aquatic habitat problem CL-20.

Project Number: **CIP03-CL-SBS01**

Project Name: **Streambank Stabilization on West Fork Downstream of 72nd Street East**

Cost Estimate: **$187,000**

Project Score: **194** **Medium-Priority**

Problem: Streambank erosion due to high streamflow. Exposed vertical banks 12-feet-high in reach 500 feet downstream and 5-feet high in reach 100-feet upstream of 72nd Street. A 3-foot deep scour hole is present downstream at culvert outlet.

Solution: Place boulder clusters in scour hole at culvert outlet to provide energy dissipation. Install streambank stabilization measures such as porous weirs or drop structures in 600 foot reach in vicinity of 72nd Street East. Purchase 100-foot-wide easement from adjacent landowners.

Benefit: Stabilizes streambanks and reduces erosion in Clear Creek. This project in conjunction with upstream other Clear Creek streambank stabilization projects will protect instream habitat in lower Clear Creek. This project will also help to eliminate a source of fine sediment to Clear Creek. The project solves erosion and riparian/aquatic habitat problem CL-19.

Project Number: **CIP03-CL-DP01**

Project Name: **West Fork Clear Creek Regional Detention**

Cost Estimate: **$3,021,000**

Project Score: **163** **Medium-Priority**

Problem: High stream flow rates have caused extensive channel erosion in vicinity of 72nd Street East and less extensive erosion in the vicinity of 64th Street East and 49th Street East. Eroded sediments wash down in the floodplain channel and accumulate on the channel bottom. Streambank stabilization projects CIP03-CL-SBS01, 03, and 04 will require peak flow reduction if they are to maintain viability over the long-term. Peak flow reduction is also needed to reduce or eliminate streambank erosion in the streams in the future.

Solution: Construct 26 acre-feet of detention storage (at one or more locations) in West Fork Clear Creek Subbasin upstream of 72nd Street East. Conduct an additional hydrologic analysis and a geotechnical investigation prior to project design to accurately define detention volume and the target release rate. The blend of streambank stabilization measures should also be considered when establishing the target release rate.

Benefit: This project reduces peak streamflow rates in the Clear Creek Subbasin, which reduces erosion and helps to maintain the long-term viability of the channel stabilization projects. With proper design of the outlet structure, it may be possible to provide a mitigate some of the impacts of the altered hydrology of the system. This project solves erosion and riparian/aquatic habitat problems CL-17, CL-19, CL-21, and CL-22. This project has the potential to provide flood control benefit and solve flooding problem CL-5 if some or all of the detention is located upstream 88th Street East.

Project Number: **CIP03-CL-DP02**

Project Name: **East Fork Clear Creek Regional Detention**

Cost Estimate: **$4,858,000**

Project Score: **163** **Medium-Priority**

Problem: High stream flow rates have caused extensive channel erosion in vicinity of 72nd Street East and less extensive erosion in the vicinity of 64th Street East and 49th Street East. Eroded sediments wash down in the floodplain channel and accumulate on the channel bottom. The streambank stabilization projects CIP03-CL-SBS02, 03, and –04 will require peak flow reduction if they are to maintain viability over the long-term. Peak flow reduction is also needed to reduce or eliminate streambank erosion in the streams in the future.

Solution: Construct 42 acre-feet of detention storage (at one or more locations) in East Fork Clear Creek Subbasin upstream of 72nd Street East. Additional hydrologic analysis and a geotechnical investigation prior to project design is needed to accurately define detention volume and the target release rate. The type of streambank stabilization measures should also be considered when establishing the target release rate.

Benefit: Reduces peak stream flow rates in the Clear Creek Subbasin, which reduces erosion and helps to maintain the long-term viability of the channel stabilization projects. With proper design of the outlet structure, it may be possible to provide a mitigate some of the impacts of the altered hydrology of the system. The project solves erosion and riparian/aquatic habitat problems CL-17, CL-20, CL-21, and CL-22.

Canyon Creek Subbasin Projects

Twelve projects were developed for the Canyon Creek Subbasin. The projects will solve six flooding, four erosion, and eight habitat problems. *Figure 9-1* shows the location of the projects described below.

Table 9.10 CANYON CREEK Recommended CIPs

ID	*Project Name*	*Project Score*	*Estimated Cost*	*Priority*
CY-RST01	Canyon Creek Stream Corridor Restoration	238	Segment 1: 472,000 Segment 2: 472,000 Segment 3: 472,000 Segment 4: 472,000 Segment 5: 472,000 Segment 6: 472,000 TOTAL: 2,834,000	High
CY-SBS01	Canyon Creek Streambank Stabilization, Reach Downstream of 80th Street East	158	161,000	Medium
CY-SBS02	Streambank Stabilization, Reach Downstream of 72nd Street East	153	161,000	Medium
CY-SBS03	Streambank Stabilization on Reach Upstream of Second Canyon Road Crossing	163	161,000	Medium
CY-SBS04	Canyon Creek Streambank Stabilization Downstream of Second Canyon Road Crossing	163	322,000	Medium
CY-SL01	58th Avenue East Setback Levee from Canyon Creek	165	552,000	Medium
CY-DP02	90th Street East Detention Facility (D138-003)	184	1,586,000	Medium
CY-DP01	Canyon Creek Regional Detention	174	3,930,000	Medium
CY-FP01	Canyon Creek Driveway Culvert Replacement	108	89,000	Low
CY-RD02	104th Street East Road Raising & Culvert Replacement - East Fork of Canyon Creek	99	113,000	Low
CY-RD01	116th Street East Roadway Improvement - West Fork of Canyon Creek	97	137,000	Low
CY-AC01	Canyon Creek Property Acquisition at 5600 block of 104th Street E	73	204,000	Low
	Total Estimated Cost for Canyon Creek CIPs		**$10,250,000**	

Project Number: **CIP03-CY-RST01**

Project Name: **Canyon Creek Stream Corridor Restoration**

Cost Estimate: **$2,834,000**

Project Score: **238** **High-Priority**

Problem: This 7,000-foot reach of Canyon Creek between Pioneer Way East and the Clear Creek confluence is severely degraded with a straightened channel, disconnected floodplain, and reduced riparian buffer with invasive riparian and aquatic vegetation. The channel has also filled with fine sediment due to upstream erosion. Most of this reach is glide habitat with very few pools and a complete absence of large woody-debris. A large unclassified wetland area abuts the stream at this location. The USBEM Phase II habitat condition assessment rated this reach as having "Poor" habitat condition.

Restoration of the full 7,000 foot reach will be broken down by segments divided as follows:

Solution: Restore7,000-foot reach between Pioneer Way East and the confluence with Clear Creek. Remove invasive vegetation and restore riparian community with conifer plantings to provide shade. Install large woody-debris in channel to form pool aquatic habitat. Purchase 300-foot-wide easement from adjacent property owners where practical.

Restoration of the full 7,000 foot reach will be broken down by segments divided as follows:

Segment 1:	Pioneer Way East to 400' south of BNSF Railroad crossing	$472,000
Segment 2:	400' south to 800' northwest of BNSF Railroad crossing	$472,000
Segment 3:	800' northwest of BNSF Railroad crossing to 4700 block of Pioneer Way East	$472,000
Segment 4:	4700 block of Pioneer Way East to 600' southwest of 44th Street East	$472,000
Segment 5:	600' southeast to 600' northwest of 44th Street East	$472,000
Segment 6:	600' northwest of 44th Street East to Clear Creek confluence	$472,000

Benefit: This project provides high quality floodplain habitat in lower Canyon Creek. The project will solve riparian/aquatic habitat problems CY-23, CY-25, and CY-26.

Project Number: **CIP03-CY-SBS01**

Project Name: **Streambank Stabilization on Reach Downstream of 80th Street East**

Cost Estimate: **$161,000**

Project Score: **158** **Medium-Priority**

Problem: Streambank erosion due to high stream flow in reach 500 feet downstream of 80th Street East.

Solution: Place boulder clusters in scour hole at culvert outlet to provide energy dissipation. Install streambank stabilization measures such as porous weirs or drop structures in 500-foot reach in vicinity of 80th Street East. Purchase 40-foot-wide easement from adjacent landowners.

Benefit: This project stabilizes streambanks and reduces erosion in Canyon Creek. This project will help to reduce a source of fine sediment to Canyon and Clear Creek. This project solves erosion and riparian/aquatic habitat problem CL-18.

Project Number: **CIP03-CY-SBS02**

Project Name: **Streambank Stabilization on Reach Downstream of 72nd Street East**

Cost Estimate: **$161,000**

Project Score: **153** **Medium-Priority**

Problem: Streambank erosion due to high stream flow in 500-foot-long reach downstream of 72nd Street East. Exposed vertical banks 12-feet-high and culvert perched 3 feet above eroded stream channel.

Solution: Install streambank stabilization measures such as roughened rock toes, porous weirs or drop structures in 500-foot reach downstream of 72nd Street East. Install boulder cluster at culvert outfall for energy dissipation. Purchase 40-foot-wide easement from adjacent landowners.

Benefit: Stabilizes streambanks and reduces erosion in Canyon Creek. This project will help to reduce a source of fine sediment to Canyon and Clear Creek. This project solves problem erosion and riparian/aquatic habitat CL-22.

Project Number: **CIP03-CY-SBS03**

Project Name: **Streambank Stabilization on Reach Upstream of Second Canyon Road Crossing**

Cost Estimate: **$161,000**

Project Score: **163** **Medium-Priority**

Problem: Streambank erosion due to high stream flow in 500-foot-long reach upstream of second Canyon Road crossing.

Solution: Install streambank stabilization measures such as roughened rock toes, porous weirs or drop structures in reach upstream of second Canyon Road crossing. Purchase 40-foot-wide easement from adjacent landowners.

Benefit: Stabilizes streambanks and reduces erosion in Canyon Creek. This project will help to reduce a source of fine sediment to Canyon and Clear Creek. The project solves problem erosion and riparian/aquatic habitat CL-20.

Project Number: **CIP03-CY-SBS04**

Project Name: **Streambank Stabilization Downstream of Second Canyon Road Crossing**

Cost Estimate: **$322,000**

Project Score: **163** **Medium-Priority**

Problem: Streambank erosion due to high stream flow in 500-foot-long reach upstream of second Canyon Road crossing.

Solution: Install streambank stabilization measures such as roughened rock toes, porous weirs or drop structures in reach upstream of second Canyon Road crossing. These types of structures direct the energy of the flowing water away from the streambanks and towards the center of the stream. Purchase 40-foot-wide easement from adjacent landowners.

Benefit: Stabilizes streambanks and reduces erosion in Canyon Creek. This project will help to reduce a source of fine sediment to Canyon and Clear Creek. This project solves problem erosion and riparian/aquatic habitat CL-21.

Project Number: **CY-SL01**

Project Name: **58th Avenue East Property Acquisition with Setback Levee**

Cost Estimate: **$552,000**

Project Score: **165** **Medium-Priority**

Problem: The East Fork of Canyon Creek has limited conveyance capacity in this reach due to a flat slope and a shallow channel. Road and property flooding occurs during the 10-year peak flood event under existing land use conditions, increasing to the 2-year peak flood event under future land use conditions. Flooding also occurs on 58th Street East due to an obstructed ditch and culvert system. The problem was validated during field reconnaissance in February 2003. This area is zoned for High-Density Residential. Conversion to this type of land use can result in loss of floodplain and an increase in effective impervious area. This area also contains a partially verified, unclassified wetland.

Solution: Acquire 11 acres of floodplain and wetland in this area to preserve the existing floodplain storage. A 625-foot-long setback levee would be installed on west side of 58th Avenue East to prevent flooding on 58th Avenue East. The project also includes the installation of new storm drain system on 124th Street Court East and 59th Avenue East to reestablish the drainage system in this area.

Benefit: This project eliminates roadway flooding at 58th Avenue East. This project also provides a habitat benefit by preserving wetland floodplain storage. The project solves flooding problem CY-5.

Project Number: **CIP03-CY-DP02**

Project Name: **90th Street East Detention**

Cost Estimate: **$1,586,000**

Project Score: **184** **Medium-Priority**

Problem: Extensive flooding occurs at 90th Street East crossing of Canyon Creek.

Solution: The County is in the process of designing an off-channel detention pond to address the problem. Install twin 48-inch-diameter concrete culverts at 88th Street East. Excavate 8-acre-feet of compensatory storage in the floodplain south of 90th Street East. This project is partially documented in the Canyon Creek Bypass Pipeline Design Report (Pierce County, 2002).

Benefit: This project eliminates property flooding at 90th Street East. The project solves flooding problem CY-1.

Project Number: **CIP03-CY-DP01**

Project Name: **Canyon Creek Regional Detention**

Cost Estimate: **$3,930,000**

Project Score: **174** **Medium-Priority**

Problem: High stream flow rates have caused extensive channel erosion in vicinity of 80th Street E, 72nd Street East and the second Canyon Road Crossing. Eroded sediments wash down in the floodplain channel and accumulate on the channel bottom. The streambank stabilization projects CIP03-CY-SBS01, 02, 03, and –04 will require peak flow reduction if they are to maintain viability over the long-term. Peak flow reduction is also needed to reduce or eliminate streambank erosion in the streams in the future.

Solution: Construct 34 acre-feet of detention storage (at one or more locations) in the Canyon Creek Subbasin upstream of 72nd Street East. Additional hydrologic analysis and a geotechnical investigation prior to project design is needed to accurately define detention volume and the target release rate. The type of streambank stabilization measures should also be considered when establishing the target release rate.

Benefit: Reduces peak stream flow rates in the Canyon Creek Subbasin, which reduces erosion and helps to maintain the long-term viability of the channel stabilization projects. With proper design of the outlet structure, it may be possible to provide a mitigate some of the impacts of the altered hydrology of the system. This project solves erosion and riparian/aquatic habitat problems CY-18, CY-20, CY-22, and CY-23. The project has the potential to provide a flood control benefit and solve flooding problems CY-3, CY-5, CY-10 if some or all of the detention is located upstream of these problem locations.

Project Number: **CIP03-CY-FP01**

Project Name: **Private Driveway Culvert Replacement**

Cost Estimate: **$89,000**

Project Score: **108** **Low-Priority**

Problem: The driveway culverts located in the public right-of-way of the 4200 block of Pioneer Way East have been classified as a barrier to fish passage by the Pierce Conservation District. A second culvert is located upstream at an abandoned driveway, but the barrier status is unknown.

Solution: Replace the existing driveway culvert with a 53-foot-long, 12-foot-span, 5-foot rise box culvert countersunk into the channel by 20 %. Removal of the upstream culvert with the unknown barrier status is recommended because the stream crossing is not used anymore.

Benefit: Replacing this structure will improve access to an additional 3,900 feet of fish habitat in Canyon Creek. This project will solve riparian/aquatic habitat problem CY-28.

Project Number: **CY-RD02**

Project Name: **104th Street East Roadway Improvement & Culvert Replacement Problem - East Fork**

Cost Estimate: **$113,000**

Project Score: **99** **Low-Priority**

Problem: The hydraulic analysis showed that roadway overtopping occurs during the 10-year peak flood event under existing land use conditions increasing to the 2-year peak flood event under future land use conditions.

Solution: Raise roadway 2.0 feet to 422.0 feet NGVD and install a 4-foot-span by 1-foor-rise concrete box culvert above the existing culvert. This project would result in a 0.5-foot reduction in the water surface elevation for the 100-year event. No downstream impacts area expected because channel conditions control the water surface upstream of the culvert and the floodplain storage is essentially unchanged.

Benefit: This project eliminates roadway flooding at 104th Street East. This project solves flooding problem CY-5.

Project Number: **CY-RD01**

Project Name: **116th Street East Roadway Improvement - West Fork**

Cost Estimate: **$137,000**

Project Score: **97** **Low-Priority**

Problem: The hydraulic analysis predicted roadway overtopping at the Canyon Creek crossing of 116th Street E, just west of Canyon Rd during the 2-year peak flood event under existing and future land use conditions. Water on Road sign and evidence of roadway overtopping was observed during site visit in February 2003. Also, downstream culverts on 112th Street East and SR-512 cause excessive backwater in this area. A 15-inch-diamter pipeline is located at 112th Street East and frequently becomes clogged with debris and causes additional flooding at 116th Street East.

Solution: Raise 200-lineal-feet of road 1.5 feet to elevation 462.0 feet NGVD. Install additional 18-inch diameter culvert adjacent to existing culvert to equalizing surface water ponding levels on both sides of the road. Replace 15-inch-diamter pipe at 112th Street East with a 24-inch-diamter pipe.

Benefit: This project eliminates roadway flooding at 116th Street East. The project solves flooding problem CY-3.

Project Number: **CY-AC01**

Project Name: **Property Acquisition at 5600 block of 104th Street East**

Cost Estimate: **$205,000**

Project Score: **73** **Low-Priority**

Problem: A resident reported flooding on at least two occasions, probably due to backwater from the 103rd Street East culvert.

Solution: Buy the property at this location. The 1991 Plan showed this culvert having insufficient conveyance capacity.

Benefit: This project solves flooding problem CY-30.

Rody Creek Subbasin Projects

Seven projects were developed for the Rody Creek Subbasin. The projects will solve three flooding, two erosion, and three habitat problems. *Figure 9-2* shows the location of the projects described below.

Table 9.11 RODY CREEK Recommended CIPs

ID	*Project Name*	*Project Score*	*Estimated Cost*	*Priority*
RY-RST01	Stream Corridor Restoration	303	Segment 1: 410,000 Segment 2: 410,000 Segment 3: 410,000 TOTAL: 1,231,000	High
RY-SBS01	Streambank Stabilization Project at 72nd Street East	155	35,000	Medium
RY-SBS02	Streambank Stabilization at 80th Street East	160	66,000	Medium
RY-DP01	Rody Creek Regional Detention Facility Expansion	123	1,313,000	Medium
RY-SWL01	62nd Avenue East Drainage Swale, Rody Creek Basin	32	17,000	Low
RY-CR01	Rody Creek at Pipeline Road & 96th Street East Culvert Replacement	65	19,000	Low
RY-CR02	Rody Creek 98th Street East Culvert Replacement	89	31,000	Low
RY-RD01	Rody Creek 90th Street East Raise Roadway	84	75,000	Low
	Total Estimated Cost for Rody Creek CIPs		$2,787,000	

Project Number: **CIP03-RY-RST01**

Project Name: **Rody Creek Stream Corridor Restoration**

Cost Estimate: **$1,231,000**

Project Score: **303** **High-Priority**

Problem: This 2,200-foot reach of Rody Creek between Pioneer Way East and the Clarks Creek confluence is severely degraded with a straightened channel, disconnected floodplain, and reduced riparian buffer with invasive riparian and aquatic vegetation. The channel has also filled with fine sediment due to upstream erosion. This reach is classified as riffle habitat with no pools and only a few pieces of large woody-debris. The USBEM Phase II habitat condition assessment rated this reach as having "Poor" habitat condition.

Solution: Restore 2,200-foot reach between Pioneer Way East and Clarks Creek confluence, removing invasive vegetation and enhancing the riparian community with conifer plantings to provide shade. Install large woody-debris in channel to form pool aquatic habitat. Purchase 300-foot-wide conservation easement from adjacent landowners.

Restoration of the full 2,200 foot reach will be broken down by segments divided as follows:

Segment 1:	Reach 700 feet downstream of Pioneer Way East	$410,000
Segment 2:	700 feet reach downstream of Pioneer Way East to 700 feet upstream of Clarks creek confluence	$410,000
Segment 3:	Reach 700 feet upstream of Clarks creek confluence	$410,000

Benefit: This project provides high quality aquatic habitat in lower Rody Creek. The project solves riparian/aquatic habitat problem RY-16.

Project Number: **CIP03-RY-SBS01**

Project Name: **Streambank Stabilization at 72nd Street East**

Cost Estimate: **$35,000**

Project Score: **155** **Medium-Priority**

Problem: High stream flow in Rody Creek has caused channel downcutting downstream of 72nd Street East. The culvert outlet at this location is perched three-feet above the channel.

Solution: Install streambank stabilization measures such as roughened rock toes, porous weirs and drop structures. These types of structures direct the energy of the flowing water away from the streambanks and towards the center of the stream. Boulder clusters should be installed at the 72nd Street East culvert outlet for energy dissipation. Purchase 40-foot-wide easement from adjacent landowners.

Benefit: This project stabilizes streambanks and reduces erosion in Rody Creek. The project will help to reduce a source of fine sediment to Clarks Creek. This project will solve erosion and riparian/aquatic habitat problems RY-14.

Project Number: **CIP03-RY-SBS02**

Project Name: **Streambank Stabilization at 80th Street East**

Cost Estimate: **$66,000**

Project Score: **160** **Medium-Priority**

Problem: Streambank stabilization measures of Rody Creek at 6100 block of 80th Street East appear to be weakening and may cause property damage if they fail.

Solution: Install streambank stabilization measures such as porous weirs or drop structures in 200-foot reach downstream of 80th Street East. Purchase 40-foot-wide easement from adjacent landowners.

Benefit: This project stabilizes streambanks and reduces erosion in Rody Creek. This project will help to reduce a source of fine sediment to Clarks Creek. The project also provides a public safety benefit by restabilizing the streambank and protecting the adjacent structure. The project will solve erosion and riparian/aquatic habitat problem RY-3.

Project Number: **CIP03-RY-DP01**

Project Name: **Rody Creek Regional Detention Facility Expansion**

Cost Estimate: **$1,313,000**

Project Score: **123** **Medium-Priority**

Problem: The streambank stabilization projects described above will require peak flow reduction if they are to maintain viability over the long-term. Peak flow reduction is also needed to reduce or eliminate streambank erosion in the streams in the future. Floodplain storage lost with culvert improvement projects CIP03-RY-CR01 and –02 needs to be replaced.

Solution: Expand existing Rody Creek regional detention facility by 10 acre-feet. Optimize pond operation to fully utilize detention storage volume. Additional hydrologic analysis and a geotechnical investigation prior to project design is needed to accurately define detention volume and the target release rate. The type of streambank stabilization measures should also be considered when establishing the target release rate.

Benefit: This project will reduce peak stream flow rates in the Rody Creek Subbasin, which reduces erosion and helps to maintain the long-term viability of the channel stabilization projects. With proper design of the outlet structure, it may be possible to provide a mitigate some of the impacts of the altered hydrology of the system. The project solves erosion and riparian/aquatic habitat problems RY-1 and RY-3 and also provides detention storage for increases in peak flow due to projects CIP03-RY-CR01 and CIP03-RY-CR02.

Project Number: **CIP03-RY-SWL01**

Project Name: **62nd Avenue East Drainage Swale**

Cost Estimate: **$17,000**

Project Score: **32** **Low-Priority**

Problem: Private property flooding at 11600 block of 62nd Avenue East due to roadway runoff from 62nd Avenue East.

Solution: Install 4-inch driveway berm at 11600 block of 62nd Avenue East. Obtain drainage easement through property and excavate drainage swale from 62nd Avenue East to Rody Creek.

