CHAPTER 4 - PROBLEM IDENTIFICATION AND ANALYSIS

This chapter generally describes stormwater-related problems throughout the basin, then identifies and analyzes specific problem sites. The problem sites were identified by extensive field reconnaissance, research of existing records, and analysis of the hydrologic effects of existing and predicted land use. Field reconnaissance by fisheries experts and maintenance staff identified some of the problems. Records reviewed include the citizen complaint databases of Thurston County, Olympia, and Lacey; several water quality reports; research conducted by The Evergreen State College; and results from surveys and public workshops. Computer modeling was used to estimate flood flow increases since development of the basin began.

4.1 OVERVIEW OF PROBLEMS

The first section provides an overview of three types of stormwater-related problems found throughout the basin:

- Flooding
- Water Quality Degradation
- Fish Habitat Degradation

Descriptions of specific problem sites in Woodland Creek basin and Woodard Creek basin follow the general problem overview. Chapter 6 summarizes the current stormwater management program that addresses each of these problem areas, and describes alternatives for increased levels of service in the future.

4.1.1 FLOODING

Flooding problems in the basins consist primarily of water ponding across roads, yards and homes in developed areas, from relatively small storm events. The flooding problems are usually caused by inadequate, unmaintained, or failed stormwater drainage systems. The soils in the northern basin do not drain well, so infiltration facilities in that area malfunction frequently.

Inadequate stormwater systems include culverts, pipes, and detention ponds without enough capacity to contain the stormwater runoff draining into them, and facilities placed in locations which cannot absorb the runoff. System failures result from insufficient capacity, poor siting, design flaws, faulty installation, increased runoff into the systems from new developments, or lack of maintenance. Appendix I describes stormwater facilities in detail.

Stormwater facilities must receive periodic inspection and maintenance in order to function properly. Maintenance activities include cleaning silt out of catch basins, removing brush and litter from ponds, and inspecting dry wells and trenches for proper operation. Failure to perform these activities can result in damaged facilities that lead to flooding.

Maintenance responsibilities vary widely between subdivisions and neighborhoods, depending primarily on when they were originally platted and built. Maintenance responsibilities often rest with non-existent or defunct homeowner associations, or unorganized groups of individual homeowners who usually do not realize that they are responsible for maintenance.

Stormwater systems fail when they clog up with silt, sediment, brush, or litter from construction sites, roads, and homeowner activities. Failed systems can be very expensive to repair, compared to the cost of improved maintenance. Underground systems are particularly expensive to rebuild, and repairing them can cause significant disruptions to neighborhood streets or lawns.

The basin plan does not address temporary flooding problems, such as clogged culverts, which can be repaired quickly by road maintenance crews. The plan only addresses chronic flooding problems that cannot be solved through routine maintenance, and require capital improvement projects or increased maintenance.

4.1.2 Water Quality Degradation

Fecal coliform contamination led to closures or restrictions on commercial shellfish harvesting areas in Henderson Inlet, in the mid-1980s. Since then, several water quality studies, cited in chapter 3, identified sources and types of water quality degradation in the basin. The principal sources of pollution identified in the studies are "nonpoint sources" of pollution such as runoff from yards, roads and pastures.

Most of the contaminants identified in the studies fall into four categories: fecal coliform, heavy metals, volatile organic compounds and nutrients. Fecal coliform can be a source of disease in humans, and coliform-contaminated shellfish can also cause sickness. Heavy metals have well-documented effects on human growth, health, and reproduction. Volatile organic compounds include chlorinated solvents and several common cleansers which have a variety of toxic effects. Nutrients cause aquatic weed growth which interferes with recreational uses of streams and lakes. In addition, nutrients act as indicators of overall water quality because they are highly-soluble, move with groundwater, and frequently occur in association with other contaminants such as pesticides.

Generally, the studies found that agricultural practices, septic systems, and stormwater discharges contributed most of the contamination to the basins' water resources. The studies also raised concerns about lawn and landscape maintenance practices. Overall, the studies indicated that:

- Non-point sources contribute most of the pollution in the Henderson Inlet watershed.
- Fecal coliform bacteria levels frequently exceed water quality standards both in the inlet and the creeks, especially following rainfalls.

- Improperly maintained septic systems discharge poorly treated effluent directly into Henderson Inlet.
- Urban stormwater runoff in Woodland and Woodard Creeks contributes the greatest bacterial loads to Henderson Inlet.
- Poor agricultural practices cause significant impacts to the streams.