Benefit: This project will eliminate private property flooding at the 11600 block of 62nd Street East. The project will solve flooding problem RY-5.

Project Number: **CIP03-RY-CR01**

Project Name: **Pipeline Road and 96th Street East Culvert Replacement**

Cost Estimate: **$19,000**

Project Score: **65** **Low-Priority**

Problem: Hydraulic analysis predicted road and property flooding of Rody Creek at Pipeline Road and 96th Street East during the 25-year and 10-year peak flood events under existing and future land use conditions, respectively. This problem was validated during field reconnaissance in February 2003.

Solution: Replace existing 18-inch diameter culvert at 96th Street East with a 30-inch diameter culvert. The existing Rody Creek detention facility located downstream has excess capacity and would be used to mitigate the expected increase in peak flows caused by this project.

Benefit: This project will eliminate flooding at 96th Street East. This project will solve flooding problem RY-7.

Project Number: **CIP03-RY-CR02**

Project Name: **98th Street East Culvert Replacement**

Cost Estimate: **$31,000**

Project Score: **89** **Low-Priority**

Problem: The hydraulic analysis predicted road and property flooding of Rody Creek at 98th Street East during the 100-year peak flood events under existing and future land use conditions. A resident of the area reported that this culvert clogs with debris on an annual basis, flooding private property and septic drain fields.

Solution: This project replaces the existing 24-inch diameter culvert with a 30-inch diameter culvert. An emergency overflow pipe should be installed on the upstream end of the culvert to allow overflow should the inlet become obstructed. The existing Rody Creek detention facility located downstream has excess capacity and would be used to mitigate the expected increase in peak flows caused by this project.

Benefit: This project will eliminate flooding at 98th Street East. The project will solve flooding problem RY-8.

Diru Creek Subbasin Projects

Three projects were developed for the Diru Creek Subbasin. The projects will solve one flooding, two erosion, and three habitat problems. *Figure 9-2* shows the location of the projects described below.

Table 9.12 DIRU CREEK Recommended CIPs

ID	*Project Name*	*Project Score*	*Estimated Cost*	*Priority*
DU-SBS01	Diru Creek Streambank Stabilization at 72nd St East	164	35,000	Medium
DU-RST01	Diru Creek Stream Restoration Downstream of Pioneer Way East	226	Segment 1: 410,000 Segment 2: 410,000 Segment 3: 410,000 1,231,000	Medium
DU-DP01	Diru Creek Regional Detention	105	2,977,000	Low
	Total Estimated Cost for DIRU Creek CIPs		**$4,243,000**	

Project Number: **CIP03-DU-SBS01**

Project Name: **Streambank stabilization at 72nd Street East**

Cost Estimate: **$35,000**

Project Score: **164** **Medium-Priority**

Problem: High stream flow in Diru Creek has caused channel downcutting downstream of 72nd Street East. Channel incision is about 8 feet deep. The culvert outlet at this location is perched above the channel.

Solution: Install streambank stabilization measures such as roughened rock toes, porous weirs and drop structures. These types of structures direct the energy of the flowing water away from the streambanks and towards the center of the stream. Boulder clusters should be installed at the 72nd Street East culvert outlet for energy dissipation. Purchase 40-foot-wide easement from adjacent landowners.

Benefit: This project stabilizes streambanks and reduces erosion in Diru Creek. This project will help to reduce a source of fine sediment to Clarks Creek. The project will solve erosion problem DU-11.

Project Number: **CIP03-DU-RST01**

Project Name: **Diru Creek Stream Corridor Restoration Downstream of Pioneer Way East**

Cost Estimate: **$1,231,000**

Project Score: **226** **Medium-Priority**

Problem: The 2,200-foot reach of Diru Creek between Pioneer Way East and the Clarks Creek confluence is severely degraded with a straightened channel, disconnected floodplain, and reduced riparian buffer with invasive riparian and aquatic vegetation. The channel has also filled with fine sediment due to upstream erosion. This reach was not included in the field investigation. However, poor habitat conditions, similar to conditions observed in Clear, Canyon and Rody Creek were noted during field reconnaissance. Private property flooding has been reported due to an undersized driveway culvert upstream of Clarks Creek.

Solution: Restore a 2,200-foot reach between Pioneer Way East and Clarks Creek confluence, removing invasive vegetation and enhancing the riparian community with conifer plantings to provide shade. Install large woody-debris in the channel to form pool aquatic habitat. Purchase a 300-foot-wide conservation easement from adjacent landowners where practical. The existing driveway culvert would be removed when the stream is relocated which would eliminate property flooding.

Restoration of the full 2,200 foot reach will be broken down by segments divided as follows:

Segment 1:	Reach 700 feet downstream of Pioneer Way East	$410,000
Segment 2:	700 feet reach downstream of Pioneer Way East to 700 feet upstream of Clarks creek confluence	$410,000
Segment 3:	Reach 700 feet upstream of Clarks creek confluence	$410,000

Benefit: This project provides high quality floodplain habitat in lower Diru Creek. This project solves riparian/aquatic habitat problem DU-10, DU-13, and flooding problem DU-14.

Project Number: **CIP03-DU-DP01**

Project Name: **Diru Creek Regional Detention**

Cost Estimate: **$2,977,000**

Project Score: **105** **Medium-Priority**

Problem: High stream flow rates have caused extensive channel erosion in vicinity of 80th Street East, 72nd Street East and the second Canyon Road Crossing. Eroded sediments wash down in the floodplain channel and accumulate on the channel bottom. The streambank stabilization projects CIP03-DU-SBS01 will require peak flow reduction if they are to maintain viability over the long-term. Peak flow reduction is also needed to reduce or eliminate streambank erosion in the streams in the future.

Solution: Construct 20 acre-feet of detention storage (at one or more locations) in the Diru Creek Subbasin upstream of 72nd Street East. Additional hydrologic analysis and a geotechnical investigation prior to project design is needed to accurately define detention volume and the target release rate. The type of streambank stabilization measures should also be considered when establishing the target release rate.

Benefit: This project will reduce peak stream flow rates in the Diru Creek Subbasin, which reduces erosion and helps to maintain the long-term viability of the channel stabilization projects. With proper design of the outlet structure, it may be possible to provide a mitigate some of the impacts of the altered hydrology of the system. The project solves erosion problem DU-11

Woodland Creek Subbasin Projects

Six projects were developed for the Woodland Creek Subbasin. These projects will solve three flooding, two erosion, and five habitat problems. *Figure 9-2* shows the location of the projects described below.

Table 9.13 WOODLAND CREEK Recommended CIPs

ID	*Project Name*	*Project Score*	*Estimated Cost*	*Priority*
WO-RST01	Woodland Creek Stream Corridor Restoration	265	Segment 1: 490,000 Segment 2: 490,000 Segment 3: 490,000 TOTAL: 1,470,000	High
WO-SBS01	Woodland Creek Streambank Stabilization at 84th Street East	150	305,000	Medium
WO-SBS02	Woodland Creek Stream Bank Stabilization at 80th Street E	142	357,000	Medium
WO-DP01	Woodland Avenue Flood Control Phase II	155	2,960,000	Medium
WO-CR02	Woodland Creek 80th Street East Culvert Replacement	88	27,000	Low
WO-CR01	Woodland Creek & 72nd Avenue East Culvert Replacement Project - 93rd Street East to 96th Street East	105	102,000	Low
	Total Estimated Cost for Woodland Creek CIPs		**$5,221,000**	

Project Number: **CIP03-WO-RST01**

Project Name: **Woodland Creek Stream Corridor Restoration**

Cost Estimate: **$1,470,000**

Project Score: **265** **High-Priority**

Problem: The 1,800 reach of Woodland Creek between Pioneer Way East and the confluence with Clarks Creek has been channelized and disconnected from the floodplain. This reach has a reduced buffer and invasive riparian and aquatic vegetation have replaced the native species. The 1000-foot-long culvert under the WSU Experimental Farm is a velocity barrier to fish passage. This reach was not included in the field investigation. However, poor habitat conditions, similar to conditions observed in Clear, Canyon and Rody Creek were noted during field reconnaissance.

Solution: Widen the floodplain and restoring stream meanders, removing invasive vegetation and enhancing the riparian community with conifer plantings to provide shade. Install large woody-debris to form pool aquatic habitat. Purchase 300-foot-wide conservation easement from adjacent landowners where practical. Replace culvert with two 20-foot long, single-span bridge.

Restoration of the full 1,800 foot reach will be broken down by segments divided as follows:

Segment 1:	Pioneer Way East to Pipeline Inlet	$490,000
Segment 2:	South 550 feet of pipeline	$490,000
Segment 3:	North 550 feet of pipeline	$490,000

Benefit: This project provides high quality floodplain habitat in lower Canyon Creek. Replacing WSU culvert will improve access to an additional 4,000 feet of fish habitat in Woodland Creek. The project solves riparian/aquatic habitat problems WO-23 and WO-29.

Project Number: **CIP03-WO-SBS01**

Project Name: **Streambank/Channel Stabilization at 84th Street East**

Cost Estimate: **$305,000**

Project Score: **150** **Medium-Priority**

Problem: High stream flows have caused channel down cutting with 5-foot-deep channel incision in reach downstream of 84th Street East. Local scour at outlet of culvert under 84th Street East with 12-foot-high cascade immediately downstream. Sedimentation in channel and floodplain upstream of 80th Street East caused by upstream erosion activity.

Solution: Install streambank stabilization measures such as drop structures and bank reshaping in 750 foot-long reach downstream of 84th Street. Plant woody material and herbaceous cover in floodplain upstream of 80th Street East to stabilize deposited material.

Benefit: This project stabilizes streambanks and reduces erosion in Woodland Creek. This project will help to reduce a source of fine sediment to Clarks Creek. This project solves erosion problems WO-24, and WO-25, and riparian/aquatic habitat problem WO-26.

Project Number: **CIP03-WO-SBS02**

Project Name: **Streambank Stabilization at 80th Street E**

Cost Estimate: **$357,000**

Project Score: **142** **Medium-Priority**

Problem: Streambank erosion and channel down cutting downstream of 80th Street East due to high stream flow. Three-foot deep channel incision. Reduced riparian buffer.

Solution: Install streambank stabilization measures such as porous weirs or drop structures in 800-foot reach downstream of 80th Street East. Remove reed blackberry and other invasive aquatic vegetation and plant conifers to provide shade. Purchase 200-foot-wide easement from adjacent landowners.

Benefit: This project stabilizes streambanks and reduces erosion in Woodland Creek. This project will help to reduce a source of fine sediment to lower Woodland and Clarks Creek. This project solves problems erosion and riparian/aquatic habitat problem WO-27.

Project Number: **CIP03-WO-DP01**

Project Name: **Woodland Avenue Flood Control Phase II CIP**

Cost Estimate: **$2,960,000**

Project Score: **155** **Medium-Priority**

Problem: Long term and extensive inundation south of 102nd Street East caused by limited conveyance capacity of storm drain system under 102nd Street East. This area has a limited surface outlet with outflow controlled by the storm drain system under 102nd Street East. The hydraulic and hydrologic analysis predicted roadway flooding would occur at 105th Street E, 106th Street E, 112th Street E, 104th Street E, and Woodland Avenue East. There were also numerous reports of property flooding in this area during the 1997 flood event.

Solution: The County is currently designing two regional detention ponds for this area. These ponds would have a combined volume of almost 40 acre-feet and would reduce the 100-year flood elevation by 1.7 feet.

Benefit: This project will reduce private property flooding and eliminate roadway flooding in the Woodland Avenue and 112th Street East area. This project solves flooding problem WO-2.

Project Number: **CIP03-WO-CR02**

Project Name: **80th Street East Culvert Replacement**

Cost Estimate: **$27,000**

Project Score: **88** **Low-Priority**

Problem: The hydraulic analysis predicted road flooding at a 2-year peak flood event under existing land use conditions and the 1-year peak flood event under future land use conditions.

Solution: Replace the existing culvert with 4-foot-span by 4-foot-rise concrete box culvert. This project is not expected to increase flows downstream because the Woodland Creek channel is relatively steep and narrow in this reach with very little floodplain storage. This culvert was also identified as a fish passage barrier during the field habitat investigation.

Benefit: This project eliminates roadway flooding at 80th Street East. Replacing this structure will improve access to an additional 300 feet of fish habitat in Woodland Creek. The project solves flooding and riparian/aquatic habitat problem WO-8.

Project Number: **CIP03-WO-CR01**

Project Name: **72nd Avenue East Culvert Replacement - 93rd Street East to 96th Street E**

Cost Estimate: **$102,000**

Project Score: **105** **Low-Priority**

Problem: The hydraulic analysis showed that Woodland Creek overtops 93rd Street Court E, 94th Street Court East and two driveway culverts at a 1-year peak flood event under existing and future land use conditions.

Solution: Replace two existing 20-inch diameter concrete culverts under driveways at 9500 block of 72nd Avenue East with 3-foot-span by 1.5-foot-rise concrete box culverts. Replace two 24-inch diameter CPEP culverts under 93rd Street East and 94th Street East with 3-foot-span by 1.5-foot-rise concrete box culverts. Maintain existing invert elevations. Total length of replacement culverts is 300 lineal feet. Recommend surveying of design area and reanalyzing before project implementation. This project is not expected to increase flows downstream because the Woodland Creek channel is relatively steep and narrow in this reach with very little floodplain storage.

Benefit: This project eliminates roadway flooding in the 9500 block of 72nd Street East. The project solves flooding problem WO-6.

Clarks Creek Subbasin Projects

Six projects were developed for the Clarks Creek Subbasin. These projects will solve three flooding, and four habitat problems. *Figure 9-2* shows the location of the Clarks Creek CIP projects.

Table 9.14 CLARKS CREEK Recommended CIPs

ID	*Project Name*	*Project Score*	*Estimated Cost*	*Priority*
CK-RST01	Clarks Creek Stream Corridor Restoration	231	Segment 1: 470,000 Segment 2: 470,000 Segment 3: 470,000 Segment 4: 470,000 Segment 5: 470,000 Segment 6: 470,000 Segment 7: 470,000 TOTAL: 3,287,000	High
CK-SP01	Clarks Creek State Hatchery Sedimentation Basin Retrofit	174	73,000	Medium
CK-PL01	112th Street East Pipeline (Woodland Elementary School)	133	180,000	Medium
CK-AC01	Clarks Creek Property Acquisition at 104th Street East	168	188,000	Medium
CK-PL02	Fruitland Avenue Pipeline - 104th Street E to 96th Street E	164	399,000	Medium
Total Estimated Cost for Clarks Creek CIPs			**$4,127,000**	

Project Number: **CIP03-CK-RST01**

Project Name: **Clarks Creek Stream Corridor Restoration**

Cost Estimate: **$3,287,000**

Project Score: **231** **High-Priority**

Problem: The 2.4-mile reach of Clarks Creek between the Puyallup River confluence and Puyallup City Limits has filled with fine sediment due to upstream erosion activity. This reach also has a reduced buffer and invasive riparian and aquatic vegetation has replaced the native species. All of this reach is glide habitat with no pools and very few pieces of large woody-debris. Sedimentation and the excessive growth of elodea and other nuisance aquatic plants have caused Clarks Creek to overflow its banks resulting in property flooding in the vicinity of Tacoma Road, Stewart Avenue, and 66th Avenue East. The USBEM Phase II habitat condition assessment rated the portion of this reach upstream of Stewart Road as having "Poor" habitat condition.

Solution: Enhance the floodplain in the 2.4-mile reach between Pioneer Way East and the confluence with Clear Creek. Based on current development patterns, it is likely that enhancement is practical in only about 2/3 of the reach, or 8,000 feet. Remove the invasive vegetation and plant the riparian community would be planted with conifers to provide shade. Purchase 150-foot-wide conservation easement from adjacent landowners where practical. The scope of this project may be significantly reduced if the restoration projects for Rody, Diru, and Woodland Creeks.

Restoration of the 2.4 mile reach will be broken down by segments divided as follows:

Segment 1: Puyallup City Limits to Woodland Creek confluence	$470,000
Segment 2: Woodland Creek confluence to 400-feet downstream of Diru Creek confluence	$470,000
Segment 3: 400-feet downstream of Diru Creek confluence to Stewart Avenue East	$470,000
Segment 4: Stewart Avenue East to second crossing of 66th Avenue East	$470,000
Segment 5: Second crossing of 66th Avenue East to 56th Street East	$470,000
Segment 6: 56th Street East to 52nd Street East (extended)	$470,000
Segment 7: 52nd Street East (extended) to Puyallup River	$470,000

Benefit: This project improves floodplain habitat Clarks Creek. The project solves problems riparian/aquatic habitat CK-1, CK-13 CK-14 CK-16.

Project Number: **CIP03-CK-SP01**

Project Name: **State Hatchery Sedimentation Basin Retrofit**

Cost Estimate: **$73,000**

Project Score: **174** **Medium-Priority**

Problem: Erosion from peak storm surges upstream of the WDFW hatchery. Upstream erosion has filled the Clarks Creek channel with fine sediments. These sediments have covered the native gravels used for fish spawning, contributed to water quality problems, and caused flooding problems due to restricted conveyance capacity.

Solution: Retrofit existing basin above State fish hatchery to serve as a sedimentation basin. Excavate sediment from existing facility and install a control structure. Implementation of this project will require coordination with the City of Puyallup and Washington State Department of Fish and Wildlife. A reduced sediment load is expected to allow flow in Clarks Creek channel to flush out the existing fine sediments over time.

Benefit: This project eliminates a source of sediment in Clarks Creek. A reduced sediment load is expected to allow flow in Clarks Creek channel to flush out the existing fine sediments over time. This project solves riparian/aquatic habitat problem CK-14.

Project Number: **CIP03-CK-PL01**

Project Name: **112th Street Drainage Improvement (Woodland Elementary School)**

Cost Estimate: **$180,000**

Project Score: **133** **Medium-Priority**

Problem: Hydraulic analysis predicted road and property flooding due to undersized storm drain system under Woodland Elementary School during the 10-year peak flood event under existing land use conditions increasing to the 2-year peak flood event under future land use conditions.

Solution: Replace existing storm drain system with 850-foot-long, 48-inch-diameter storm drain system from 112th Street East crossing to discharge outfall to detention pond behind school.

Benefit: This project eliminates private property and roadway flooding at 112th Street East. The project solves flooding problem CK-9.

Project Number: **CIP03-CK-AC01**

Project Name: **Property Acquisition - 9200 Block of 104th Street E**

Cost Estimate: **$188,000**

Project Score: **168** **Medium-Priority**

Problem: Property and structure flooding occur at this location because the structure is located in the floodplain. The structure is nearly at the level of the creek.

Solution: Acquire flood-prone property.

Benefit: This project eliminates a flood hazard at this location by acquiring property and removing the flood-prone structure. This project may also benefit floodplain habitat if the acquired property is restored to its natural function. This project solves flooding problem CK-2.

Project Number: **CIP03-CK-PL02**

Project Name: **Fruitland Avenue Pipeline - 104th Street East to 96th Street E**

Cost Estimate: **$399,000**

Project Score: **164** **Medium-Priority**

Problem: The existing ditch and culvert system on Fruitland Avenue East near 104th Street East is undersized and a chronic maintenance problem. Plugged culverts and ditch overtopping have been reported at Fruitland Avenue, 104th Street E, 109th Street E, 146th Street E, and 142nd Avenue East.

Solution: Replace the existing ditch and culvert system with a 2,800-foot-long 12- to 24-inch-diameter storm drain system along the west side of Fruitland Avenue East from 104th Street East to 96th Street East. Connect the new system to the existing ditch and culvert system on the south side of 96th Street East, which discharges to Clarks Creek.

Benefit: This project eliminates nuisance roadway flooding on Fruitland Avenue East. The project solves flooding problem CK-10.

Potholes Subbasin Projects

Seven projects were developed for the Potholes Subbasin. These projects will solve six flooding problems. *Figure 9-3* shows the location of the projects described below.

Table 9.15 POTHOLES Recommended CIPs

ID	*Project Name*	*Project Score*	*Estimated Cost*	*Priority*
PH-1P01	128th Street East Infiltration Pond	346	469,000	High
PH-PL04	144th and 94th Avenue E Pipeline 135th Street Pothole	252	1,282,000	High
PH-PL05	Springfield Pothole Pipeline Project	124	379,000	Medium
PH-PL03	136th Street Pipeline, 135th Street Pothole	190	509,000	Medium
PH-PL06	South Hill Pump Station Discharge Pipeline	181	2,466,000	Medium
PH-PL01	92nd Ave East Storm Drainage Pipeline	115	34,000	Low
PH-PL02	156th Street East Regional Pipeline	120	288,000	Low
	Total Estimated Cost for Potholes CIPs		$5,427,0000	

Project Number: **CIP03-PH-IP01**

Project Name: **128th Street East Infiltration Facility**

Cost Estimate: **$469,000**

Project Score: **346** **High-Priority**

Problem: Frequent roadway and private property flooding occurs at the 10300 block of 128th Street East due to undersized and clogged dry wells.

Solution: Construct a 1.2 acre-foot infiltration facility near 128th Street East, east of Meridian Avenue. Construct 1,000 feet of 24-inch-diamter storm along 128th Street East drain to convey stormwater from Meridian Avenue and residential areas to infiltration facility.

Benefit: This project solves flooding in the 10300 block of 128th Street East. The problem solves flooding problem PH-1.

Project Number: **CIP03-PH-PL04**

Project Name: **144th Street East and 94th Avenue East Regional Drainage Improvement (D174-003)**

Cost Estimate: **$1,282,000**

Project Score: **252** **High-Priority**

Problem: Drainage problems exist in three depressions along 144th St East between Meridian and 86th Ave. Drainage courses are not well defined and are easily overwhelmed by increased runoff due to the change from semi-rural character to medium residential and high-density commercial and public uses.

Solution: Acquire property at 9600 block of 144th Street East and excavate 12-acre-foot detention pond (D174-006 Alternative 3). Install 1500 lineal-feet of 24-inch-diamter and 580-lineal-feet of 36-inch-diamter CPEP storm sewer pipe from the 9600 block of 144th Street East to the Collingswood channel. Excavate Collingswood channel to Afdem Pit to provide additional conveyance capacity (D174-006 Alternative 1). Project CIP03-PH-PL02 is proposed to connect to this pipeline.

Benefit: Eliminates frequent roadway and private property flooding on 144th Street East. This project with CIP03-PH-PL04 solves flooding problems PH-14, PH15 and PH-18.

Project Number: **CIP03-PH-PL05**

Project Name: **Springfield Pothole Pipeline**

Cost Estimate: **$379,000**

Project Score: **124** **Low Priority**

Problem: Springfield Pothole overflows during large storm events and floods surrounding properties and adjacent low-lying residential areas.

Solution: Construct a 36-inch-diameter pipeline from the Springfield Pothole to the South Hill Pump Station. Install an additional 150 hp pump at the South Hill Pump Station. Acquire 6.4 acres surrounding Springfield pothole. Replace existing 24-inch-diamter culvert at 152nd Street East with a 36-inch-diameter pipe.

Benefit: This project solves extensive flooding in the Springfield Pothole Subbasin. The project will solve flooding problem PH-23.

Project Number: **CIP03-PH-PL03**

Project Name: **136th Street Pipeline**

Cost Estimate: **$509,000**

Project Score: **190** **Medium-Priority**

Problem: The Willow Tree subdivision on 98th Avenue Court East and 152nd Street East (west of Meridian Avenue) was constructed in a low-lying area adjacent to a natural wetland. The subdivision has a private infiltration facility, which overflows during periods of high groundwater. As a result, roads and property experience chronic flooding during heavy rains.

Solution: Construct 1600-lineal-feet of 24-inch diameter CPEP storm sewer due north from the 9600 block of 144th Street East to the 9th Street Pit located at 131Street East and 86th Avenue East. Acquire property at 9600 block of 144th Street East.

Benefit: This project eliminates roadway and property flooding in the Willow Tree subdivision and restores floodplain storage. The project with CIP03-PH-PL03 solves flooding problem PH-18.

Project Number: **CIP03-PH-PL06**

Project Name: **South Hill Pump Station Discharge Pipeline**

Cost Estimate: **$2,466,000**

Project Score: **181** **Medium-Priority**

Problem: The South Hill Pump Station leases a 42-inch pipeline owned by Tacoma Public Utilities (TPU) to transport floodwaters to the Puyallup River. The TPU pipeline exists to drain the McMillan Reservoir when maintenance is required. Pierce County Water Programs pays $30,000 annually for the right to use the TPU pipeline and energy dissipater on a temporary basis. A dedicated discharge pipeline is needed to protect the long-term viability of the South Hill Pump Station and related improvements and the investment of public funds associated with the improvements.

Solution: Construct a 42-inch force main from the existing force main that connects to the McMillan Reservoir outlet pipeline to the Puyallup River.

Benefit: This project provides a dedicated, permanent discharge line for the South Hill Pump Station.

Project Number: **CIP03-PH-PL01**

Project Name: **92nd Avenue East Storm Drain Improvement**

Cost Estimate: **$34,000**

Project Score: **115** **Low-Priority**

Problem: The hydraulic analysis predicted road and property flooding on 11500 block of 92nd Avenue East on a 5-year recurrence interval under existing land use conditions and a 2-yr recurrence interval under future land use conditions. The drainage system from 92nd Avenue East discharges into a 24-inch diameter pipeline located between two properties on 92nd Avenue East. The storm drain is undersized and causes surcharging in the catch basin inlet located in the front yard of one of the properties. The catch basin inlet is also located lower than the street.

Solution: Abandon the existing inlet and install and new inlet at the edge of the roadway. Construct a berm on the edge of the roadway to direct roadway runoff to the new inlet and away from private property.

Benefit: This project eliminates private property and roadway flooding in the 11500 block of 92nd Avenue East. This project solves problem PH-6.

Project Number: **CIP03-PH-PL02**

Project Name: **156th Street East Regional Drainage Improvements**

Cost Estimate: **$288,000**

Project Score: **120** **Low-Priority**

Problem: The hydraulic analysis showed that roadway and property flooding occurs at 156th Street East and on properties located in the 9700 block of 156th Street East and the 15700 block of 97th Avenue Court East. The existing storm drain system discharges north to a closed depression and is unable to freely discharge from the site.

Solution: Connect the 156th Street storm drain system to the proposed 144th Street East pipeline installed as part of the 144th Street East and 94th Avenue East Regional Drainage Improvement Project (CIP03-PH-PL03, D174-003) (KCM, 2002). Install 1500-foot-long, 24-inch diameter pipeline from outlet at 156th Street East to 152nd Street East. Outfall new pipeline to existing ditch on 152nd Street East and 96th Avenue East (private) and connect to proposed 144th Street East and 94th Avenue East regional drainage improvement project (D174-003). Purchase 20-foot-wide drainage easement along 96th Avenue East from adjacent landowners.

Benefit: This project eliminates private property and roadway flooding in the vicinity of 156th Street East and 97th Avenue Court East. This project solves flooding problem PH-15.

9.3.3 Programmatic Measures

Twelve (12) programmatic measures address drainage, water quality and habitat issues in the Clear/Clarks Creek Basin.

Table 9.16 Recommended Programmatic Measures by Priority

ID	*Project Name*	*Project Score*	*Estimated Cost*
High-Priority			
PRG00-02	Update Stormwater Management Standards (Manual)	380	6,200
PRG00-01	Low Impact Development Program	346	27,600
PRG00-11	Enhanced Cooperative Arrangements with Cities & Other Jurisdictions	315	38,000
PRG00-08	Establish a BMP Manual for Surface Water Maintenance Activities	427	43,600
PRG00-09	Invasive Species Management Program	420	43,600
PRG00-04	Land Acquisition Program for Flood Hazard Reduction & Storm Drainage Practices Impact Mitigation	389	56,100
PRG00-06	Create an Education, Outreach, & Technical Assistance Program	325	212,000
PRG00-05	Riparian & Wetland Restoration Program to Restore Flood Storage and Maintain Water Quality	325	692,100
PRG00-07	Surface Water Monitoring Program	244	985,000
	Basin Monitoring		422,000
PRG00-03	Increase Enforcement Inspections	398	1,272,000
	Subtotal for High-Priority Measures		**2,678,200**
Medium-Priority			
PRG00-12	Stormwater Facility Design Process	195	21,200
	Subtotal for Medium-Priority Measures		**21,200**
Low-Priority			
PRG00-10	Flood Disclosure Statements on Property Titles	128	22,400
	Subtotal for Low-Priority Measures		**22,400**
	Total Estimated Cost of Recommended Programmatic Measures		**$2,721,800**

Each programmatic measure is described below.

Project Number: **PRG00-02**

Project Name: **Adopt Updated Stormwater Management Standards**

Cost Estimate: **$6,200**

Cost Assumptions: **Includes 0.25 FTE as a one-time, one-year cost. Prorated for the Clear/Clarks Creek Basin share of the countywide cost (21.2 %)**

Project Score: **380** **High-Priority**

The Washington State Department of Ecology provided local jurisdictions, including Pierce County, with updated guidance on stormwater management standards with issuance of the 2001 Stormwater Management Manual for Western Washington. Adoption of either Ecology's manual or an equivalent manual is required for all municipalities currently covered under the National Pollutant Discharge Elimination System (NPDES) Municipal Stormwater Permit. The County should also consider adopting the optional flow duration standard for systems that drain to canyon reaches. This standard matches the existing flow duration and helps to prevent erosion in the steep, erosion-prone reaches.

Project Number: **PRG00-01**

Project Name: **Establish a Low Impact Development Program**

Cost Estimate: **$130,000 County-Wide, Clear/Clarks Creek Basin share would be $27,600**

Cost Assumptions: **Includes 1.0 FTE and $30,000 per year in professional services**

Project Score: **346** **High-Priority**

Establish a program that would work with development industry, agencies, environmental groups, and communities in the County to actively promote the use of LID in new development and redevelopment. Program activities might include developing standards for use of LID principles in public road construction and reconstruction where it makes sense, initiating and coordinating pilot projects, providing training and technical assistance in the application of LID techniques and principles, investigating regulatory and other barriers to LID and identifying solutions, and educating citizens about LID and its benefits.

Project Number: **PRG-00-11**

Project Name: **Enhanced Cooperative Arrangements with Cities and Other Jurisdictions"**

Cost Estimate: **$150,000 County-Wide, Clear/Clarks Creek Basin share would be $38,000**

Cost Assumptions: **1.0 FTE per year countywide over a 10-year period life-cycle cost; prorated for the Clear/Clarks Creek Basin share of the countywide cost (21.1%) plus additional at SWAB direction to increase commitment to Clear/Clarks Creek to 0.5 FTE**

Project Score: **315** **Priority: High**

Problem: Pierce County has an established countywide surface water management program that emphasizes drainage basins. Basin planning is an effective way to identify and evaluate problems, analyze and select solutions, monitor their effectiveness, and inform and educate citizens. However, there are limitations that hinder the program's effectiveness and ability to reduce flood impacts and improve and preserve water quality and aquatic habitat. The principal limitation is that Water Programs is the surface water management utility for the unincorporated areas of Pierce County only. Most of its programs and services begin and end at the incorporated limits of cities, whereas flooding, water quality, and aquatic habitat problems do not recognize political boundaries. Although the primary statutory drivers for stormwater management are the same for incorporated and unincorporated Pierce County (i.e., federal Clean Water Act, in particular Sections 402, 404, 303d, and 319); federal Endangered Species Act; and federal National Flood Insurance Program, each jurisdiction develops and manages its own approach. The Puyallup River and Carbon River levee system is an exception. It protects citizens from both incorporated and unincorporated areas from flood hazards. However, the levee system is managed and maintained by Water Programs with funds from unincorporated County citizens.

In 2005-2006, cities in the Basin will come under the state's municipal stormwater National Pollution Discharge Elimination System (NPDES) permit requirements. The permit requirements have applied to unincorporated Pierce County and the City of Tacoma since 1995. Water Program's experience in complying with NPDES permit provisions, its current and planned programs, could help cities to meet the new standards.

Solution: The Pierce County Storm Drainage and Surface Water Management Advisory Board (SWM Advisory Board) recommended that Water Programs initiate more cooperative arrangements for surface water management services with cities and other jurisdictions within the Clear/Clarks Creek Basin and countywide. Arrangements can be formal (such as interlocal agreements) or informal as long as they maintain the objectives of reducing flooding, protecting water quality, and protecting aquatic habitat.

Benefits: This approach will foster cooperation between the County and cities to address watershed management issues. It will increase deliberative and informed discussions of the costs and benefits of various choices being considered and will provide opportunities for collaboration. An increase in cooperative efforts will enhance the results of recommended projects and programs in this Basin Plan and lead to more efficient surface water management countywide.

Project Number:	**PRG00-04**
Project Name:	**Develop and Implement a Land Management Program for Flood Hazard Reduction, Water Quality and Habitat Impact Mitigation**
Cost Estimate:	**$56,100**
Cost Assumptions:	**Includes 0.5 FTE for one year to develop the inventory and establish the policies and procedures for acquisition and management; also, a 0.25 FTE per year for nine years to pursue acquisitions and oversee property management. Prorated Clear/Clarks Basin share of the countywide cost (21.2 %)**
Project Score:	**389** **High-Priority**

Develop a system for acquiring and managing properties for multiple benefits. The program should have the following elements:

- **Standards for Property Management**: Develop standard procedures for determining which properties or types to acquire and how they can be managed for multi-use.
- **Inventory Development**: Develop, reconcile, and maintain an electronic inventory of existing holdings and desired properties.
- **Consultation with other Stakeholders**: Develop standards for coordination with other departments, agencies, or groups of citizens that have a stake in property acquisitions sites or the program.
- **Management**: Develop a program to manage properties. The program would address issues such as access, preventing vandalism and illegal dumping, restoration, maintenance, and liability. Pierce County may consider working with private or non-governmental agencies on mapping certain parcels where appropriate.
- **Acquisition through various methods**: Pursue acquisition through fee-simple and alternatives (e.g., conservation and flood easements, rights of entry, purchase of development rights, and other legal instruments) in order to preserve high quality and flood-prone properties and to restore degraded acquisition systems.

Project Number: **PRG00-05**

Project Name: **Develop and Implement a Program to Enhance Degraded Riparian Habitat and Water Quality and Attenuate Flood Hazard**

Cost Estimate: **$692,100**

Cost Assumptions: **Includes 1 FTE to establish and run the program (costs estimated for a 10-year period); prorated for the Clear/Clarks Creek Basin share of the countywide cost (21.2 %)**

Project Score: **325** **High-Priority**

Build internal capacity to implement restoration and enhancement projects in riparian and wetland areas to improve ecosystem functions, where property owners have given permission and on properties owned by Pierce County Water Programs. Soft bank engineering techniques, such as those contained in the WDFW's Integrated Streambank Protection Guidelines should be developed and enhanced. The primary function of the program would be to manage the restoration sites contained in the Basin Plan. Duties would include identifying potential projects, obtaining access, developing restoration plans, identifying resources to help in the restoration including recruiting volunteers where appropriate or hiring contractors, ordering supplies, and publicizing planting events or completed projects. The County could form partnerships with volunteer groups and other organizations such as the Conservation District, Port of Tacoma, and the Puyallup Tribes to work cooperatively on enhancement projects. This program would be applicable to all creeks in the Clear/Clarks Creek Basin.

Project Number: **PRG00-08**

Project Name: **Develop and Implement a BMP Manual for Surface Water Maintenance Activities**

Cost Estimate: **$43,600**

Cost Assumptions: **Includes a one-time cost for 0.5 FTE plus $75,000 for a consultant contract to develop a BMP manual and an additional 0.1 FTE annually to support on-going training sessions and updates; life-cycle cost over 10 years, prorated for the Clear/Clarks Creek Basin share of the countywide cost (21.2 %).**

Project Score: **427** **High-Priority**

Develop a maintenance manual containing BMPs for Pierce County's surface water management facilities. The manual would address pond, river, and levee maintenance activities. The maintenance manual would be patterned after the Tri-County transportation facilities approach and the Pierce County Stormwater Management and Site Development Manual. The manual would include practices and techniques that protect water quality and habitat while preserving the flood control functions of the facilities. The manual would provide standard operating procedures for work crews. It would also be designed to achieve compliance with Pierce County's NPDES permit. Distribution of the manual would be accompanied by training sessions on its purpose and use.

Project Number:	**PRG00-09**
Project Name:	**Develop and Implement an Invasive Species Management Program**
Cost Estimate:	**$43,600**
Cost Assumptions:	**Includes one-time cost for 0.5 FTE and $7,500 for a consultant to develop the Best Management Practices (BMP) document, complete the inventory and data layer, and 0.1 FTE annually for on-going volunteer organization and implementation; life-cycle cost over 10 years then prorated for the Clear/Clarks Creek Basin share of the countywide cost (21.2 %).**
Project Score:	**420** **High-Priority**

Develop a program for addressing invasive species impacts to surface water and County surface water management facilities. Pursue an Integrated Pest Management approach, and use a variety of methods, including hand pulling, mechanical harvesting, and herbicides, as appropriate. A general inventory of invasive plant problems in Pierce County would be conducted and entered into Pierce County's GIS database. A BMP manual would be developed to offer guidance in identifying problematic species, information on their preferred conditions, and options for controlling each problem species. Water Programs would confer with other agencies, including the Noxious Weed Control Board, Ecology, WDFW, and the Washington State University Cooperative Extension programs in developing the guidance document. Upon completion of the guidance document, invasive species training would be provided to drainage system maintenance personnel and invasive species issues would be included in public outreach and education programs. Water Programs would survey their facilities and properties to identify the presence of invasive species and the extent to which they are impacting the facility. This information will be incorporated into division work plans. Implementation of this recommendation could also include organizing and orchestrating volunteer groups and working with other groups and agencies to conduct invasive species control such as hand or mechanical harvesting, native species plantings, and other techniques. This program would be applicable to all creeks and storm drainage facilities in the Clear/Clarks Creek Basin.

Project Number: **PRG00-06**

Project Name: **Develop and Implement an Education, Outreach, and Technical Assistance Program**

Cost Estimate: **$212,000**

Cost Assumptions: **Includes 0.25 FTE per year countywide over a 10-year life-cycle cost; prorated for the Clear/Clark Creek Basin share of the countywide cost (21.2%)**

Project Score: **325** **High-Priority**

Develop a comprehensive education, outreach, and technical assistance program for floodplain preservation that includes the following elements:

- **Public Awareness**: Activities under this element include public notification of department activities, availability of data such as updated floodplain and groundwater information and mapping, and Basin Plan-related information as it is developed.
- **Topics**: Topics may address specific pollutants such as pathogens, metals, nutrients; or issues such as flooding, lawn and garden chemicals, native plant landscaping, maintaining instream flow, or small farm management. Generally, increasing public awareness of "Best Management Practices" (BMPs) that they can implement to reduce water quality, flooding, and habitat impacts in their basin will be the focus of each educational effort. Emergency information related to flooding needs to be well coordinated and easily accessible.
- **Target Audiences**: Audiences would include Basin residents but may also target specific stakeholders such as floodplain residents, business owners, real estate professionals, or homebuyers. Coordination with other education providers such as schools and non-governmental organizations would be addressed.
- **Methods**: Means to distribute information may include a variety of techniques such as posting information on the internet, use of libraries and public bulletin boards, speakers, news releases, newsletters, utility bill inserts, targeted mailings, fair booth displays, billboards, Pierce County Speaks segments, and other options. Methods used should be based on the information to be distributed and the target audience.
- **Technical/Financial Assistance**: In addition to basin awareness, Pierce County's education program could include an assistance program to directly aid residents in taking desired actions. This may include supporting volunteer monitoring programs, offering technical and financial assistance to floodplain residents, offering incentives for establishing buffers, and coordinating with other agencies that provide technical support such as the Conservation District. Additional incentives might come in the form of free native plants, discounts at local stores, free workshops, tax breaks, or other methods.
- **Coordination**: In order to efficiently communicate Water Programs messages, the education, outreach and other technical assistance program will include a coordination element with other agencies, groups, or jurisdictions. Coordination efforts will include other education providers but also technical staff.

Project Number:	**PRG00-07**
Project Name:	**Develop and Implement a Surface Water Monitoring Program**
Cost Estimate:	**$985,000 (Clear/Clarks Creek Basin is 21.2 % of cost of Countywide program) + basin specific of $422,000 = $1,407,000**
Cost Assumptions:	**County-wide estimate assumes total of 3.75 FTEs countywide plus a $91,000 life-cycle cost over 10 years.**
	Actual monitoring assumes purchase and setup of gauges. A more detailed cost estimate is included in Appendix J.
Project Score:	**244** **High-Priority**

Develop and implement a monitoring program that would include the following aspects for the Clear/Clarks Creek Basin:

- **Water Quantity**: Monitor base and flood flow volumes on each of the Clear/Clarks Creek Basin tributaries and Roosevelt Ditch. No flow data currently exists that can be used to determine rates of erosion or the rate at which peak flows are increasing or decreasing. Before flow curves can be established and rates of erosion on Clear/Clarks Creek Basin streams can be quantified, stream flows must be monitored for a period of at least 10 years. Groundwater depths and pothole flooding should be measured in areas where septic systems may interact with groundwater and in pothole areas where infiltration is poor and flooding is frequent.
- **Water Quality**: Compliance with State water quality standards in areas of the County's stormwater facilities and trends elsewhere.
- **Biological Health**: Currently, Pierce County participates in macroinvertebrate sampling which follows the protocols established for the Benthic-Index of Biological Integrity (B-IBI). Continue this sampling program unless a more effective protocol or methodology is identified to assess the biological health of water bodies.
- **Aquatic Habitat**: Assess aquatic habitat by arranging to have selected streams surveyed at least once every five years. Use the Tri-County Urban Issues assessment methodology to maintain consistency with surveys performed to characterize the original basin plans. Compare the results of the surveys to identify trends and to analyze the effectiveness of regulations, education programs, public acquisition efforts, restoration projects, and incentives for protecting riparian habitat.
- **Waterbodies**: Include methodologies for evaluating conditions in streams, wetlands, and surfacing groundwater in the sampling/monitoring program.
- **Dissemination/Mapping**: Evaluate and share with information collected under this monitoring program with other agencies. Where feasible, data can be recorded in GIS systems and mapped, enabling the posting of updated information on the internet.
- **Adaptive Management**: As the monitoring program generates data, information would be shared and used to assess the effectiveness of policies, programs, and procedures. Every

three to five years, Pierce County Water Programs would perform an in-depth analysis of available data and publish a report on the overall health of the Basin and on the effectiveness of applicable programs.

- **Training**: Competent personnel are needed to generate reliable data. Water Programs would train existing staff, hire or consult with experts, work with other agency personnel with capable staff, or develop a pool of volunteers that can competently collect data.
- **Basin Specific**:

ST0301 Flow and Water Quality Monitoring.

Measure flow volumes on all of the creeks and Roosevelt Ditch to establish flow curves. Sample water quality in all of the subbasins to ensure reliable water quality data is available when the Ecology establishes the State of Washington 303(d) List.

Estimated Cost: $422,000

Stream flow monitoring gauges maintained by Pierce County and the USGS should be maintained in order to build a long-term record of the hydrology of the Clear/Clarks Creek Basin. Flow curves are needed to document peak flow volumes and duration as a baseline for measuring change. Continuing monitoring is needed to gauge how well this Basin Plan has addressed water quantity concerns over the next ten years.

Table 9.17 sets out the recommended locations for flow monitoring gauges and water quality sampling.

Table 9.17 Recommended Flow and Water Quality Monitoring	
Roosevelt Ditch *No water quality or flow data exists*	Sample for standard water quality parameters, plus temperature, total suspended solids (TSS) and turbidity during storm events Gauge flow Recommended sampling & gauge location: near the point of entry into the City of Tacoma in road right-of-way
Swan Creek *On current 303(d) list for fecal coliform.* *Deep incising in canyon section* *Provides water to City of Tacoma & Port of Tacoma wetland mitigation banks*	Microbial source tracking for fecal coliform bacteria Sample for standard water quality parameters, plus temperature; sample for turbidity and TSS during storm events. Gauge flow. Recommended sampling & gauge location: below the sedimentation pond before the City of Tacoma diversion weir. Additional gauge location before the stream enters the canyon reach.
Squally Creek *No water quality or flow data*	Sample for standard water quality parameters & temperature Recommended sampling & gauge location: upstream of Pioneer Way E
Clear Creek *On current 303(d) list for fecal coliform.* *Provides water to Trout Lodge Hatchery & Port of Tacoma off-channel rearing & wetland mitigation bank*	Microbial source tracking for fecal coliform bacteria Sample for standard water quality parameters, plus temperature. Recommended sampling & gauge locations: Gauge at representative upstream location with an additional gauge in the valley prior to intersection with Canyon Creek. Sample near valley gauge for standard water quality parameters & temperature.
Canyon Creek *Major tributary to Clear Creek* *Contributes water to Port of Tacoma off channel rearing & wetland mitigation bank*	Sample for standard water quality parameters, plus temperature. Sample for turbidity and TSS during storm events. Recommended sampling & gauge location: Lower reach prior to merging with Clear Creek
Rody Creek *Contributes flow to Clarks Creek*	Sample for standard water quality parameters, plus temperature Recommended sampling & gauge location: Lower reach prior to merging with Clarks Creek
Diru Creek *Provides water to the Puyallup Tribe's Fish Hatchery & Clarks Creek*	Sediment – sampling for turbidity and TSS during storm events Sample for standard water quality parameters, plus temperature Recommended sampling & gauge location: Not identified

Woodland Creek *Deep incising in canyon sections*	Sample for turbidity and TSS during certain storm events Sample for standard water quality parameters, plus temperature Recommended sampling & gauge location:
Clarks Creek *On current 303(d) list for fecal coliform and pH.* *Provides water to new Puyallup Tribe Fish Hatchery* *Provides water to the WDFW Fish Hatchery*	Sample for standard water quality parameters, plus temperature Recommended sampling & gauge location:
Hemlock Pond	Sample for standard water quality parameters, plus temperature
Afdem Pond	Sample for standard water quality parameters

Project Number: **PRG00-03**

Project Name: **Increase Enforcement Inspection for Compliance with Stormwater Requirements and NPDES Permit**

Cost Estimate: **$1,272,000**

Cost Assumptions: **Includes 6.0 FTEs per year countywide. Life-cycle cost prorated for the Clear/Clarks Creek Basin share of the countywide cost (21.2 %)**

Project Score: **398** **High-Priority**

Increase inspection of public and private stormwater facilities to ensure compliance with current regulations (including NPDES requirements). Both existing and new stormwater facilities would be inspected to confirm that regular maintenance is occurring and that maintenance standards and agreements are being met. When a violation is identified, inspectors would offer education and technical assistance, but enforcement actions would be taken when necessary.