Storm drain outfalls discharge untreated stormwater into streams, wetlands, and lakes throughout the basin. Stormwater runoff can contain sediment, nutrients, oil by-products, plastic derivatives, solvents, and other pollutants. The Davis and Coots study (1989) characterized stormwater runoff and catchbasin sediment quality in the Woodland and Woodard Creek basins. Overall, the study found that:

- The basins' stormwater catchments act as sinks that concentrate pollutants in sediment, especially toxic metals such as zinc and lead, and several other organic and inorganic contaminants.
- Stormwater runoff in the basins contains contaminants which can be toxic to aquatic life that is chronically exposed to them.
- Stormwater runoff in the basins contains sufficient phosphorous to promote nuisance weed growth in the streams, according to EPA guidelines.

4.1.3 Fish Habitat Degradation

Fish habitat consists of the conditions required for fish to survive. Fish habitat requirements include sufficient food and refuge, adequate water quality and quantity, and unobstructed access to sufficient spawning and rearing areas (Sedell et al 1982). Specific habitat requirements vary between species and change with the seasons. Generally, the following habitat problems were observed in Woodland and Woodard Creeks:

- Stream side vegetation removal has destroyed food sources, increased erosion, and reduced shading for stream (shade prevents water temperatures from rising to levels that can harm fish).

- Urban development has increased impervious areas and reduced the portion of rainfall that recharges ground water, resulting in less ground water flowing into streams during the summer months. This has caused stream flows to drop too low for adequate habitat, and has caused streams to dry up completely in some reaches.

- Frequent high stream flows caused by runoff has significantly degraded fish habitat in both creeks. Increased runoff can wash away eggs, spawning gravels and woody debris, erode stream banks, create velocities too fast for spawning and rearing fish to swim against, and reduce the number of places where fish may take refuge. High flows can also change the shape of the stream channel and reduce the number of pools.

- Clearing of large woody debris by stream side residents has eliminated refuge habitat, reduced available food, reduced the number of pools, and contributed to bank erosion.

- Inadequate culverts have created blockages to fish passage.

Culverts pose a significant obstacle to fish migration on both creeks. Undersized culverts clog frequently, create extremely high velocities at the outfall, dump sediments at the inlet, and scour the stream bed at the outlet. Long, smooth culverts may not provide sufficient resting places for fish to successfully pass through them. Culverts placed too high can form dams and create cascades too high for fish to jump. Steep culverts can create velocities too high for fish to swim through (Sedell et al 1982). The state Department of Fish and Wildlife identifies culverts that block fish passage, and works with the local jurisdictions to correct them. Table 4-1, below, shows the culvert design criteria recommended by the Department of Fisheries for various anadromous fish species.

Table 4-1 Fish Passage Design Criteria for Culvert Installation[1]

Culvert length (ft)	Maximum Velocity (feet per second)[2]			
	Juvenile salmonid[3]	Adult trout	Adult pink, chum	Adult chinook, coho, sockeye, steelhead
10-60	4.0	4.0	5.0	6.0
60-100	Not allowed[4]	4.0	4.0	5.0
100-200	"	3.0	3.0	4.0
>200	"	2.0	2.0	3.0
	Minimum depth (feet)[5]			
All	0.3	0.8	0.8	1.0
	Culvert discharge pool dimensions[6]			
All	Length>20 feet; Width=1.5 channel toe widths; Depth=4 feet			

[1] Washington Department of Fisheries, 1987
[2] Design flow is the two-year high flow unless otherwise specified
[3] Juvenile salmonid passage requirement applicability determined by agency site visit.
[4] Culverts longer than 60 feet pose excessive risk to juvenile salmonids
[5] Design flow is the 2-year, 7-day low flow unless otherwise specified; depth requirement does not apply to structures with natural beds
[6] Area available for natural pool formation, or size of constructed pool

4.2 PROBLEMS IN WOODLAND CREEK BASIN

Woodland Creek basin contains numerous flooding problem sites, untreated stormwater outfalls, and degraded habitat areas. The following sections describe the sites in greater detail.

4.2.1 LOCAL FLOODING PROBLEMS IN WOODLAND CREEK BASIN

This section describes local flooding sites that require remedial action, summarized in table 4-2. Chapters 7 and 8 describe the proposed solutions. Fish habitat problem sites associated with stream flooding are described later in this chapter.