Project Number: **PRG00-12**

Project Name: **Develop a stormwater facility design process that integrates public involvement and alternatives for multiple uses of facility sites**

Cost Estimate: **$21,200**

Cost Assumptions: **Includes 1.0 FTEs for one year countywide. The Clear/Clarks Creek Basin share of the countywide cost is 21.2% of the total estimate.**

Project Score: **195** **Medium-Priority**

Initiate, coordinate with other County agencies and develop a stormwater facility design and project scope approach that can be included in Water Programs CIP project management manual. Include objectives of design process transparency and public involvement, facilities that complement the vision expressed in community plans, public safety, water quality, economic development and aquatic habitat enhancement.

Project Number: **PRG00-10**

Project Name: **Require Flood Disclosure Statements on Property Titles**

Cost Estimate: **$53,000**

Cost Assumptions: **Includes 0.25 FTE per year countywide over a 10-year life-cycle cost; prorated for the Clear/Clarks Creek Basin share of the countywide cost (21.2 %)**

Project Score: **128** **Low-Priority**

Require that a disclosure statement of flood hazard designation be placed on the titles of buildings located in Special Flood Hazard Areas (SFHAs). Some measure of protection for buyers is provided through RCW 64.06.020 (1994), a state law that requires sellers of real property to disclose to buyers if a property is within a designated floodplain or designated flood hazard zone. Disclosure is based on the seller's actual knowledge of the flood hazard when the disclosure form is completed. Response options for floodplain disclosure are "yes," "no," and "don't know," with no further explanation or documentation required. Because the basis for this disclosure is the seller's knowledge of flood hazard rather than a determination based on scientific and historical evidence, this disclosure has limited effectiveness in informing potential buyers about flood hazard risk.

9.3.4 Recommendations for Monitoring and Additional Studies

Table 9-18. Recommended Studies to Fill Information Gaps

Study Number	Name	Estimated Cost
ST03-01	West Fork Clear Creek Floodplain Analysis	$33,000
ST03-02	Sediment Sources Identification	$35,000
ST03-03	Roosevelt Ditch Channelization Study	$78,000
ST03-04	Swan Creek Upland Riparian Restoration	$78,000
	Total Estimated Cost	$224,000

ST03-01—Analyze the Floodplain for West Fork Clear Creek from 88th Street East to 84th Street East.

Estimated Cost: $33,000

Extensive road and property flooding has been reported in this area. Several structures appear to be located in the floodplain. However, accurate elevations of structure low-water entry and culvert elevation information are not available. A detailed hydrologic and hydraulic analysis is needed to quantify the extent of the flooding problem. The floodplain should be mapped and the Base-Flood elevation established so that flood hazard regulations apply and floodplain storage is protected.

ST03-02 Identify Sediment Sources in the Basin

Estimated Cost: $35,000

The stream survey performed to support the habitat analysis did not cover every reach in the system. Therefore, it is unlikely that all eroding sections of stream channels and associated sediment sources in the basin were identified during the development of this plan. For this reason, a comprehensive survey of the creeks upstream of the areas investigated in the Basin Plan should be performed with the purpose of identifying locations of eroding streambanks and other sources of fine sediment. The study should provide an estimate of the amount of sediment and develop appropriate control measures.

ST03-03 Roosevelt Ditch Channelization Study

Estimated Cost: $78,000

The history of Roosevelt Ditch is sketchy, but signs exist that the ditch conveys water that formerly had a natural channel. Development decisions in the drainage reinforce the use of the ditch as urban infrastructure. Filling of wetlands and enclosing the channel during property

development continue to affect the quantity, the peaks, and the duration of stormwater conveyed by the ditch.

The scope of work for the Clear/Clarks Creek Basin Plan did not include a survey of aquatic habitat conditions for Roosevelt Ditch. Citizens have asked for additional analysis of conditions in and along the ditch followed by collaborative problem solving with key stakeholders. The product would be a set of recommendations (an action plan) for managing the ditch. Concerned citizens have asked that the County work with other agencies, groups, businesses, and citizens to research and record the historical facts, help them (1) to articulate a vision for the drainage and (2) the steps to achieve the vision. Pierce County Water Programs would sponsor, lead, and participate in collaborative development of a conceptual plan for Roosevelt Ditch

ST03-04 Swan Creek Upland Riparian Restoration Program

Estimated Cost: $78,000

The scope of work for the Clear/Clarks Creek Basin Plan did not include a survey of aquatic habitat conditions upstream of the culvert barrier to fish passage at 72nd St E. Citizens have asked for additional analysis of conditions in and along the creek followed by collaborative problem solving with property owners, the drainage district, the Puyallup Tribe, and other key stakeholders. The product would be a set of recommendations (an action plan) for restoration of aquatic habitat and floodplain in the upland portion of the creek.

Sponsor, lead, and participate in the collaborative development of an action plan for restoring aquatic habitat and floodplain in the upland portion of the Swan Creek drainage area, south of 72nd Street East.

Some upstream reaches of Swan Creek have been channelized and diked. Floodplain wetlands have been filled and replaced with detention ponds and urban development. Riparian cover has been removed. Areas that historically drained to the creek may have been routed to adjacent drainages.

9.4 Implementation

9.4.1 Capital Facilities Element of Pierce County Comprehensive Plan

The annually updated Capital Facilities Element of the *Comprehensive Plan for Pierce County, Washington* (Pierce County Code 19E) is the capital improvement program for Pierce County Water Programs. It lays out the capital projects over $100,000 that Water Programs intends to construct in a six-year period. It also presents the non-capital (non-structural) alternatives that can be used with capital projects to help meet the level of service standard for storm drainage and surface water management facilities. Water Programs has two entries in the Capital Facilities Plan: 19E.50.130, River Improvement Facilities; and 19E.50.170, Surface Water Management. The Capital Facilities Plan sets the stage for Water Programs annual budget.

9.4.2 Annual Budget for Pierce County Water Programs

The Pierce County budget each year authorizes the activities of Water Programs. Programmatic measures, studies, and capital improvement projects appear in the detailed annual budget. Capital improvement projects in the annual budget generally come from the Capital Facilities Element of the County's Comprehensive Plan described in Section 9.4.1 or in response to an unexpected problem.

9.4.3 Order of Implementation

Implementation of the recommended actions will generally follow the prioritization groupings of High-Priority, Medium-Priority, and Low-Priority in a logical order of sequencing. To realize the full benefits of projects, implementation will not follow the exact progression of the first project to the last project in the High category, followed by the first action in the Medium category, and so forth. Several factors exist that will result in implementation of actions that are not in the exact order of the recommended actions depicted in *Table 9.2*, High-Priority Recommended Projects; *Table 9.3*, Medium-Priority Recommended Projects; and *Table 9.4*, Low-Priority Recommended Projects. Influencing factors include the following:

- Availability of funds;
- The completion of other projects or activities on which a project relies;
- Available staff and professional services;
- Cooperation from private landowners;
- Identification of a implementing agency other than Pierce County Public Works and Utilities; and
- New information, regulations, or emerging issues.

9.4.4 Economic Development Criteria

Implementing projects and programs recommended in the Basin Plan is expected to reduce flood hazards, and preserve or protect water quality and floodplain habitat. Collectively and individually, these projects are aimed at protecting Pierce County's quality of life. Projects and programs in the Basin Plan will:

- Afford resource protection as the community develops
- Preserve, enhance or protect natural floodplain functions
- Balance structural and nonstructural approaches
- Reduce potential County environmental liabilities
- Help achieve environmental compliance and long term sustainability

Collectively, these attributes help make Pierce County a livable community where quality of life issues will provide indirect, passive economic development benefits to businesses and individuals looking to locate or stay in Pierce County.

In addition, Water Programs will consider the following criteria in developing its annual proposed capital facilities plan updates:

- Is the project located in an employment center zone (or handle flow from those zones)?
- Is the project located in another type of commercial zone (or handle flow from those zones)?
- Will the project reduce permitting timelines for industrial/commercial projects?
- Will the project assure access to an employment center via road and /or rail?
- Will the project increase the supply of developable property?
- Will the project reduce overall development costs?
- Are there partners willing to contribute to the development costs of the project?
- Does the project allow / provide for land development?

In light of these and other factors, following action on the Basin Plan, Pierce County will develop an implementation strategy designed to sequence, schedule and assign resources for the various recommended actions. This implementation strategy will be developed in collaboration and coordination with other potential implementers and in consideration with available financial and staff resources. The implementation strategy will include performance measurements and provide for periodic evaluation of progress.

9.4.5 Voluntary Actions by Other Interested Parties

Broad, multi-stakeholder groups such as the Puyallup River Watershed Council can be instrumental in implementation of the Basin Plan. Representatives of environmental interest groups, tribes, business, economic development, and individual citizens provide valuable suggestions about specific activities. Their support of specific activities and the ongoing progress of Basin Plan implementation will be an essential component of successful implementation. For example, these groups can be instrumental in carrying out effective public education.

Businesses in the Basin can be involved in implementation of the Basin Plan recommendations. The private sector will need to comply with regulations to protect the water resources and habitat of the Clear/Clarks Creek Basin. Additionally, businesses can be partners in developing creek

and natural resource protection strategies, and may also offer funding assistance for individual and/or ongoing watershed activities.

Farmers and other large landowners with extensive property along the creeks can play a critical role in addressing the temperature and sedimentation problems. The establishment and revegetation of riparian buffers is the single most important measure for improving water quality within the Basin.

9.5 Problems and CIP Solutions Cross-Reference

Table 9.9. Problems and CIP Solutions Cross-Reference

RECOMMENDED ACTION		PROBLEMS ADDRESSED
HIGH-PRIORITY		
PH-IP01	128th Street East Infiltration Pond	PH-1 (Flooding, also Water Quality – instream flows)
CL-RST01	Clear Creek Stream Corridor Restoration	CL-1 (Flooding), CL-16 (Water Quality)
RY-RST01	Rody Creek Stream Corridor Restoration	RY-16 (Habitat), RY-19 (Water Quality)
PH-PL04	144th and 94th Avenue Pipeline	PH-14 (Flooding), PH-15 (Flooding), PH-18 (Flooding)
SW-AC01	Swan Creek at 112th Street Floodplain Storage/Headwaters Preservation	SW-5 (Flooding), SW-10(Flooding), SW-27 (Water Quality-Instream Flow), SW-30 (Flooding)
WO-RST01	Woodland Creek Stream Corridor Restoration	WO-23 (Water Quality, Habitat), WO-29 (Habitat), WO-30 (Habitat), WO-31 (Water Quality)
CY-RST01	Canyon Creek Stream Corridor Restoration	CY-25 (Water Quality, Habitat), CY-26 (Habitat)
CK-RST01	Clarks Creek Stream Corridor Restoration	CK-1 (Flooding), CK-12 (Water Quality), CK-13 (Water Quality, Habitat), CK-14 (Water Quality, Habitat), CK-16 (Flooding), CK-21 (Water Quality)
RD-DP01	Portland Avenue Regional Detention Facility, Roosevelt Ditch Area	RD-7 (Flooding)
CL-AC01	Clear Creek Floodplain Repetitive Loss Land Acquisition	CL-1 (Flooding)
SW-DP01	Swan Creek Regional Detention Facility	SW-3 (Habitat), SW-4 (Flooding), SW-6 (Flooding), SW-21 (Water Quality, Habitat), SW-22 (Water Quality, Habitat), SW-23 (Water Quality, Habitat), SW-30 (Flooding), SW-35 (Water Quality, Habitat), SW-36 (Water Quality), SW-37 (Water Quality)

MEDIUM-PRIORITY		
SW-SBS03	Swan Creek 64th Street East Culvert Outfall Repair	SW-21 (Water Quality, Habitat), SW-23 (Water Quality, Habitat),
RD-SWL01	20th Avenue E Drainage Swale, Roosevelt D	RY-5 (Flooding), RY-6 (Flooding)
CL-SBS03	Clear Creek Streambank Stabilization in vicinity of 49th Street	CL-17 (Habitat, Water Quality), CL-21 (Habitat, Landslide)
CL-SBS04	Clear Creek Streambank Stabilization on West Fork Clear Creek Downstream of 64th Street E	CL-17 (Habitat, Water Quality), CL-22 (Habitat, Water Quality)
DU-SBS01	Diru Creek Streambank Stabilization at 72nd St East	DU-11 (Landslide, Habitat, Water Quality)
RY-SBS01	Rody Creek Streambank Stabilization at 72nd Street East	RY-14 (Habitat, Water Quality)
CL-CR01	Clear Creek 88th Street E Culvert Replacement	CL-5 (Flooding)
CL-VC01	Clear Creek at 104th Street E Vegetation Control	CL-4 (Flooding, Water Quality)
RY-SBS02	Rody Creek Streambank Stabilization at 80th Street East	RY-3 (Water Quality, Habitat)
CK-SP01	Clarks Creek State Hatchery Sedimentation Basin Retrofit	CK-14 (Habitat, Water Quality), CK-15 (Habitat, Water Quality)
CL-SBS05	Clear Creek Streambank Stabilization 5000 block of Vickery Avenue East	CL-33 (Habitat, Water Quality)
SW-SBS01	Swan Creek Streambank/Channel Stabilization at 72nd Street E Outfall	SW-3 (Habitat, Water Quality), SW-21 (Habitat, Water Quality), SW-35 (Habitat)
SQ-VC01	Squally Creek at Pioneer Way E Vegetation Control	SQ-4 (Habitat, Water Quality), SQ-6 (Flooding, Habitat, Water Quality)
CL-SBS02	Clear Creek Streambank Stabilization on East Fork Downstream of 72nd Street E	CL-17 (Habitat, Water Quality), CL-20 (Habitat, Water Quality)
CY-SBS03	Canyon Creek Streambank Stabilization on Reach Upstream of Second Canyon Road Crossing	CY-20 (Habitat, Water Quality), CY-23 (Habitat, Water Quality)
CY-SBS01	Canyon Creek Streambank Stabilization on Reach Downstream of 80th Street East	CY-18 (Habitat, Water Quality), CY-23 (Habitat, Water Quality)
CY-SBS02	Canyon Creek Streambank Stabilization on Reach Downstream of 72nd Street East	CY-22 (Habitat, Water Quality), CY-23 (Habitat, Water Quality)
CK-PL01	112th Street East Drainage Improvement (Woodland Elementary School)	CK-9 (Flooding)
CL-SBS01	Clear Creek Streambank Stabilization on West Fork Downstream of 72nd Street E	CL-17 (Habitat, Water Quality), CL-10 (Habitat, Water Quality)
CK-AC01	Clarks Creek Property Acquisition at 104th Street East	CK-2 (Flooding)
SW-SBS02	Swan Creek Streambank/Channel Stabilization from 72nd Street E to 64th St E	SW-4 (Habitat, Water Quality), SW-21 (Habitat, Water Quality)
WO-SBS01	Woodland Creek Streambank/Channel Stabilization at 84th Street East	WO-24 (Habitat, Water Quality), WO-25 (Habitat, Water Quality), WO-26 (Habitat, Water Quality)
CY-SBS04	Canyon Creek Streambank Stabilization Downstream of Second Canyon Road Crossing	CY-21 (Habitat, Water Quality), CY-23 (Habitat, Water Quality)

MEDIUM-PRIORITY		
WO-SBS02	Woodland Creek Streambank Stabilization at 80th Street E	WO-26 (Habitat, Water Quality), WO-27 (Habitat, Water Quality),
PH-PL05	Springfield Pothole Pipeline	PH-7 (Flooding)
CK-PL02	Fruitland Avenue Drainage Improvement - 104th Street E to 96th Street E, Clarks Creek	CK-10 (Flooding)
PH-PL03	136th Street Pipeline, 135th Street Pothole	PH-3 & PH-4 (Flooding)
CY-SL01	Canyon Creek 58th Avenue East Setback Levee	CY-1 (Flooding), CY-5 (Flooding), CY-6 (Flooding)
SW-SBS04	Swan Creek Streambank Stabilization Downstream of 64th Street East	SW-21 (Habitat, Water Quality), SW-24 (Habitat, Water Quality), SW-35 (Habitat, Water Quality)
DU-RST01	Diru Creek Stream Corridor Restoration Downstream of Pioneer Way East	DU-9 (Water Quality), DU-10 (Water Quality, Habitat)
RY-DP01	Rody Creek Regional Detention Facility Expansion	RY-14 (Water Quality, Habitat)
CY-DP02	Canyon Creek 90th Street East Detention (D138-003)	CY-1 (Flooding), CY-6 (Flooding), CY-18 (Habitat, Water Quality)
PH-PL06	South Hill Pump Station Pipeline to Puyallup River	PH-23 (Flooding)
WO-DP01	Woodland Avenue Flood Control Phase II	WO-1 (Flooding), WO-2 (Flooding), WO-5 (Flooding), WO-24 (Habitat, Water Quality, WO-25 (Habitat, Water Quality), WO-26 (Habitat, Water Quality)
CL-DP01	West Fork Clear Creek Regional Detention	CL-5 (Flooding), CL-17 (Habitat, Water Quality, Flooding), CL-19 (Habitat, Water Quality), CL-21 (Habitat, Water Quality), CL-22 (Habitat, Water Quality)
CY-DP01	Canyon Creek Regional Detention	CY-1 (Flooding), CY-6 (Flooding), CY-18 (Habitat, Water Quality)
CL-DP02	East Fork Clear Creek Regional Detention	CL-17 (Habitat, Water Quality, Flooding), CL-20 (Habitat, Water Quality), CL-21 (Habitat, Water Quality), CL-22 (Habitat, Water Quality)

LOW-PRIORITY		
RY-SWL01	62nd Avenue East Drainage Swale, Rody Creek	RY-5 (Flooding), RY-6 (Flooding)
RY-CR01	Rody Creek at Pipeline Road & 96th Street East Culvert Replacement	RY-7 (Flooding)
WO-CR02	Woodland Creek at 80th Street East Culvert Replacement	WO-8 (Flooding, Habitat)
RY-CR02	Rody Creek at 98th Street East Culvert Replacement	RY-8 (Flooding)
PH-PL01	92nd Ave East Storm Drainage Pipeline, Black Swamp Pothole	PH-6 (Flooding)
SW-PL01	84th Street East Pipeline Storm Drain Replacement, Swan Creek	SW-16 (Flooding)
RY-RD01	90th Street East at Rody Creek Raise Roadway	RY-17 (Flooding)
CY-FP01	Canyon Creek Driveway Culvert Replacement at Pioneer Way East	CY-28 (Habitat)
WO-CR01	Woodland Creek & 72nd Avenue East Culvert Replacement - 93rd Street East to 96th Street East	WO-6 (Flooding)
SW-CR01	Swan Creek 80th Street E Culvert Replacement	SW-1 (Flooding, Habitat)
CY-RD02	104th Street East Road Raising & Culvert Replacement - East Fork of Canyon Creek	CY-10 (Flooding)
CY-RD01	116th Street East Road Raising - West Fork of Canyon Creek	CY-3 (Flooding)
CY-AC01	Canyon Creek Property Acquisition at 5600 block of 104th Street E	CY-30 (Flooding)
PH-PL02	156th Street East Regional Pipeline	PH-15 (Flooding)
DU-DP01	Diru Creek Regional Detention	DU-9 (Habitat, Water Quality

Also, see Appendix J for a cross-reference table that lists all identified problems followed by the recommended solutions, both capital improvement projects and programmatic measures.

*CIP Project Numbers

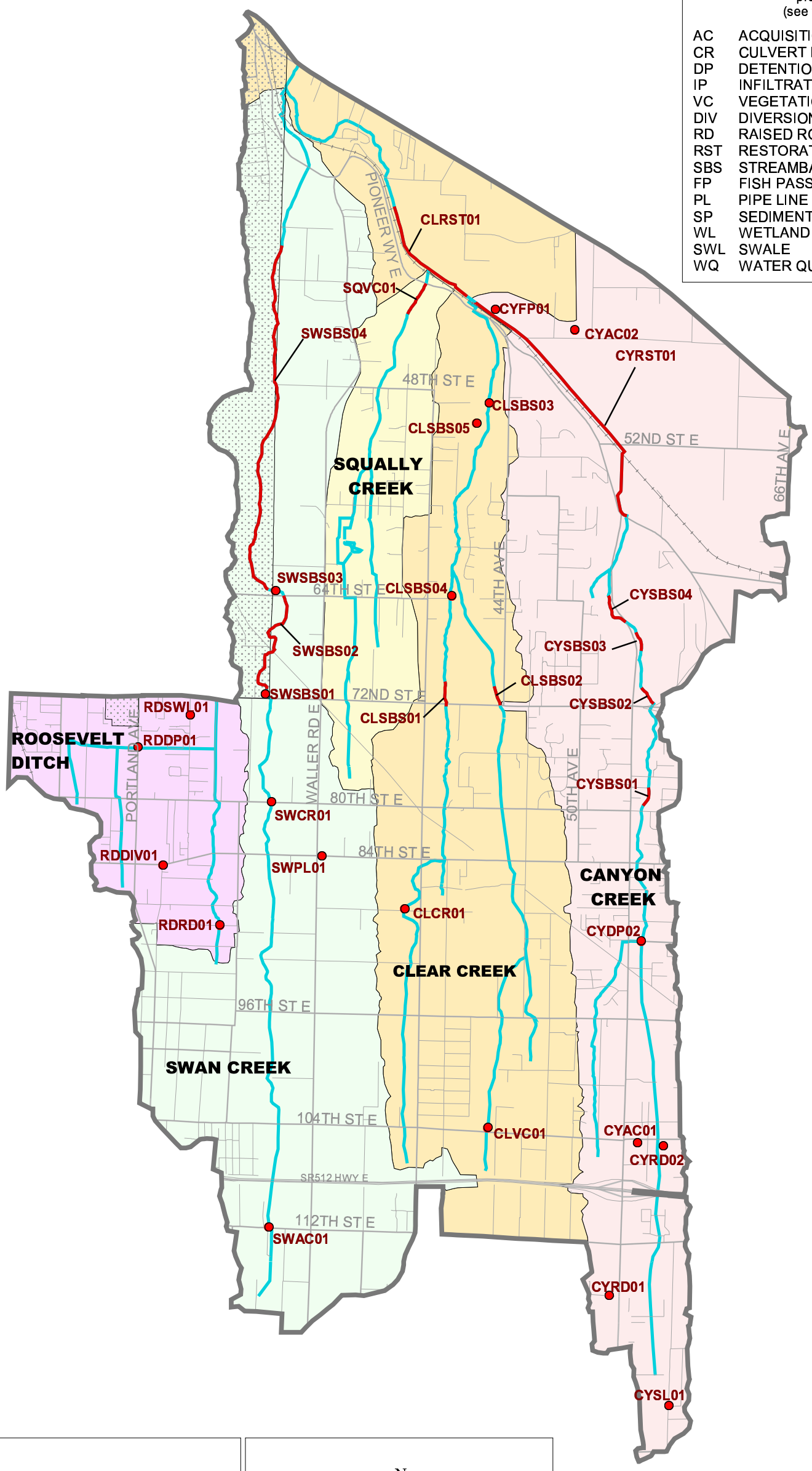
CL CR 01

Refers to Subbasin name

Refers to project type (see table below)

Project number - sequentially by project type in subbasin

AC	ACQUISITION
CR	CULVERT REPLACEMENT
DP	DETENTION POND
IP	INFILTRATION POND
VC	VEGETATION CONTROL
DIV	DIVERSION
RD	RAISED ROAD
RST	RESTORATION
SBS	STREAMBANK/CHANNEL STABILIZATION
FP	FISH PASSAGE
PL	PIPE LINE
SP	SEDIMENTATION POND
WL	WETLAND
SWL	SWALE
WQ	WATER QUALITY



LEGEND

- CIP Projects*
- CIP Projects
- Cities
- BNSF Railroad
- Streams
- Arterials

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Figure 9-1
Clear Creek Basin and Roosevelt Ditch CIP Projects

PIERCE COUNTY CLEAR/CLARKS CREEK BASIN

Pierce County Water Programs

CH2MHILL

*CIP Project Numbers

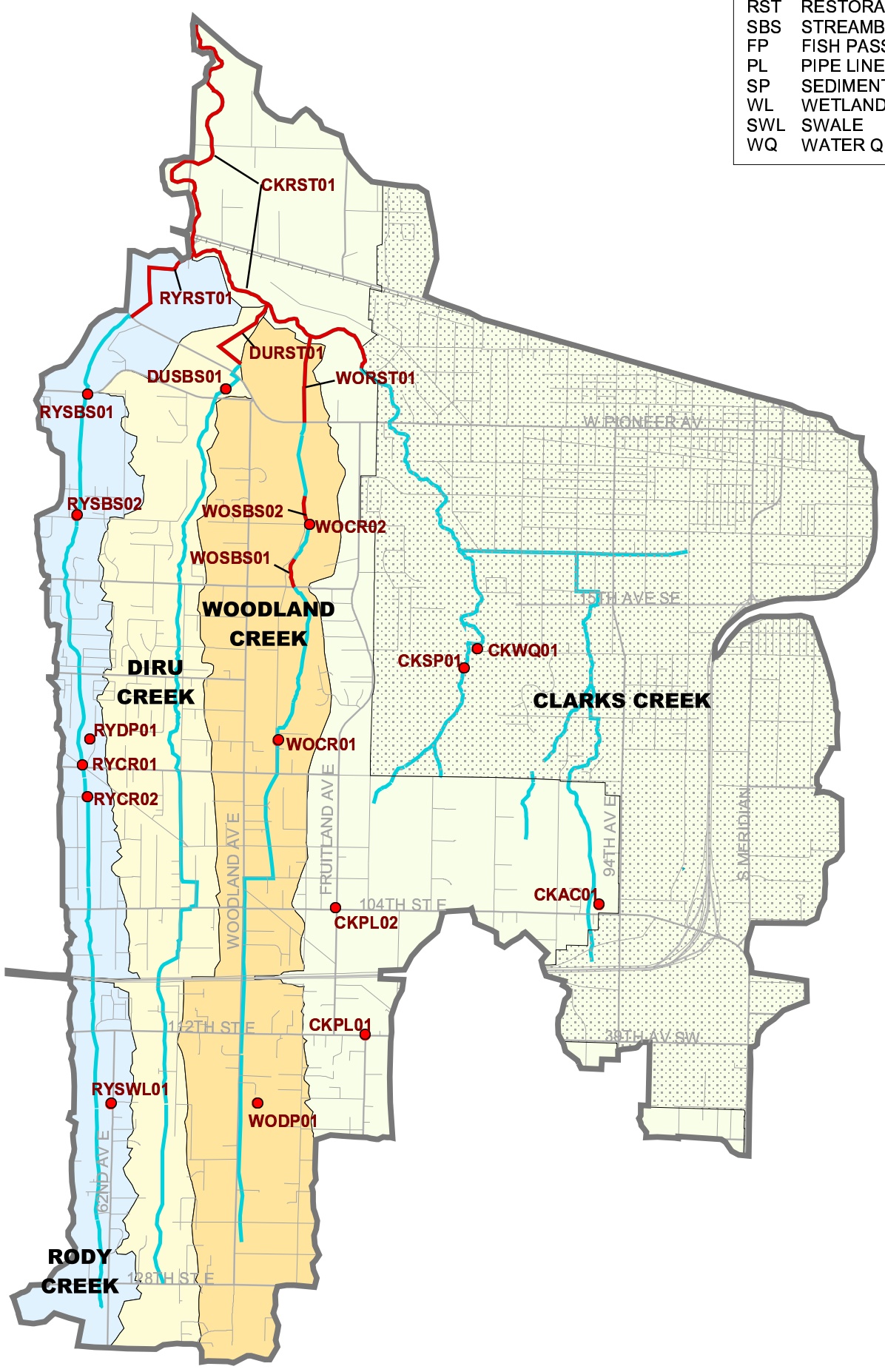
CL CR 01

Refers to Subbasin name

Refers to project type (see table below)

Project number - sequentially by project type in subbasin

AC	ACQUISITION
CR	CULVERT REPLACEMENT
DP	DETENTION POND
IP	INFILTRATION POND
VC	VEGETATION CONTROL
DIV	DIVERSION
RD	RAISED ROAD
RST	RESTORATION
SBS	STREAMBANK/CHANNEL STABILIZATION
FP	FISH PASSAGE
PL	PIPE LINE
SP	SEDIMENTATION POND
WL	WETLAND
SWL	SWALE
WQ	WATER QUALITY



LEGEND

- CIP Projects*
- CIP Projects
- Cities
- BNSF Railroad
- Streams
- Arterials

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Figure 9-2
Clarks Creek Basin
CIP Projects

PIERCE COUNTY
CLEAR/CLARKS
CREEK BASIN

Pierce County Water Programs

CH2MHILL

*CIP Project Numbers

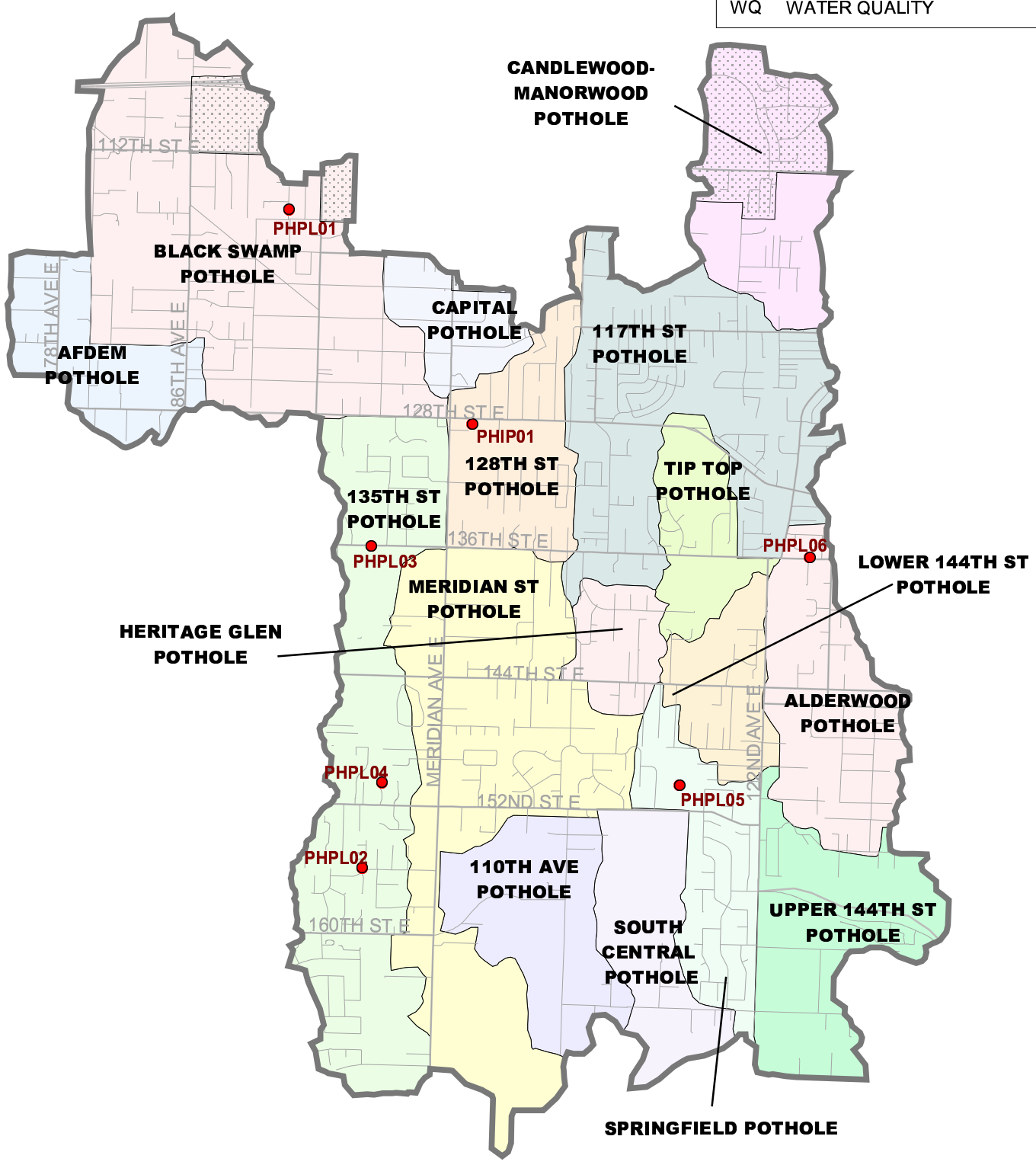
CL CR 01

Refers to Subbasin name

Refers to project type (see table below)

Project number - sequentially by project type in subbasin

AC	ACQUISITION
CR	CULVERT REPLACEMENT
DP	DETENTION POND
IP	INFILTRATION POND
VC	VEGETATION CONTROL
DIV	DIVERSION
RD	RAISED ROAD
RST	RESTORATION
SBS	STREAMBANK/CHANNEL STABILIZATION
FP	FISH PASSAGE
PL	PIPE LINE
SP	SEDIMENTATION POND
WL	WETLAND
SWL	SWALE
WQ	WATER QUALITY



LEGEND

- CIP Projects*
- Cities
- BNSF Railroad
- Streams
- Arterials

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Figure 9-3
Potholes Basin
CIP Projects

PIERCE COUNTY
CLEAR/CLARKS CREEK BASIN

Pierce County Water Programs

CH2MHILL

Chapter 10

Final Supplemental Environmental Impact Statement

for the

Clear/Clarks Creek Basin Plan

May, 2006

Pierce County

Public Works & Utilities
Water Programs

FACT SHEET

Title and Description of Proposed Action	**Proposed Clear/Clarks Creek Basin Plan** Pierce County proposes to update its *1991 Storm Drainage and Surface Water Management Plan and Capital Improvement Program* (1991 Plan) by adopting and appending the Proposed Clear/Clarks Creek Basin Plan to the 1991 Plan. Since its adoption, the 1991 Plan has served as a guide for the identification, design, construction, and operation of storm drainage and surface water management facilities in unincorporated Pierce County. The Proposed Clear/Clarks Creek Basin Plan recommends a set of capital improvement projects and programmatic measures (activities) designed to solve flooding, water quality, aquatic habitat, and other storm drainage problems in the unincorporated parts Clear/Clarks Creek Basin. The No-Action Alternative would continue annual capital project selection based on the 1991 Plan list and in response to urgent problems. The Final Supplemental Environmental Impact Statement (Final SEIS) adds information to the 1991 *Draft & Final Environmental Impact Statements* for the *Pierce County Storm Drainage and Surface Water Management Plan* to reflect changes to regulations and policies since 1991; stormwater facilities constructed since 1991, new development and other changes to existing conditions; and new information pertaining to the Clear/Clarks Creek Basin.
Location of Proposal	Unincorporated Pierce County in the Clear Creek drainage area, the Clarks Creek drainage area, the Roosevelt Ditch drainage area, and an area of potholes on South Hill (Potholes Area) in the Puyallup River Watershed. The area lies south of the Puyallup River between the cities of Tacoma and Puyallup including much of the South Hill and Mid-County Communities.
Proponent	Pierce County Department of Public Works & Utilities, Water Programs Division
Proponent Contact	Marsha Huebner, Senior Planner Pierce County Public Works & Utilities, Water Programs 9850 64th Street West University Place, WA 98467-1078 (253) 798-4662

Lead Agency	Pierce County Planning and Land Services
Lead Agency Contact	Adonais Clark, Senior Planner Environmental Designee Pierce County Planning and Land Services 2401 South 35th Street Tacoma WA 98409-7490 (253)798-7165
Tentative Adoption Date	Winter 2006 after public hearings before the Pierce County Council.
List of Approvals/Permits Required	Adoption of an ordinance of the Pierce County Council approving the Clear/Clarks Creek Basin Plan Permits for capital improvement projects for work in- and to adjacent water (e.g., Hydraulic Project Approvals, Shoreline Substantial Development Permits, Section 404 Permits, Critical Areas Approvals, and others) will be required for certain capital projects at the time they are proposed for construction. Project-specific environmental review will precede issuance of applicable development permits and construction.
Authors and Principal Contributors	Jerry Scheller, P.E., CH2M Hill, Incorporated Marsha Huebner, Senior Planner; Damon DeRosa, P.E.; and Dan Wrye, Program Services Manager Pierce County Public Works & Utilities, Water Programs
Date of DSEIS Issuance	August 30, 2005
Written Comments Due Date	September 29, 2005
Public Meetings & Hearings	Pierce County Storm Drainage and Surface Water Management Advisory Board discussed the Draft Basin Plan on May 19, June 16, and July 21, 2005. Informational meeting on the Draft Basin Plan and Draft SEIS at Summit Library, September 21, 2005 Pierce County Planning Commission public hearing at the Pierce County Public Services Building, 2401 South 35th Street, Tacoma, on September 27, 2005 A public hearing will be conducted by the Economic & Infrastructure Development Committee of the Pierce County Council on December 6, 2005.

Date of Final Action	Action by the Pierce County Council is expected during Winter 2006
Subsequent Environmental Review	Pierce County Water Programs conducts project-specific environmental review for construction projects and programmatic actions prior to construction or implementation, respectively.
Location of FEIS on the "1991 Plan"	Pierce County Water Programs; 9850 64th Street W; University Place, Washington 98467; (253)798-2725; or Pierce County Planning and Land Services, 2401 South 35th Street, Tacoma, WA 98409, (253)798-7210
Locations of Proposed Clear/Clarks Creek Basin Plan and Final SEIS	View on the internet at: **www.piercecountywa.org/clear** Printed copies are available at the following libraries: • Fernhill Branch of Tacoma Public Library, 765 South 84th Street, Tacoma • Swan Creek Branch of Tacoma Public Library, 3828 Portland Ave, Tacoma • Summit Library, 5107 112th Street East, Tacoma • South Hill Library, 15420 Meridian Ave East, South Hill • Puyallup Public Library, 324 South Meridian, Puyallup
Cost of Printed Final SEIS	The Proposed Basin Plan & Final SEIS may be purchased for the cost of printing at the following locations: Pierce County Public Work & Utilities, Environmental Services Building; 9850 64th Street W, University Place WA, 98467; (253) 798-2725 or Pierce County Planning & Land Services Department 2401 South 35th Street, Tacoma WA 98409 (253) 798-7210

CHAPTER TEN
Final Supplemental Environmental Impact Statement

10.1 Summary

Pierce County Public Works and Utilities, Water Programs Division, proposes to adopt and implement the Proposed Clear/Clarks Creek Basin Plan (Basin Plan). If adopted, the Basin Plan would amend the County's 1991 Storm Drainage and Surface Water Management Plan (1991 Plan), adding a new section for the Clear/Clarks Creek Basin.

Purpose of this Nonproject Draft Supplemental Environmental Impact Statement (DSEIS)

The State Environmental Policy Act (SEPA), Chapter 43.21C RCW, requires that an Environmental Impact Statement (EIS) be prepared for proposed "actions" with probable significant adverse environmental impacts. "Actions" include new or revised plans. A nonproject EIS was prepared for the original 1991 Plan to compare the adverse environmental effects of the Proposed 1991 Plan with those of the No-Action Alternative. Decisions on plans, policies, and programs are 'nonproject actions'. Nonproject EISs provide a general discussion of significant adverse environmental impacts.

The purpose of a Supplemental EIS (SEIS) is to describe probable significant adverse environmental impacts that new information has brought to light. Updated information exists on water quality, flooding problems, stormwater induced erosion and sedimentation, and aquatic habitat in the Basin. New stormwater management standards, new legal requirements, and changes to public preferences expressed in the adopted Comprehensive Plan for Pierce County exist. They bear on the County's decision to continue to implement the 1991 Plan in the Clear/Clarks Creek Basin or adopt the proposed Proposed Clear/Clarks Creek Basin Plan.

This Final SEIS is based in part on information provided in the EIS for the 1991 Plan. However, because some of the information provided in the 1991 Plan EIS has changed, this Final SEIS contains new and updated information. Potential impacts from implementation of the 1991 Plan that were evaluated in the 1991 EIS are not addressed again here.

Alternatives Considered in this Final SEIS

This Final SEIS compares implementation of the Proposed Clear/Clarks Creek Basin Plan with the "No-Action" Alternative.

No-Action Alternative

The "No-Action" Alternative is the continued implementation of the 1991 Plan. The 1991 Plan was adopted to provide a surface water management program where none existed before. evaluated 26 drainage basins within unincorporated and non-federal lands of Pierce County and identified storm water and surface water management measures. Basins were evaluated at different levels, depending upon whether they were considered urban or rural. The 1991 Plan studied eight urban and urbanizing areas in more detail. The Clear/Clarks Creek Basin was one of the urban areas.

The Proposal

Pierce County proposes to adopt and implement the Proposed Clear/Clarks Creek Basin Plan. If adopted, the Basin Plan would amend the County's 1991 Storm Drainage and Surface Water Management Plan (1991 Plan), replacing the information and projects set forth for the Clear/Clarks Creek Basin in the 1991 Plan with the information and recommendations in the Proposed Clear/Clarks Creek Basin Plan. The capital improvement program (CIP) for the Pierce County Storm Drainage and Surface Water Management Utility and for "Water Programs" would rely on the Clear/Clarks Creek Basin Plan instead of the 1991 Plan as a source of projects and activities needed to solve storm drainage and surface water management problems in the Basin. Recommended programmatic measures would be added to the ten-year work program for Water Programs.

Since the 1991 Plan was prepared, surface water management has increased in complexity mainly due to Stormwater National Pollutant Discharge Elimination System (NPDES) permit requirements, Endangered Species Act (ESA) listings, Federal Emergency Management Agency (FEMA) Community Rating System (CRS), and Growth Management Act (GMA) mandates. The 1991 Plan emphasized flood protection. Water quality, aquatic habitat, protection of critical areas, and support for community design and multiuse preferences have become important concerns. Since 1991, growth in the County has made development impacts on storm drainage systems and associated surface water more widespread and apparent.

The State GMA required the establishment of "critical areas", such as flood hazard areas, channel migration zones, wetlands, steep slopes, fish and wildlife conservation areas, and streams. It also required their protection. GMA directed a revision of the Pierce County Comprehensive Plan (Comprehensive Plan)[1] to meet statewide growth management objectives. The GMA required consistency, the internal consistency of the various elements of the Comprehensive Plan, and consistency of implementing plans and budget decisions with the policies of the Comprehensive Plan. Adopted in 1994, the County Comprehensive Plan designated urban growth areas and rural areas; it set out policy on environmental protection, economic development, public facilities and services, and land uses.

In 1995, jurisdictions with populations over 100,000, including Pierce County, were required by the Washington State Department of Ecology to create stormwater management programs under the federal "Clean Water Act's" National Pollution Discharge Elimination System (NPDES) program. In the late 1990s, the federal government administering the ESA listed Chinook salmon and bull trout found in Pierce County waters. Any impact to a listed species is considered significant.

Additionally, in the late 1990's, Pierce County received a "Class 5" CRS rating for flood preparedness by FEMA.

The requirement to maintain consistency with these factors led Water Programs to initiate an update of the 1991 Plan through a series of basin plans. The Proposed Clear/Clarks Creek Basin Plan is one of the set. The Proposed Basin Plan evaluates current conditions and problems and prioritizes recommended projects. It addresses changes in policies and planning efforts needed

[1] The title of Pierce County's Comprehensive Plan is "*Comprehensive Plan for Pierce County, Washington*".

to meet the requirements of the Clean Water Act, the Endangered Species Act, CRS, and the Growth Management Act.

The Proposed Alternative

The Proposed Clear/Clarks Creek Basin Plan offers a specific and comprehensive approach to reducing flood hazards, improving aquatic habitat, improving water quality, ensuring responsible use of public resources, and providing guidance for new development.

The Proposed Basin Plan provides a more detailed analysis of flooding, drainage, water quality, and aquatic habitat problems in the basin than was possible for the 1991 Plan. Citizens in the basin provided information about the basin and commented on problem solutions at public meetings and other public outreach efforts. Their concerns regarding flooding, erosion, habitat, water quality, and water quantity in the creeks were addressed within the Proposed Plan.

In addition to the capital construction projects, the Basin Plan recommends programmatic/non-structural measures. Programmatic measures include programs that would be specific to the Clear/Clarks Creek Basin and also programs that would be undertaken Countywide but benefit the Clear/Clarks Creek Basin. Examples of programmatic measures include policy guidelines, site design standards, operational policies, technical assistance, land management programs, public outreach, and educational programs.

The Proposed Basin Plan refers solutions for some of the drainage problems to other agencies. For example, the Proposed Basin Plan refers culverts on private property to Pierce Conservation District. Flooding problems whose resolution lies in road maintenance are referred to the Pierce County Public Works and Utilities, Road Maintenance Division.

The Proposed Basin Plan proposes 65 capital improvement projects and twelve (12) programmatic measures to reduce flooding and drainage problems in the Basin, including projects to improve water quality and fish habitat to meet legal mandates. The list of CIPs includes the following types of projects:

- Six (6) culvert replacement projects
- One (1) infiltration pond
- Nine (9) detention ponds
- Nine (9) pipeline projects
- One (1) setback levee
- Eighteen (18) streambank/channel stabilization projects
- Six (6) stream corridor restoration projects
- Forty-two (42) water quality-related projects

Proposed programmatic measures include the following activities;

- Update the Pierce County Stormwater Management and Site Development Manual
- Develop and Implement a “Best Management Practices” (BMP) Manual for Pierce County Water Programs Facilities Maintenance Activities

- Develop and Implement an "Invasive Species Management Program"
- Develop and Implement a "Land Management Program" for Aquatic Habitat Protection and Flood Hazard Reduction
- Develop a "Low Impact Development" program
- Develop and implement an "Education, Outreach, and Technical Assistance Program"
- Develop and implement a "Restore Degraded Aquatic Habitat and Protect Water Quality and Attenuate Flood Hazards Program"
- Develop and implement a "Surface Water Monitoring Program"
- Increase inspections for compliance with storm drainage and surface water management regulations
- Require flood disclosure statements on property titles
- Enhance coordination with cities and other jurisdictions or agencies with storm drainage or surface water management programs

Descriptions of the proposed CIPs and programmatic measures can be found in Chapter Nine of the Proposed Basin Plan.

10.1.1 Final SEIS Supplements 1991 EIS, Non-project and Phased Environmental Review

The Final SEIS is based on information provided in the 1991 Plan EIS. However, because some of the information provided in the 1991 EIS has changed or was not complete, this Final SEIS provides new and additional information to assess the effects of the Proposed Basin Plan on the environment. Many potential impacts from implementation of the 1991 Plan were evaluated within the original 1991 EIS and are not addressed again here. Copies of the 1991 Storm Drainage and Surface Water Management Plan and the 1991 Environmental Impact Statement are available for review at the Pierce County Water Programs office, 9850 64th Street West, University Place, WA 98467-1078, (253) 798-2725 and at Pierce County Planning and Land Services Department, located at 2401 S. 35th St., Tacoma, WA, 98409, (253) 798-7210.

Because the Proposed Clear/Clarks Creek Basin Plan consists of recommendations for actions and Water Programs will not implement a particular recommendation until it is included in a CIP, Pierce County Budget, or other approved program. The Proposed Basin Plan meets the definition of a nonproject proposal, per WAC 197-11-704 and WAC 197-11-774. The environmental review in this Final SEIS is nonproject. Future project-specific environmental review may be required prior to implementation of the construction projects and certain programmatic measures.

10.1.2 Format of Final SEIS

This Final SEIS is a chapter of the Proposed Clear/Clarks Creek Basin Plan (Part IV). Because much of the Basin Plan includes descriptions of the environmental conditions, the Final SEIS frequently summarizes and/or refers to other sections in the Basin Plan.

Chapters 1, 2, 3, 4, and 5 of the Proposed Basin Plan constitute Part I, the "*Basin Characterization*". The characterization describes the environmental attributes of the watershed, focusing on stream reaches, wetlands associated with streams, critical areas, federally listed and non-listed fish habitat, areas of localized flooding, and future land use changes. Therefore, the Affected Environment sections of the Final SEIS summarize and refer to specific sections of the Basin Plan. Other environmental elements not addressed in the Proposed Basin Plan are summarized based on the 1991 EIS and other sources.

Part II of the Proposed Clear/Clarks Creek Basin Plan, contains the "*Basin Analysis*". Chapter 6 analyzes flooding and storm drainage problems and alternatives, Chapter 7 assesses water quality problems, and Chapter 8 evaluates aquatic habitat and identifies alternatives to solve problems. Part II includes analysis of the benefits and adverse impacts of proposed storm drainage and surface water management measures. The Impact Analysis section of the Final SEIS summarizes and refers to specific sections of the "*Basin Plan Analysis"* chapters of the Proposed Plan. Remaining environmental elements not addressed in the Basin Plan are included in the Final SEIS.

Part III, Chapter 9, is the "*Clear/Clarks Creek Basin Plan"* itself. The Description of Alternatives section in the Final SEIS will summarize and refer to the Basin Plan, where pertinent.

10.1.3 Summary of Impacts

Table 10-1 summarizes adverse impacts to elements of the environment, as discussed in the Alternatives and Impacts and Mitigation sections of this Final SEIS. Identification of likely adverse environmental impacts assumes that implementation activities will be conducted in accordance with applicable local, State of Washington, and federal land use, development, and environmental regulations.

TABLE 10-1 Summary Comparison of Impacts

Element	Proposed Action	Significant Adverse Environmental Impact?	No Action Alternative	Significant Adverse Environmental Impact?
Water Resources	Temporary reductions in water quality associated with culvert replacement projects during construction.	No	Temporary reductions in water quality associated with culvert replacement projects during construction.	Potential
	Purchasing property, detention ponds, improved culverts would result in an improvement in flooding and drainage conditions on roadways and private property	No	Many flooding problems would continue to occur	Yes, housing, roads, and private property in situations not covered in the 1991 Plan could be damaged by flood water
	Potential for temporary water quality impacts during the removal of barriers to fish migration or stream restoration projects	Minor, projects will be designed & managed to use Best Management Practices	No replacement of culverts that are a barrier to fish passage & no stream restoration projects	No. Temporary water quality impacts. But decision not to remove barriers or restore stream corridors has significant adverse effects on water temperature, pH, dissolved oxygen, fecal coliform bacteria, and salmonids
	Water quality would be improved by projects and actions	No	Water quality would not be improved by proposed projects	Potential
	Purchasing properties in flood-prone areas would provide better flood control	No	Continuation of the existing repetitive loss program	No
	Adopting updated stormwater standards and increasing inspection for compliance	No	Maintain current standards and inspection program	Potential
	Implementing a land management program to preserve floodplains	No	Without a land management program	Potential

TABLE 10-1 Summary Comparison of Impacts

Element	Proposed Action	Significant Adverse Environmental Impact?	No Action Alternative	Significant Adverse Environmental Impact?
Water Resources (continued)	Implementing an education and outreach program regarding flood hazards could contribute to an improvement in flooding conditions	No	Continuation of the existing outreach program about flood hazards	Potential
Fishery Resources	Potential for short-term increase in stream sediment during construction of culvert replacements and stream restoration projects	No, instream work will follow BMPs in Regional Road Maintenance Guidelines	Potential for short-term increase in stream sediment during construction of culvert replacements and stream restoration projects	Potential
	County stream restoration and bank stabilization would improve aquatic habitat by reducing fine sediment loading and deposition during storm events	No (benefit likely)	Habitat improvements would be carried out mainly by others	Potential
	Replacement of culverts would provide additional areas of fish habitat	No (benefit likely)	Culverts replaced if not able to handle runoff, not if a barrier to fish passage	Potential
	Base stream flows better protected	No (benefit likely)	Low channel flows are expected to worsen further degrading fish habitat	Yes
	Implementing a land acquisition program to manage flood-prone areas would improve fish/aquatic habitat conditions	No (benefit likely)	Development as permitted by County Critical Areas Regulations	Potential for cumulative impacts
Plants and Animals	Stream banks would be revegetated to improve aquatic habitat, reduce water temperatures and improve water quality	No (benefit likely)	Vegetation will continue to be adversely affected in developing areas of the basin with no coordinated plan for protection	No

TABLE 10-1 Summary Comparison of Impacts

Element	Proposed Action	Significant Adverse Environmental Impact?	No Action Alternative	Significant Adverse Environmental Impact?
	Temporary impacts to vegetation may occur during construction activities	No, restoration required	Temporary impacts to vegetation may occur during construction activities	No, restoration required
	Improvements to riparian buffers will result in a net increase in riparian area and vegetation	No (benefit likely)	No improvements to existing condition	Potential
	During construction activities, wildlife may be temporarily displaced	No, minimizing adverse effects is required	During construction activities, wildlife may be temporarily displaced	No, minimizing adverse effects is required
	Removal of invasive and non-native plant species during restoration projects may result in temporary displacement of wildlife species due to loss of cover	No	N.A.	Nor
	Floodplain acquisition and enhancement would aid wildlife by improving habitat conditions	No (benefit likely)	No improvement to existing habitat programs	Potential
	Implementing a land management program to protect surface water quality would improve habitat conditions	No (benefit likely)	Development according to Pierce County Development Regulations	Potential
Soils	Streambank stabilization projects would reduce erosion and eliminate sources of fine sediments	No	Stream channelization would continue under peak stream flow rates causing scouring of streambed soils	Potential
	Channel stabilization projects would reduce scour & erosion	No	No streambank or channel stabilization projects	Yes

TABLE 10-1 Summary Comparison of Impacts

Element	Proposed Action	Significant Adverse Environmental Impact?	No Action Alternative	Significant Adverse Environmental Impact?
	Removal of invasive and non-native plant species during restoration projects could temporarily increase potential for soil erosion	No, temporary erosion & sedimentation controls are required followed by stabilizing the site with new plants	No removal of invasive and non-native vegetation	Potential
	Culvert replacement projects could temporarily increase soil erosion during construction	No, temporary erosion & sedimentation controls are required followed by stabilizing the site with new plants	Culvert replacements per the 1991 Plan could temporarily increase soil erosion during construction	No, temporary erosion & sedimentation controls are required followed by stabilizing the site with new plants
Land and Shoreline Use	Development would be directed away from floodplains & valuable habitat resources toward areas with fewer constraints	No	Continued reduction of riparian corridor for single family residences and other reasonable use exceptions	Potential
	Stormwater facility development would be consistent with adopted policy and regulation	No	Stormwater facility development would be consistent with adopted policy regulation	No
	Basin Plan information would guide and/or support development of land use plans that reduce impacts to water resources	No	Development impacts to water resources would continue, the Master Plan emphasis is on CIP development; support for land use decisions is not provided	Potential
	The Basin Plan is proactive in reducing development related impacts Purchasing properties in flood prone areas would reduce flood hazard areas	No	The existing program is reactive to development related impacts	Potential

TABLE 10-1 Summary Comparison of Impacts

Element	Proposed Action	Significant Adverse Environmental Impact?	No Action Alternative	Significant Adverse Environmental Impact?
Aesthetic, Historic and Cultural Resources	Temporary aesthetic impacts associated with tree/vegetation removal for construction of infiltration ponds, detention facility and other projects	No	Temporary aesthetic impacts associated with tree/vegetation removal for construction of infiltration ponds, detention facility and other projects	No
Public Services and Utilities	During facility construction roads/lanes could be closed temporarily resulting in potential delays for emergency vehicles	No	During facility construction roads/lanes could be closed temporarily, resulting in potential delays for emergency vehicles	No
	Upgrades of under-capacity culverts would reduce the incidence of road closures due to flooding	No	Limited upgrades of several under-capacity culverts would reduce, somewhat, the incidence of road closures due to flooding	Potential
	Implementation of projects and programs would improve public safety and reduce the need for some public services	No	Public safety and the need for some public services will be minimally improved.	Potential

10.2 Alternatives, Including the Proposed Action

10.2.1 Introduction

This section describes alternatives to achieve the long term goals of the 1991 Pierce County Storm Drainage and Surface Water Management Plan (the 1991 Plan). The alternatives evaluated are the **Proposed Action**, adoption of a basin plan for the Clear/Clarks Creek Creek Basin (Proposed Basin Plan) and the **No Action Alternative**, continued use of the Capital Improvements Program element of the 1991 Plan as the basis for project implementation. This section also provides background on the original 1991 Plan that would be altered by the Proposed Clear/Clarks Creek Basin Plan.

10.2.2 Background - Pierce County Storm Drainage and Surface Water Management Plan (1991 Plan)

The Pierce County Council established the County's Surface Water Management Utility in March 1988 by Ordinance 87-205. In 1991, the County adopted the original Stormwater

Drainage and Surface Water Management Plan (1991 Plan). The 1991 Plan was intended to provide a comprehensive program for surface water management operations, funded by service charges. A Surface Water Management Utility was established pursuant to Chapters 36.89 and 39.34 RCW (Authorizes surface water management fees, and provides for cooperation between local agencies, respectively). It was also prepared to satisfy Washington Department of Ecology requirements for a Comprehensive Flood Control Management Plan (WAC 173-145).

The 1991 Plan addressed all 26 of the drainage basins in Pierce County to varying degrees. Urban areas were studied in more detail than rural basins. Eight basins were studied in detail: Gig Harbor, Hylebos Creek, Clear/Clarks Creek, Clover/Steilacoom Creek, Chambers Bay, Tacoma West/Browns-Dash Point, Muck Creek, and American Lake.

The 1991 Plan contains recommendations for both structural and non-structural means of accomplishing goals and objectives. Non-structural recommendations tend to be broad and county-wide rather than basin or study area specific. The 1991 Plan focuses primarily on capital projects addressing flooding problems existing in 1991. Specific flood control projects were recommended in the 1991 Plan to be included in a Capital Improvement Program (CIP).

The long term goals were to be goals for the life of the storm drainage and surface water management program. The goals are shown in *Table 10-2*:

TABLE 10-2
Goals of Pierce County Storm Drainage and Surface Water Management Plan (1991 Plan)

Goal	Description	Objectives
1. Prevent the Loss of Life, the Creation of Public Health or Safety Problems and the Loss or Damage of Public and Private Property.	Prevent the loss of life or property due to flooding events.	Nonstructural measures should be preferred over structural measures. Protection of existing facilities and structures should take preference over the protection of undeveloped lands. Land use and related regulations and zoning should reflect the natural constraints of the streams, floodplains, meander zones, and riparian habitat zones. Together, this plan, program and codes should present consistent goals and objectives.
2. Establish and Adopt a Systematic and Comprehensive Approach	Storm water management should occur in the context of an ongoing, systematic and comprehensive approach to solving existing problems and preventing future problems.	Continue the role of the Citizens Advisory Committee or similar body in an advisory role of the Utility. The body should represent the entire County and citizens with a variety or [sic] reasons for their interest in surface water management. Strategies for surface water management should balance engineering, economic, environmental, and social factors in relationship to stated comprehensive planning goals and objective. Public understanding of the various capabilities and limitations of storm water management should be improved through a variety of educational efforts. The goals and objectives of the 1991 Plan should be evaluated at regular intervals (i.e. every 5 years) to maintain consistency with other related programs affecting the environment.
3. Minimize Expenditure of Public Funds		A stable, adequate, and publicly acceptable long-term source of financing should be established and maintained for the Utility and the comprehensive management program.

TABLE 10-2
Goals of Pierce County Storm Drainage and Surface Water Management Plan (1991 Plan)

Goal	Description	Objectives
4. Maintain the Varied Uses of the Existing Natural Drainage System within the County	Storm water management in Pierce County should occur in the context of the varied uses associated with the natural drainage systems within the County. These include agricultural, commercial, industrial and residential, fish and wildlife habitat, water supply, open space, and recreation.	Storm water management measures should preserve to the fullest extent possible opportunities for other uses. Structural flood control measures should not obstruct fish passage. Structural flood control measures should preserve or enhance existing flow characteristics for fisheries, and other uses of the riparian zone. Flood control activities should not result in a net loss of, or damage to fish and wildlife resources, but whenever possible develop or improve the diversity of habitat.
	Preserve to the fullest extent possible, the scenic, and ecological qualities of the natural drainage system in harmony with those uses which are deemed essential to the life of its citizens, and wherever possible, enhance the instream and riparian uses of the streams, wetlands and lakes of Pierce County.	Changes in land use should try to restore the lands natural character to the natural state whenever possible.
5. Prevent the degradation of the quality of both surface water and the water entering the regions aquifers.	Urbanization normally leads to a reduction in the quality of storm water runoff. This can become a problem both for the wildlife which depends on the stream system and the local populace.	The use of natural drainage system is preferred over the use of pipelines or enclosed detention systems. The preservation of natural wetland, floodplains and streams is to be actively pursued. The County will apply for a NPDES permit and will strive to be in compliance with the requirements for the preservation of water quality. All storm water runoff from impervious surfaces should be treated before it is allowed to enter the natural drainage system, infiltrate into the ground, or enter Puget Sound.
6. Coordinate with Public and Private Sectors	Stormwater management measures should be compatible with the various public and private sectors affected.	Planning and design/construction of stormwater management measures should include opportunity for identification of acceptable storm water management measures. The SWM Advisory Board should provide information about existing and pending regulations that are incompatible with the goals of the 1991 Plan. Efforts should be made to work with the Cities towards standardization of regulations which impact stormwater management.

Pursuit of these goals continues. Most goals were related to the planning, construction, operation and maintenance of storm drainage facilities. Many of the objectives have been met. (See Appendix B of the Proposed Basin Plan.)

In addition to goals, the 1991 Plan established objectives for each of the 26 study areas (i.e., basins). Six surface water management objectives apply to the Clear/Clarks Creek Basin:

1. Prevent existing flooding problems in the Pothole area from becoming worse.
2. Eliminate the existing flooding problem from the Puyallup River.
3. Prevent stormwater problems before they occur.
4. Coordinate with the Cities of Tacoma and Puyallup.
5. Coordinate actions with the Puyallup Indian Tribe.
6. Eliminate existing localized flooding problems.

10.2.3 Use of the 1991 Plan as Principal Focus of CIP has Evolved

The 1991 Plan has been used as a basis for Capital Improvement Program (CIP) proposals since 1991. However, project planning, funding, construction, and maintenance activities have been affected by significant changes. Projects selected every year are now adopted by the County Council as part of the six-year Capital Facilities Element of the County's Comprehensive Plan. Although many of the projects still come from the original 1991 Plan, other projects have been developed to respond to more recent information and drainage problems that were not contained in the 1991 Plan. Additionally, since the 1991 Plan was developed, the cities of University Place, Lakewood, and Edgewood have incorporated and eliminated the County's responsibility for surface water management in these areas. Other cities such as Puyallup, Tacoma, and Fife have annexed adjoining areas also reducing the County's responsibilities.

The 1991 Plan was developed before the Growth Management Act and the adoption of the County Comprehensive Plan. Development regulations (zoning, site development regulations, critical areas regulations, and the like) have changed development patterns in some areas of the County and the future growth estimates used to develop the 1991 CIP list are no longer valid. Many of the projects proposed as part of the 1991 Plan have been constructed, while others cannot not be constructed because development patterns have made acquisition of construction sites prohibitively expensive.

Several of the smaller projects in the 1991 Plan, such as culvert replacement or maintenance activities within road rights-of-way, were completed by the Transportation Services Division of Public Works and Utilities.

10.2.4 Proposed Action: the Clear/Clarks Creek Basin Plan

The proposed action is adoption and implementation of a Basin Plan for surface water management in the Clear/Clarks Creek Basin. The Proposed Basin Plan documents existing conditions that bear on the Basin's storm drainage and surface water resources, identifies storm drainage and surface water resource problems and issues, and recommends a plan to improve conditions in the Basin. It includes recommendations for capital projects and programmatic activities designed to remedy existing problems and projected needs. Plan goals are translated into a comprehensive list of action recommendations, including projects, programs, and studies to address the water quality, flooding, erosion, and aquatic habitat problems identified in the Basin Plan. The Proposed Basin Plan would update and append the 1991 Plan. Projects included in the Basin Plan would append and update the 1991 Capital Improvement Plan, Volume II of the 1991 Plan. Programmatic recommendations would augment the nonstructural recommendations contained in the 1991 Plan. The Basin Plan will provide guidance for Water Program's future Capital Improvement Projects (CIPs), non-capital expenditures, water resource protection policies, responsible use of public resources, and for new development in the Clear/Clarks Creek Basin.

The Proposed Basin Plan has been developed in accordance with the framework document "Guidance for Basin Planning" prepared by Pierce County Water Programs. The guidance document contains a list of tasks for preparation of a basin plan and direction for completing the tasks.

There are a total of 65 CIP's proposed in this Plan. Locations are shown in *Figure 9-1*. Their distribution by problem type is shown below.

- Six (6) culvert replacement projects
- One (1) infiltration pond
- Nine (9) detention ponds
- Nine (9) pipeline projects
- One (1) setback levee
- Eighteen (18) streambank/channel stabilization projects
- Six (6) stream corridor restoration projects
- Forty-two (42) water quality-related projects (includes some of the projects listed above)

Twelve proposed programmatic measures include the following activities;

- Update the Pierce County Stormwater Management and Site Development Manual
- Develop and Implement a "Best Management Practices" (BMP) Manual for Pierce County Water Programs Facilities Maintenance Activities
- Develop and Implement an "Invasive Species Management Program"
- Develop and Implement a "Land Management Program" for Aquatic Habitat Protection and Flood Hazard Reduction

- Develop a "Low Impact Development" program
- Develop and implement an "Education, Outreach, and Technical Assistance Program"
- Develop and implement a "Restore Degraded Aquatic Habitat and Protect Water Quality and Attenuate Flood Hazards Program"
- Develop and implement a "Surface Water Monitoring Program"
- Increase inspections for compliance with storm drainage and surface water management regulations
- Enhance coordination with cities and other jurisdictions
- Develop a stormwater facility design process that integrates public involvement and alternatives for multiple uses of facility sites
- Require flood disclosure statements on property titles.

The specific CIPs and programmatic measures are described in Chapter Nine of the Proposed Basin Plan.

Each proposed project and programmatic action is prioritized in the Basin Plan first through evaluation of individual project or programmatic recommendations against standard criteria, then by estimated cost. The rating evaluation assigns points based on the ability of a project or program to accomplish the goals and objectives of the basin planning program. *Appendix "H"* of the Basin Plan contains copies of the rating sheets. Summary rating criteria follow:

- Flood Reduction (level and frequency)
- Water Quality Improvement (source reduction)
- Natural Resource Improvement (restoration and protection)
- Recreational and Multiple Use Opportunities
- Aesthetics

10.2.5 No Action Alternative

The "No Action" Alternative means that the proposed Clear/Clarks Creek Basin Plan would not be adopted and the current ad-hoc method of solving flooding, water quality, and aquatic habitat problems continues. Under the No-Action Alternative, stormwater facilities would continue to be managed using the 1991 Plan, which does not consider needs based on planned growth within the Basin. No-Action means continuing Water Programs activities as the program currently exists, using the 1991 CIP and problems as they arise as the basis for the Capital Facilities Element of the County Comprehensive Plan and the annual budget of Water Programs. As the list of high priority projects in the 1991 Plan are completed, and as the 1991 Plan becomes more dated, the County will increasingly rely upon more opportunistic means of identifying and prioritizing capital projects, such as citizen complaints and judgment of County staff.

Most of the problems within the Clear/Clarks Creek Basin identified in the 1991 Plan are related to the loss of flood storage areas and undersized culverts. For the Clear/Clarks Creek Basin, the

1991 Plan CIP identified project costs totaling $11,516,000, of which $7,040,000 were for high priority projects (12 culvert replacements costing $300,000 and $600,000 for miscellaneous drainage projects.)

Table 10-3 lists original high priority CIP projects in the Clear/Clarks Creek Basin.

TABLE 10-3
Original High Priority CIP Projects, Clear/Clarks Creek Basin

Project Number	Description and Location of Project	Constructed?
CL-CULV-H	Replace 12 county owned culverts	partial
CL-proj(a)	Levees along Clear Creek at Puyallup River	
CL-proj(d)	Diru Creek Pipeline, 750 feet of 48" pipe	
CL-proj(e)	58th Street pipeline capacity improvement	
CL-proj(f)	Portland Ave. to Roosevelt Ditch pipeline capacity improvement	
CL-proj(g)	New pipeline from 64th Street E. @ Vickery to Clear Creek	
CL-cDET	Detention facility along the E. Fork of Clear Creek at 84th Street E	X
CL-dDET	Detention facility along Canyon Creek at 72nd St. East	
CL-eDET	Detention facility along Diru Creek upstream of 114th	
CL-yDET	Detention facility along Diru Creek upstream of 84th	
CL-gDET	Detention facility at Northern Pothole	X
CL-mDET	Flood plain zoning at Upper Meridian Pothole	
CL-nDET	Flood plain zoning at Black Swamp Pothole	
CL-o1DET	Flood plain acquisition at 80th Avenue Pothole (vicinity 82nd Ave)	
CL-rDET	Flood plain zoning at 136th Street E. (Central) Pothole	
CL-tDET	Flood plain zoning at Springfield Pothole	
CL-vDET	Flood plain zoning at 116th Street Pothole	
CL-wDET	Flood plain zoning at 128th Street Pothole	
CL-bbDET	Detention facility along the West Fork of Clear Creek at 72nd Ave	
CL-ffDET	Detention facility along Woodland Creek at 84th Street	X
CL-ggDET	Detention facility along Swan Creek at 84th (tributary)	X
CL-hhDET	Detention facility along Canyon Creek at Pipeline Road	
CL-xDET	Flood plain zoning at 117th Street Pothole	
CL-misc	Miscellaneous drainage projects (allowance for undefined projects)	X

Other Projects included in No-Action

In addition to the 1991 Plan, the U.S. Congress established an Army Corps of Engineers General Investigation New Start Program to fund large complex projects where a federal interest exists and when co-sponsored by a local government, agency, or non-profit with local matching funds. The program identified a number of potential projects that could help in restoring water quality and fish habitat in the Puyallup/White River watershed. Several of the identified projects lie within the Clear/Clarks Creek Basin and are discussed further under the No-Action Alternative in the Water Resources, Fishery Resources, and Plants and Animals Sections of this Final SEIS.

10.3 Affected Environment, Significant Impacts, and Mitigation Measures

10.3.1 Water Resources

Much of the Proposed Basin Plan deals with improving the flow regime and water quality within the Clear/Clarks Creek Basin. This section reviews the adverse impacts and benefits of the Proposed Basin Plan upon water resources in the Clear/Clarks Creek Basin and the lower Puyallup River.

Affected Environment

The Clear/Clarks Creek Basin drains approximately 33 square miles, including the 8.3-square-mile Pothole area and the 1.0-square-mile Roosevelt Ditch area. The natural stream channels of the Clear/Clarks Creek Basin system include approximately 33 miles of streams, according to Pierce County's 2002 GIS hydro coverage. The Clear/Clarks Creek Basin streams form part of the Lower Puyallup sub-watershed (in Water Resources Inventory Area No.10 – Puyallup-White). Both Clear Creek and Clarks Creek flow from the northern slope of the hillside between east Tacoma and southwest Puyallup. The two drainage basins converge with the Puyallup River within three miles of salt water; and tidal fluctuations in the river create regular backwater flows at the mouths of these streams.

The Clear/Clarks Creek Basin includes Clarks Creek, Clear Creek, Diru Creek, Woodland Creek, Canyon Creek, Squally Creek, Rody Creek, and Swan Creek, Roosevelt Ditch and numerous pothole areas. The Basin is composed of 16 subbasins, eight of them are potholes.

Drainage and Flooding

In general, drainage problems in the Basin are being compounded by ongoing development. The addition of each single-family home results in more impervious surface area and results in additional surface water runoff. With the increasing development of the Clear/Clarks Creek Basin, there are issues related to the loss of floodplain storage area, reduction of perennial stream flow, undersized culverts, and the loss of flow capacity due to invasive species in the conveyance systems.

Forty-eight sites were evaluated for flooding or erosion problems within Clear/Clarks Creek Basin. *Figure 6-2* in Chapter Six shows these locations. The flooding problems are summarized in *Table 6-3* in Chapter Six. The most common flooding problem is water overtopping roads due to insufficient culvert capacity. In addition, 24 instances of property flooding are documented. The highest density of drainage problems occur in the Roosevelt Ditch, Canyon Creek, Rody Creek and Woodland Creek subbasins. Further information on existing water resource conditions and problems can be found in Chapters 4, 5, and 6.

Water Quality

Elevated levels of fecal coliform bacteria, erosion, and sedimentation are the primary water quality issues for the Clear/Clarks Creek Basin. Three streams are listed for fecal coliform bacteria (Swan, Clear, Clarks). While the potential sources of fecal coliform bacteria vary from creek to creek, the likely sources in the Clear/Clarks Creek Basin are livestock, waterfowl, residential runoff, and failing septic systems. In addition to generally high levels of fecal coliform, the referenced reports noted sporadic occurrences of elevated pH levels, high nutrient loading, and sedimentation. However, these areas were not widespread (both Clarks Creek and

Meeker Ditch are also listed for pH). Find further information on existing water quality in chapters four and seven.

Regulatory Compliance

Numerous federal, State of Washington, and local regulations, laws, policies, and programs affect how stormwater and surface water are managed in unincorporated Pierce County. For more detailed information regarding these policies and programs, see Chapter 2 in the Proposed Basin Plan.

Impacts and Mitigation Measures

Proposed Action

The proposed action includes numerous capital improvement projects to reduce roadway flooding, improve culvert capacity, provide stormwater detention, improve water quality, and restore and/or enhance stream and riparian habitat. In addition to the capital improvement projects, the Proposed Basin Plan recommends several programmatic measures to more broadly address and improve flooding, drainage, and water quality conditions within the Basin. Implementation of the Clear/Clarks Creek Basin Plan is expected to result in major long-term benefits to the quality of surface water in the Basin. By association, water quality in the Lower Puyallup River could improve. The following subsections discuss the effects of the proposed action on drainage and flooding, and water quality within the Clear/Clarks Creek Basin.

Drainage and Flooding

Proposed capital improvement projects would improve water resource conditions along most of the creeks in the Basin, to stabilize eroding stream channels and restore aquatic habitat. In the plateau area in the southern portion of the Basin, channel overflows would be reduced, minimizing flooding of adjacent property. Numerous road culverts would be increased to provide sufficient capacity and reduce roadway flooding. Acquisition of ponding or flood prone areas would reduce future flood hazards by restricting development and using the areas as flood control facilities.

The proposed action includes recommendations for additional studies and programmatic measures to develop and implement projects and programs that will serve to reduce flood hazards. The programmatic measures would result in improvements to flooding and drainage conditions on a broader level over a longer period of time. Chapter 9 describes the intentions of the programmatic measures and their anticipated benefits.

10.3.2 Water Quality

Regulatory Compliance

Numerous federal, State of Washington and local regulations, laws, policies and programs affect how stormwater and surface water are managed in unincorporated Pierce County. Chapter 2 of the Basin Plan describes those pertinent to storm drainage and surface water management activities in the Clear/Clarks Creek Basin. This section discusses the ability of the Proposed Basin Plan to demonstrate coordination and consistency with the adopted policies and plans.

National Pollutant Discharge Elimination System (NPDES)

The proposed action includes site-specific water quality, flooding, and habitat problems related to stormwater runoff. It recommends some site-specific solutions to these problems. Phase I

NPDES stormwater permit holders are required to protect water quality in accordance with the permit terms and state water quality standards. The proposed alternative is consistent with the NPDES stormwater permit requirements. The Proposed Basin Plan recommends solutions to both site-specific and broad stormwater problems. Recommended solutions range from programmatic activities, such as water quality monitoring, to erosion control projects to remedy sediment and turbidity problems.

Clean Water Act (CWA)

Two sections of the CWA are affected by the proposed action:

Section 303(d) List and Total Maximum Daily Loads (TMDLs)
Washington's 1998 303(d) list of impaired water bodies includes Swan Creek, Clear Creek, and Clarks Creek for exceeding standards for fecal coliform bacteria and Clarks Creek for pH. The Proposed Basin Plan addresses each of these listings with projects intended to alleviate the conditions leading to the water quality impairment. The No-Action Alternative provides limited projects with opportunity for correcting water quality problems.

Section 404 Wetland Fill Permits
The Proposed Basin Plan includes site-specific and programmatic measures to protect and enhance floodplain and wetland habitat hydrology in the Basin. The No-Action Alternative maintains a largely structural set of projects with potential to aggravate wetland losses.

National Flood Insurance Program

The Proposed Basin Plan includes all of the program elements for the County to achieve a "Class 4" or better rating in the Community Rating Program. On a Countywide basis, the Proposed Basin Plan also includes the adoption of more restrictive flood hazard regulations and improved mapping of flood hazard areas, consistent with objectives the National Flood Insurance Program.

Aquifer and Wellhead Protection

The Proposed Basin Plan takes into account the locations of wells and wellhead protection requirements in siting new storm drainage facilities or recommending improvements to existing facilities. Stormwater infiltration facilities included in the proposed action will be designed to meet groundwater quality standards and sited to avoid areas where shallow groundwater intersects aquifers providing potable water supplies. Although the No-Action Alternative is silent on this issue, facilities with potential to adversely affect aquifers and wells would have to be designed to avoid or overcome adverse impacts to aquifers and wells.

10.3.3 Other Agencies Conducting Water Resources Enhancement Projects

As described in Chapter 2, the Army Corps of Engineers General Investigation New Start Program funds large complex projects where there is a federal interest and when co-sponsored by a local government, agency or non-profit with local matching funds. The intent behind the New Start projects is to restore water quality and fish habitat in the watershed. Projects and programs identified in the Proposed Basin Plan would complement these other watershed improvement projects by contributing towards improved water quality and habitat. The Proposed Basin Plan's effects on the individual projects are discussed below:

Swan Creek Stream Restoration (in progress), City of Tacoma
The proposed action alternative could potentially reduce fine sediment loading downstream of Swan Creek.

Clear Creek Floodgate Removal (partially completed through a Port of Tacoma project), Pierce County Water Programs
Detention facilities included in the proposed action alternative would reduce peak flows and potentially reduce flood hazard in the Clear Creek area.

Clear Creek Off-Channel Habitat, Port of Tacoma
The Proposed Basin Plan would compliment the Clear Creek Off-Channel Habitat project by restoring stream habitat upstream of the Port of Tacoma project.

Puyallup-Lower Sub-Basin Barrier Removals, Pierce Conservation District
The Proposed Basin Plan identifies and recommends removal of fish barriers to restore fish habitat in the Lower Puyallup River drainage.

Clarks Creek & Meeker Ditch Confluence Improvement, City of Puyallup
The Proposed Basin Plan would remove sources of fine sediment from Clarks Creek, improving water quality conditions. Bank stabilization, riparian restoration, and detention projects would also contribute to improved stream habitat.

Public Water Supplies

Both the Proposed Action and the No-Action Alternative include routing stormwater to regional infiltration facilities in the Basin. Infiltrated stormwater can enter groundwater supplies, potentially affecting individual wells and public water drawn from groundwater. As part of the Proposed Basin Plan and as part of Pierce County policy, detention and infiltration facilities would be equipped with water quality treatment components that guard against untreated stormwater entering aquifers.

No-Action Alternative

Under the No-Action Alternative, stormwater would continue to be managed in the Clear/Clarks Creek Basin as it is today. Water Programs' efforts would continue to focus on serious drainage complaints rather than assuming a more proactive, comprehensive approach. Periodic maintenance of ditches, culverts, and other County facilities by Water Programs maintenance crews would continue. Short-term impacts and mitigation measures from these projects are similar to capital facilities impacts discussed under the Basin Plan alternative.

Drainage and Flooding

Under the No Action Alternative, Swan and Woodland Creeks would experience the largest increases in peak flow rates for more frequent storm events. The duration of flow above the 2-year peak flow rate (channel shaping flow) would also increase in Swan and Woodlands Creeks, as well as the upland reaches of Canyon Creek. Because stream flow rates in excess of the 2-year peak flow rate most heavily influence channel shaping, higher peak flows of long duration would likely increase the rate of erosion in these streams.

Regulatory Compliance

Under the No Action Alternative, the 1991 Plan would not adequately address the numerous federal, State of Washington, and local regulations, laws, policies, and programs that have been created, amended, or adopted since it was written in 1991. Projects implemented under the Army Corps of Engineers General Investigation New Start Program may successfully fulfill

portions of regulations, pertaining to stormwater and surface water management, but would not be sufficient to demonstrate compliance with all of them.

10.3.4 Fishery Resources

Affected Environment

Clear/Clarks Creek Basin supports five species of salmonids including chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), steelhead trout (*O. mykiss*), and cutthroat trout (*O. clarki*) (Don Nauer, WDFW area habitat biologist, personal communication, 2001; Russ Ladley, Puyallup Tribe fisheries biologist, personal communication, 2001). Cutthroat trout are likely to be present in both the anadromous and resident forms. One federally protected fish species, Chinook, is found in the Clear/Clarks Creek Basin. Chinook use spawning habitat in Clear and Swan Creeks in the vicinity of Pioneer Way, and perhaps a short distance upstream. Additional information on species of concern that are present in the Clear/Clarks Creek Basin can be found in Section 4.4 (*Table 4-19*). Salmon populations in Clear and Clarks Creeks are significantly influenced by hatchery releases. There are three hatcheries within the Clear/Clarks Creek Basin; these include the Puyallup Tribe hatchery, a Washington Department of Fish and Wildlife (WDFW) Hatchery, and the Trout Lodge Hatchery. For specific locations and production numbers see Section 4.4.1.

Chapter 8 documents the channel erosion and associated loss of stream habitat in the Clear/Clarks Creek Basin. This has resulted due to large increases in both the frequency and magnitude of high flows resulting from development within the Basin. Reduced infiltration due to increases in impervious area may also result in reduced stream base flows and intermittent flow conditions in the upper portions of some streams. The altered hydrologic regimes of the creeks in the Clear/Clarks Creek Basin are a major reason for the reduction of aquatic habitat. Another important reason for degraded stream conditions is a lack of riparian buffer along many of the upper reaches of the streams. The hydrologic changes combined with a lack of riparian buffers have resulted in generally poor fish habitat within the Basin. Most of these problems are typical of streams in urbanized areas.

The habitat problems resulting from increased peak flows include erosion, sediment deposition, excessive bedload movement, loss of pools, and reduction in habitat complexity. Water quality is also a problem, at least in Clarks Creek and its tributaries. Fish passage is a limiting factor in all streams. Low summer base flows limit habitat potential to the lower sections of each stream. Riparian communities are generally good, but the high peak flows are removing the large woody debris (contributed by the riparian trees) from the stream channels. Additional information on existing conditions can be found in Section 4.4, 5.4, and Chapter 8.

Proposed Action

The Proposed Basin Plan includes culvert replacements that would remove fish passage barriers. Many channel stabilization projects would also be included that would lessen erosion and sedimentation, thereby improving fish habitat conditions.

Six creeks - Clear, Canyon, Rody, Diru, Woodland and Clarks creeks - would undergo stream restoration projects with the Proposed Basin Plan. Restoration projects would include habitat restoration projects to restore wetlands, stream habitat and/or riparian areas. Many of the

restoration projects would benefit water quality also because they would control sedimentation due to erosion and provide shade.

The Proposed Basin Plan also includes eight detention and infiltration facilities that would contribute towards reducing peak flows. Reduced peak flows would improve the existing stream habitat by reducing erosion within the stream, which can erode and damage a stream. Some of the detention ponds could also improve base flow in the creeks if designed to encourage infiltration (refer to recommended study ST-03-00-ST-01, Evaluate the Feasibility of Augmenting Low Base Flow Through the Use of Stormwater Infiltration Facilities).

Programmatic solutions in the Proposed Basin Plan would benefit existing habitat and reduce future habitat losses. An acquisition and land management program would identify and preserve high quality floodplain/riparian corridors. Enhancement programs would help to prioritize and facilitate habitat restoration. Monitoring programs would track the health of streams. Refer to Chapter 8 for more detail regarding the effects of the Proposed Basin Plan on fish resources.

Endangered Species Act

The salmonid listings have broad regulatory effects on storm drainage and surface water management plans. Water quantity and water quality, crucial features of fish habitat adversely affected by certain ways of solving flooding and storm drainage problems, must be addressed to protect listed species. The Proposed Basin Plan includes a number of programmatic measures that are consistent with recent Section 4(d) (of ESA) rules. These rules identify specific activities that can be conducted without constituting an unlawful take of the threatened species. Section 9.2 in the Basin Plan describes several approaches that would demonstrate compliance with the provisions of ESA. A few examples of these approaches include:

- Preference for Non-Structural Solutions
- Low Impact Development
- Critical Areas Conservation
- Public Involvement and Education
- Compliance Assurance

No Action Alternative

Under the No Action Alternative, “flashy” hydrology within the Clear/Clarks Creek Basin would likely continue. The significant amounts of impervious surface in the Basin have increased runoff and peak flows. High peak flows cause erosion in the ravine (canyon like) sections of streams and sediment is deposited in the downstream reaches. Sediment destroys spawning and rearing habitat and high peak flows can destroy salmon nets. Furthermore, flashy hydrology often means lower flows in summer months, adversely affecting resident and spawning fish.

Long-term adverse effects to streambanks and fish habitat due to flashy hydrology in the Basin are expected to continue. The absence of detention ponds and the continued erosion and sediment deposition would continue to degrade fish habitat.

Regulatory Compliance

Under the No-Action Alternative, guidance and capital projects in the 1991 Plan would continue to be carried out within the Clear/Clarks Creek Basin. Since the 1991 Plan was adopted, new species of fish have been listed as threatened in the Puget Sound Area. These species include the chinook salmon (listed as threatened in March 1999) and the bull trout (listed as threatened in October 1999). NOAA Fisheries has indicated that additional salmonid species may be listed in the next few years. Chinook salmon are found in the Clear/Clarks Creek Basin (see Section 4.4). Therefore, under the No Action Alternative, the 1991 Plan does not adequately meet provisions set forth under the ESA.

10.3.5 Plants and Animals

Affected Environment

The Basin supports several plant communities including conifer, deciduous, and mixed conifer-deciduous forests, grassland (agriculture), and shrubland. These plant communities can be divided into three habitat types:

- Upland
- Riparian
- Wetland

Riparian habitat is discussed in association with fishery resources in the previous section.

The wetland and upland habitats specific to the Clear/Clarks Creek Basin are described below:

Wetland

Wetlands are important habitats for plants and animals. Fish, amphibians, waterfowl, birds of prey, and wetland mammals, such as beaver and muskrat, depend on wetlands for food, forage, nesting, and cover. Wetlands help to maintain water quality and quantity through floodwater storage, biofiltration, and groundwater recharge for streams.

Wetland habitats in the Basin include primarily freshwater emergent, scrub-shrub, and forested communities. The Clear/Clarks Creek Basin currently encompasses 1,919 acres of freshwater wetland habitat, which represents approximately 9% of the total basin area (*Table 4-25*). The Clear Creek Basin has the greatest number and acreage of wetlands of all 16 subbasins.

Wetlands located in the eight Pothole subbasins (*Figure 4-9*) are especially important for groundwater recharge. Pothole basins do not have surface outlets; therefore, runoff generally infiltrates into the soil and drains from the Basin via subsurface flow. This groundwater recharges streams and rivers in the lower and adjacent basins, making wetlands in these areas a valuable water resource. For additional information regarding wetlands in the Clear/Clarks Creek Basin, see Section 4.4.1.

Upland

Upland habitats such as vegetated buffers help reduce or eliminate adverse impacts to streams from nearby land uses. The effectiveness of riparian buffers generally increases with buffer width and presence of streamside conifers.

Upland habitat in the Clear/Clarks Creek Basin includes primarily coniferous and deciduous forestland, grassland, and landscaped areas associated with residential, commercial, and light industrial development. Most of the uplands in the Basin have been disturbed, leaving fragmented patches of forestland and grassland in a matrix of suburban development. With these changes in land use, invasive plants, most notably Scotch broom and bent grass, have established themselves throughout the Basin.

The lower reaches of many of the creeks that drain the Basin have considerable intact forestland associated with them. Many of these large tracts of forested land are also associated with parks such as Swan Creek Park, Orangegate Park, and Clarks Creek Park. In many cases, these greenbelts and parks are one and the same. One of the most substantial forestlands observed in the Basin is located in the headwaters of Clarks Creek. This forested land is especially important because the City of Puyallup supplements its drinking water supply from Maplewood Springs in the Clarks Creek Basin. Douglas fir and big leaf maple dominate most of the upland forest in the Basin. The understory is dominated by salal, service berry, and red osier dogwood, with red alder saplings in open pockets. The dominant species in the forest edge are young Douglas fir, western red cedar, red alder, big leaf maple, and Himalayan blackberry. Much of the conifer and deciduous forest in the Basin has been lost to agriculture and residential land uses.

Grass species dominate the agricultural areas in the Basin. Trees are sparse and are limited mainly to riparian areas and to wetlands with soils that are too wet to farm. Agricultural and developmental disturbances have significantly modified the species composition in the Basin.

Vegetation in residential and commercial areas is dominated by non-native ornamental trees and shrubs. Turf and non-native grasses are also a prevalent ground cover in the non- forested areas.

Wildlife

Wildlife found in the project area consists of native wildlife associated with the lowlands of Puget Sound and with wildlife found in suburbanized human environments that can tolerate or benefit from close association with humans and habitat fragmentation. The variety of habitat types results from the marine influence off Puget Sound, the glacial plains (soils) and associated vegetation, and various hydrological and topographic features in the Basin.

A wide variety of wildlife occurs or potentially occurs within the Clear/Clarks Creek Basin. Blacktail deer, raccoon, beaver, coyote, and a variety of bats and rodent species commonly inhabit the forests. Prairie habitats provide food and cover for small to medium sized mammals such as mice, shrew, voles, cottontail rabbits, and coyotes with occasional blacktail deer.

Prairie habitat contains raptors of several species (redtail, northern harrier, etc.) to the American robin to the migrant violet-green swallow. Waterfowl, primarily geese and ducks, inhabit prairie communities as foraging grounds.

A number of species are in decline and have special state or federal designation, also referred to as Species of Concern. These include the peregrine falcon, bald eagle, and marbled murrelet are federally listed as threatened species.

Impacts and Mitigation Measures

Proposed Action

The Proposed Basin Plan includes several CIPs that are defined as habitat restoration projects and would result in improvements to vegetation. Stream banks would be revegetated to improve habitat, reduce water temperatures and improve water quality. Improvements to riparian buffers will result in a net increase in riparian area and vegetation. Removal of invasive and non-native plant species during restoration projects would result in wetland and upland habitat improvements. Floodplain enhancement would provide improved or additional high quality habitat/wetland area

Implementing a land acquisition program to manage habitat quality would improve habitat conditions

Temporary impacts to vegetation may occur during construction activities. Removal of invasive and non-native plant species during restoration projects may result in temporary displacement of wildlife species due to loss of cover. During construction activities, wildlife may be temporarily displaced.

The Proposed Basin Plan includes programmatic solutions to preserve existing aquatic habitat and prevent future habitat losses. Land acquisition programs would identify and preserve high quality habitat areas. Enhancement programs would help to prioritize and facilitate habitat restoration. Monitoring programs would track the health of the natural systems. Implementation of an Invasive Species Management Program would help to protect native habitat.

Appendix "H" contains the Project Analysis sheets for each of the specific habitat restoration projects.

No Action Alternative

Under the No Action Alternative, the absence of detention ponds and the continuation of erosion and sediment deposition would continue to result in degraded habitat for plants and animals.

10.3.6 Soils

Affected Environment

Soil associations in the Basin, shown in *Figure 4-2* of Chapter 4, consist of three types: Alderwood-Everett, Kapowsin, and Puyallup-Sultan. The Natural Resource Conservation Service (NRCS) classifies soils into four hydrologic soil groups based on the soil's runoff potential. The four groups are A, B, C and D. Type A soils typically have a very high infiltrative capacity and generate the least amount of runoff relative to the other soil groups. Conversely, type D soils have the lowest infiltrative capacity and generate the highest amount of runoff. Type D soils are typically associated with saturated soil conditions. *Figure 4-2* also illustrates the general distribution of the soil groups across the Basin. This figure shows that the Clear/Clarks Creek Basin contains all four soil groups.

Lowlands near the Puyallup River

The soils in the lowlands area near the Puyallup River are of the Puyallup-Sultan association. They are generally located in the area bounded by the Puyallup River to the north, Pioneer Way

to the south, and the City of Puyallup to the east. Puyallup-Sultan soils are nearly level, well-drained soils that formed in alluvium, deposited on the floodplains by the floodwaters of the White and Puyallup Rivers. The upper 20 to 30 feet of alluvium consists primarily of silt, muck, and fine sand and some gravel deposits. According to the Soil Survey of Pierce County (SCS, 1979), the Sultan soils are moderately well drained, and the Puyallup soils are well drained. Puyallup soils, fine sandy loam soils, underlie most of the City of Puyallup, whereas the remainder of the lowlands area is intermixed with both Sultan and Puyallup soils. Puyallup and Sultan soils are classified as hydrologic soil type A and C, respectively.

Western Uplands

The soils in the western half of the upland portion of the Clear/Clarks Creek Basin are of the Kapowsin association generally west of 86th Avenue East and south of Pioneer Way. Kapowsin soils are classified as hydrologic soil type D. Perched groundwater and areas of standing water form are characteristic of Kapowsin soils during the wetter months. Stormwater infiltration systems are not appropriate for areas with these soil characteristics. The gravelly loamy soils formed in glacial till and are typically moderately well drained soils on undulating to rolling uplands. There are two types of glacial tills associated with the Kapowsin soils. Lodgment till consists of up to 200 feet of glacial deposits that were compacted by the weight of the overlying glaciers. Because of the compact and dense nature of lodgment till, it is often referred to as hardpan, and has very low permeability. Lodgment till restricts the infiltration of water and can create extremely saturated surface soil during the wet seasons. The second type of glacial till in the Basin is ablation till, which was formed as glaciers melted and left sediment that had been carried by the ice. In contrast to the lodgment till, ablation till consists of loose well-drained sands and gravels. Ablation till is found on the top of lodgment till and tends to vary in thickness from zero to several feet (USGS, 1994).

Eastern Uplands & Potholes

Alderwood-Everett association soils are located south of the City of Puyallup in the eastern half of the Basin and within the majority of the pothole area. These soils are moderate to excessively well drained formed in glacial till and recessional outwash on the uplands. The Alderwood series consists of moderately well drained soils that formed in glacial till, with a hardpan layer just below the surface that reduces infiltration and results in standing water, wetlands, and high seasonal groundwater table (KCM, 2000). Alderwood soils are classified as hydrologic soil type C. The Everett series soils are generally excessively well drained because they were formed in loose, gravelly glacial outwash deposits. Everett soils are classified as hydrologic soil type A.

Salmon Springs Aquitard

Along the deep canyons near the mouths of Swan Creek, Clear Creek, Canyon Creek, Rody Creek, and Diru Creek, are areas where erosion and down cutting has exposed a geological deposit known as the Salmon Springs Drift, a land form older than the Vashon Drift (see Section 4.1). The Salmon Springs Drift is extremely impermeable and restricts the downward movement of water (USGS 1994). Many springs are present where the overlying, highly permeable Vashon advance gravel deposits meet the layer of Salmon Springs Drift. The springs were noted during the field surveys as part of this study (see also the Section 4.4).

Alderwood and Kapowsin soils in the uplands portion of the Clear/Clarks Creek Basin provide less than optimal conditions for on-site sewer systems and stormwater infiltration systems. Both Alderwood and Kapowsin soils are underlain by glacial till, with seasonal high or perched

groundwater tables, and can cause hydraulic overloads of poorly designed on-site sewer systems. Stormwater infiltration systems are not appropriate for the areas with these soil characteristics. On the other hand, the excessively draining Everett soils provide for rapid drainage from onsite septic systems and stormwater infiltration systems, but may not provide for adequate treatment of pollutants, and can potentially cause groundwater pollution (KCM, 2000).

Impacts and Mitigation

Proposed Action

The Proposed Basin Plan would include CIPs that would reduce peak stream flow rates, thereby reducing stream channelization and associated scour of streambed soils. Streambank stabilization projects are included in the proposed action alternative that would reduce sedimentation of fine soils into streams.

No Action Alternative

Under the No-Action Alternative, stormwater would continue to be managed in the Clear/Clarks Creek Basin as it is today, including related soil erosion problems.

10.3.7 Land and Shoreline Use

Affected Environment

Typical land cover in the Clear/Clarks Creek Basin is a patchwork of grass pastures and laws associated with a mostly rural/residential landscape. Land use patterns and percentages by category are presented in *Tables 4-3* through *4-6* in Chapter Four. Approximately 45% of the Basin consists of low-density residential areas of houses, with densities generally than or equal one dwelling unit per acre. Vacant lands and open spaces comprise approximately 22% of land use. However, this Basin includes the southwestern half of the City of Puyallup and a small portion of the City of Tacoma. Medium-density residential developments, schools, and commercial land uses dominate this area. Much of these areas are nearing their ultimate development density (i.e., built out), so future development will likely occur as infill of vacant parcels. In addition, Commercial businesses are primarily located along the Meridian Avenue (SR 161), Stewart Avenue, and the interchange of Pioneer Way with SR 161. These areas are considered the upper watershed of the Clear/Clarks Creek Basin, and have been a central focus points for development. The Meridian (SR 161) corridor is zoned as a Mixed Use District. Mixed Use Districts are meant to become concentrations of commercial, office, and multi-family developments located along major arterials, state highways, highways, and major transit routes.

The southeastern portion of the Clear/Clarks Creek Basin is currently experiencing rapid development, as are many other areas throughout Pierce County and the Puget Sound region. This portion of the Basin, which is part of the South Hill Community area, contains some of the last few large undeveloped parcels, which are zoned for Moderate Density Single Family Residential uses. Several of these parcels have been platted for development, but have remained undeveloped for several years. The addition of neighborhoods will require that proper stormwater treatment and detention controls be implemented within developing areas. The cumulative effects of moderate to high-density development can pose a threat to the surface water and groundwater within the watershed.

As a basin becomes developed, the hydrologic characteristics are altered due to construction of impervious surfaces and structures, compaction of soils, and stream channel modifications. Trees and grasslands are removed, and soils become compacted for paving and grading of roads and buildings. Natural drainage features are often replaced with man–made pipes and channels. Therefore, when rain falls on the land surface, the amount of natural infiltration and storage is reduced, thereby increasing the volume of surface runoff into stream channels. Of the primary physical attributes used for a watershed is the calculated effective impervious area (EIA).

For the Clear/Clarks Creek Basin, the percentage of EIA was computed for each of the 47 subbasins using ArcView GIS software. According to these estimates, the Clear Creek Basin averages 19% EIA, the Clarks Creek Basin averages 25% EIA, and the Pothole Basin is approximately 27% EIA. The Clarks Creek Basin includes a significant amount of commercial area along Meridian Avenue, and a significant amount of medium-density residential development. The overall EIA for the Clear/Clarks Creek Basin is approximately 23%.

The Comprehensive Plan for Pierce County, Washington was developed and adopted in 1995 in response to the requirements of the Washington State Growth Management Act (GMA), as described in Section 2.1. The Pierce County Comprehensive Plan seeks to obtain and balance 13 different planning goals. These goals include reducing sprawl while still encouraging development, protecting the environment while protecting property owners' rights, encouraging economic development, preserving historical sites and structures, and processing permits in a timely manner, while at the same time encouraging citizen participation in the planning process. This Comprehensive Plan, codified as Title 19A of the Pierce County Code, indicates that the entire Clear/Clarks Creek Basin, including the City of Puyallup, lies within the 1994 Comprehensive Urban Growth Area (CUGA) for Pierce County.

The Land Use Element of the Comprehensive Plan includes a growth and development strategy section that aims to direct how and where development will occur in the future. It is important to consider the proximity of existing surface water within the Basin to future designated Employment Centers, Commercial Centers, Mixed-Use Districts, High-Density Residential Districts, and Rural Activity Centers. A more detailed discussion of future land use designations and their potential effect effects on natural resources is provided in Section 4.2. Specific geographic locations of future land use designations are shown in *Figure 4-5*.

The Comprehensive Plan contains land use and planning policies. The following planning and stormwater management policies are derived from comprehensive plan policies:

- Provide urban level facilities and services only within the designated Urban Growth Area.
- Maintain the adopted level of service standard (LOS) for stormwater facilities. According to the *Capital Facilities Element* of the Comprehensive Plan, stormwater conveyance is to be designed for a 25-year, 24-hour design storm. Holding facilities for runoff are to be designed for 100-year, 24-hour design storm or a 100-year, 7-day design storm, whichever results in a larger facility. Water quality treatment is to be designed for a 6-month, 24-hour design storm. Stormwater runoff projections used for forecasting future stormwater facility and identifying non-structural alternatives in the basin plans are based on the LOS in the Comprehensive Plan.

- Maintain compatibility between facilities and adjacent land uses.
- Foster and retain community character.
- Nonstructural measures should be preferred over structural measures
- Involve the public and others with a stake in the outcome in water quality and stormwater management planning.
- Use of natural drainage systems for runoff is preferred over construction of facilities.
- Manage and plan water resources on a watershed basis.
- Support community education to conserve water resources
- Provide for buffers of undisturbed vegetation in all new facility developments next to streams, ponds, lakes and Puget Sound.
- Pursue public acquisition of critical fish and wildlife habitat areas.
- Maintain existing flood control structures on Pierce County rivers and streams.
- Evaluate the effectiveness of existing requirements for on-site stormwater retention and detention and revise where flooding issues are not adequately addressed.
- Pursue public acquisition of flood hazard areas.
- Protect, conserve and enhance the historic and cultural heritage of Pierce County
- Upgrade and maintain existing capital facilities.

Impacts and Mitigation Measures

Proposed Action

Implementation of the Proposed Basin Plan would not be expected to significantly affect land or shoreline use in the Basin. No unavoidable significant adverse impacts or cumulative impact to land use are expected to result from the implementation of the recommendations in the proposed action alternative.

Regulatory Compliance

Land use decisions drive stormwater management infrastructure needs. Adopted land use/zoning and current development regulations are used in this basin plan to model future hydrologic conditions and determine the type, size and location of facilities that will be needed to support planned growth. Critical areas designations are used to indicate potential sites for stormwater facilities, such as infiltration ponds (aquifer recharge areas) or natural stormwater detention sites (wetlands and riparian corridors). Conversely, surface water management recommendations can influence land use density and intensity choices, for instance if a basin plan identifies stream reaches that must be protected from the adverse hydrologic effects of new development.

Existing and planned land uses are described in Chapter 4, Existing Conditions.

No-Action Alternative

Implementation of the No-Action Alternative would not be expected to significantly affect land use in the Basin. However, there is inherent inconsistency of the action recommended in the 1991 Plan ("No Action") in that the document was prepared before the County adopted its current Comprehensive Plan. The "No Action" Alternative would continue that inherent inconsistency.

10.3.8 Aesthetic, Historic and Cultural Resources

Affected Environment

The Clear/Clarks Creek Basin contains several aesthetic views of both natural and manmade features. Several parks and natural areas, that provide views and open space, are located in the Basin. These include the Western Washington fairgrounds, Wildwood Park, Bradley Lake Park, Clarks Creek Park, Orangegate Park, DeCoursey Park, Swan Creek Park, and Thun Field.

A search of the Washington State Office of Archaeology and Historic Preservation's (OAHP) database was conducted to determine if any areas within the Clear/Clarks Creek Basin were listed in the National Register of Historic Places and/or the Washington Heritage Register. Three listings turned up on the National Register and six listings were designated as historic places in Washington. The three resources listed on the National Register of Historic Places are all located in the City of Puyallup and within the Clear/Clarks Creek Basin:

- Christ Episcopal Church – 210 Fifth St., SW
- Loetz, J.H., House – 1004 2nd Ave., NW
- Meeker Mansion - 321 Pioneer Ave., E

In addition to the three cultural resources mentioned above, three other properties located within the Clear/Clarks Creek Basin are listed in the Washington Heritage Register. These include:

- Indian Cemetery – Off Highway 167 near the Puyallup River
- Peace Lutheran Church – 214 East Pioneer Avenue, Puyallup
- Puyallup Assembly Center – Meridian Street South at 10th Avenue SE

The Pierce County Register of Historic Places was searched, but no properties within the Clear/Clarks Creek were found on the list. A number of properties within the Clear/Clarks Creek Basin are eligible to be listed in the Pierce County register.

Impacts and Mitigation Measures

Proposed Action

The Proposed Basin Plan includes a collection of recommendations to manage stormwater within the Clear/Clarks Creek Basin. Many of these recommendations include regulatory action, stormwater BMPs, studies and public education programs that would not likely affect aesthetic, historical, and cultural resources in the Clear/Clarks Creek Basin. The proposed CIPs include a list of specific projects, ranging from culvert improvements to stream/riparian habitat improvements that would involve some type of construction activity. Culvert replacement would not cause significant impacts. Stream and riparian habitat restoration would add vegetation

alongside water bodies and would improve the aesthetic views of those areas. The proposed detention ponds would remove some vegetation. This would only result in a short-term impact, as these sites would be revegetated and landscaped, as appropriate to mitigate any aesthetic impacts. No impacts to park views are expected.

While only one listed cultural resource was located in the Clear/Clarks Creek Basin, there is the potential to encounter other cultural resources during construction. If any cultural resources are discovered during construction activities, the Water Programs would immediately consult with the OAHP in Olympia. These would include conducting investigations of cultural resources that could be affected on the project site and identifying appropriate mitigation prior to proceeding with any work that could adversely affect cultural resources.

No Action Alternative

Under the No Action Alternative, stormwater would continue to be managed in the Clear/Clarks Creek Basin as it is today. A limited number of culvert upgrades would eventually be constructed. No impacts to aesthetic, historic, or cultural resources would be expected. If any cultural resources are discovered during construction, the Water Programs would immediately consult with the OAHP in Olympia and other appropriate officials regarding appropriate measures.

10.3.9 Public Services and Utilities

Affected Environment

Schools

The project area is served by the following two school districts: Puyallup School District #3 and Franklin Pierce School District 402. Although attendance boundaries have been established for schools within these districts, students may attend other schools within the system. The service area of each school varies with the area's population density and the schools grade level.

The majority of Clear/Clarks Creek Basin lies within Puyallup School District #3. One community college is located within the Basin, and that is Pierce College of Puyallup. The facility is located at 1601 39th Avenue SE is one of two colleges run by the Pierce College District, which serves nearly 30,000 individuals each year.

Medical

Medical Services within the Clear/Clarks Creek Basin includes one hospital, Good Samaritan Community Hospital in Puyallup. Other than that hospital, medical services are limited to fire stations, which generally consist of fire fighters/paramedics and ambulances that transport patients to nearby hospitals.

There are a couple other hospitals that are near the Clear/Clarks Creek Basin. These hospitals are Saint Claire Hospital in Lakeview and Puget Sound Hospital in Tacoma.

Fire

Fire protection and other emergency services within the Clear/Clarks Creek Basin are provided by the Pierce County Fire District and Puyallup Fire and Rescue.

Pierce County Fire Districts #6, and #14 serve the Clear/Clarks Creek Basin area that is located outside of the City of Puyallup. Central Pierce Fire and Rescue (District #6) has 9 fire stations,

two of which are located within the Clear/Clarks Creek Basin. Riverside Fire and Rescue (District #14) has only one fire station, which consists of 2 engines, 1 tender, 1 aid unit, 1 light rescue utility truck, 1 rescue boat, and 40 volunteers.

Puyallup Fire and Rescue has a total of 4 stations to serve the City of Puyallup. One of these fire stations is located within Clear/Clarks Creek Basin. Station 3 is located at 311 W. Pioneer Avenue in downtown Puyallup.

Police

Police protection within the Clear/Clarks Creek Basin is provided by the Pierce County Sheriffs Department and the Puyallup Police Department.

The Puyallup Police Department is a full-service law enforcement agency consisting of 51 sworn officers and 22 non-sworn personnel. The Police Department also has a 32-bed Corrections Unit with a staff of 10 corrections officers located in downtown Puyallup at City Hall. The department has a Community Resource/Crime Prevention Unit, a Parking Enforcement Unit, Motor Officers, Bike Patrols, K-9 Officers, Special Operations Group, Drug Lab Team and Crime Scene Technicians.

The Pierce County Sheriff's Department is also a "full service" police agency. That means that the residents of unincorporated Pierce County and of contract cities can be assured that, regardless of the situation, highly trained and equipped Deputies are available to maintain peace and safety.

The South Hill Precinct (located at the corner of 160th Street East and Meridian Avenue East) lies within the Clear/Clarks Creek Basin. This is the home for a variety of services for the east county area, including patrol, property crimes detectives, volunteer services, the Youth Emergency Services (YES) Team, crime analysis and more.

Water

Domestic drinking water and fire protection water within the Clear/Clarks Creek Basin (within the City of Puyallup) is provided by the Puyallup Public Works Department. Outside the city limits, domestic drinking water is provided by Firgrove Mutual Inc., Fruitland Mutual Water Co., Summit Water and Supply Co., and the City of Tacoma. It is important to mention that some of the residents within the Clear/Clarks Creek Basin may utilize private wells as a source for drinking water.

The City of Tacoma provides drinking water to a population of 262,500, which includes a significant number of residents living in unincorporated Pierce County. The City of Puyallup provides drinking water to an estimated population of 28,000. The other water service providers in the Clear/Clarks Creek Basin serve much smaller populations between 7,000 and 15,000.

Drinking water within the Clear/Clarks Creek Basin comes from two watersheds: the Puyallup and the Duwamish.

Solid Waste

Solid waste collection and recycling within the Clear/Clarks Creek Basin is provided by two different franchises. The majority of the Basin is served by Murrey’s Disposal, and a small portion in the southwest corner of the Basin is served by Pierce County Refuse (LeMay Enterprises).

The solid waste collection rates and services are regulated by the Washington Utilities and Transportation Commission (WUTC). No solid waste landfills are located directly within the Clear/Clarks Creek Basin. The nearest disposal facilities are Murrey's Transfer Station (located at 4622 70th Ave. E.) and Hidden Valley Transfer Station, Compost Factory, and Recycling Center located at 179th and Meridian, south of Puyallup.

Electrical Power

Energy within the Clear/Clarks Creek Basin is provided by Puget Sound Energy (PSE) and Tacoma City and Light.

Natural Gas

Natural gas is supplied to portions of the Clear/Clarks Creek Creek Basin by PSE.

Impacts and Mitigation Measures

Proposed Action

Roadway bypasses would reduce flooding occurrences at roadways, therefore a reduced incidence of road closures due to flooding would occur. Upgrades of under-capacity culverts would reduce the incidence of road closures due to flooding, as well. The implementation of projects and programs would improve public safety and reduce the need for some public services.

During facility construction, roads and/or lanes could be closed temporarily resulting in potential delays for emergency vehicles

No Action Alternative

Under the No Action Alternative, roadways would continue to experience localized flooding, causing road closures and potentially reducing access for emergency vehicles.

No other impacts to Public Services and Utilities are expected.

RESPONSE TO COMMENTS

This section of the Final SEIS documents the written comment submitted within the 30-day comment period, from August 30, 2005 to September 29, 2005. One letter was received from the Water Division of Tacoma Public Utilities. A copy is reproduced in this section.

TACOMA WATER

3628 South 35th Street
Tacoma, Washington 98409-3192

TACOMA PUBLIC UTILITIES

September 13, 2005

Marsha Huebner
PC Environmental Services
9850 64th Street West
University Place, WA 98467-1078

Subject: Supplemental Environmental Impact Statements
Clear/Clarks Creek Basin Plan

Location: Unicorporated areas draining into Roosevelt Ditch, Swan Creek, Squally Creek, Clear Creek, Canyon Creek, Rody Creek, Diru Creek, Woodland Creek, Clarks Creek, and the Potholes on South Hill

Dear Ms. Huebner:

Tacoma Water has reviewed the above subject and has no comments.

Sincerely,

Grant Whitley
Utility Services Specialist

GW:ro

Draft and Final SEIS Mailing List

City of Tacoma
City of Puyallup
City of Puyallup Public Library
Drainage District #10
Drainage District #14
Drainage District #19
Fern Hill Branch – Tacoma Public Library
Mid-County Community Plan Advisory Board
Muckleshoot Indian Tribe
Pierce Conservation District
Pierce County Planning Commission
Pierce County Planning and Land Services long-range planning
Pierce County Planning and Land Services central reception
Pierce County Transportation
Puyallup River Watershed Council
Puyallup Tribe of Indians
South Hill Branch - Pierce County Library System
Swan Creek Branch – Tacoma Public Library
Washington State Department of Ecology (2 copies)
Washington State Department of Fish & Wildlife

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