WL1 - Forestglen Court/Alderglen Drive West of Pattison Lake, the area around the intersection of Forestglen Court and Alderglen Drive in the Forestglen Subdivision (Division 4) experiences chronic flooding because approximately 12 dry wells have failed. Sediment clogging the dry wells prevents them from draining, although the underlying soil consists of mostly deep, well-drained outwash soils. The contributing drainage encompasses 55 acres, which is too large an area for so few dry wells.

Table 4-2 Local Flooding Problems in Woodland Creeks Basin

Problem #	Location	Cause of flooding	Jurisdiction
WL1	Forestglen Court at Alderglen Drive	Failed infiltration system	TC
WL2	Ruddell Road at Ruddell Loop	Inadequate conveyance	L
WL3	Steilacoom Rd at School Street	Inadequate retention pond capacity	TC
WL4	6th Avenue SE/Bulldog/Ranger	Failing drywells	TC,L
WL5	Husky Way/Kinwood Rd & Martin Way/Carpenter Rd in Tanglewilde	Undersized conveyance and drywells	TC,L
WL6	Quinault Dr./Marvin Rd./Queets Dr.	Failing drywells	L,TC
WL7	15th Ave NE from Enterprise to Judd	Inadequate conveyance	L,TC,O
WL8	Flooding between Long/Lois Lake	Uncontrolled runoff from Long Lake	TC
WL9	Ida Jane Way/35th/36th SE	Failed dry wells	L
WL10	Homann Drive SE	Inadequate dry well capacity	L
WL11	1703 Alder Street SE	Failed dry well	L
WL12	49th Avenue SE/Lakemont Drive	Failed dry wells	TC
WL13	Failing dry wells/infiltration	Poor soil or inadequate design	L,TC,O

WL2 - Ruddell Road/Ruddell Loop Ruddell Road flooded frequently near Ruddell Loop due to inadequate drainage systems at two locations on Ruddell Loop. Ruddell Road is an important arterial for the city of Lacey and Thurston County. The city of Lacey addressed this problem when they widened the road in 1994.

WL3 - Tanglewilde Division 15 The infiltration ponds to the northeast and northwest of Steilacoom Road and School Street are too small for the amount of runoff that drains into them. The ponds do not infiltrate adequately, and they overflow periodically and flood McGimpsey Estates and Steilacoom Road, a significant east/west arterial for Thurston County (see figure 7-1).

WL4 - Tanglewilde Division 9 South The intersection of 6th Avenue SE and Bulldog Street SE in Tanglewilde Division 9 floods frequently, completely inundating the street and overflowing into the yards and buildings on Bulldog Street SE. Flooding has damaged a garage at this location. Flooding also occurs on 6th Avenue SE at the intersections of Ranger Drive and Cougar Street, and on 5th Way west of Seahawk Street.

The drainage system consists of several catch basins that drain to dry wells and infiltration trenches on 6th Avenue and Bulldog Street, and to a drainage easement between Bulldog Street and Seahawk Street (see figure 7-2). The system has an overflow pipe that drains to a pond on Seahawk Street south of 5th Way SE, and the vertical drop in the pipe between Bulldog Street and the pond is only about two feet. An infiltration trench connects the pond to two failed dry wells on 5th Way.

The entire system is too small and the infiltration trenches do not function properly. Flooding on Bulldog Street causes debris to wash into the catch basins frequently, and the pond has filled with dumped yard waste and debris, which has reduced its capacity and clogged the pipe outlet from the infiltration pond. The system was installed in 1977, prior to adoption of drainage standards, and the approved plat did not require the homeowner association to maintain the facilities. The pond lies on a dedicated open space tract in private ownership.

WL5 - Tanglewilde @ Husky Way/Kinwood/Carpenter Frequent flooding of streets in the Tanglewilde subdivision south of Martin Way poses a health and safety problem for residents, particularly at the Husky Way SE/Kinwood Road SE intersection, and near the Carpenter Road/Martin Way intersection.

The drainage system south of Martin Way consists of catch basins and pipes that begin along Trailblazer Court SE and run down Husky Way and Kinwood Road to discharge on the south side of Martin Way, 250 yards east of Woodland Creek. Stormwater is collected in the drainage system described above, and in several dry wells. About 270 acres drain to these systems. The drainage pipes are too small for the amount of runoff, 41% of the dry wells have failed, and an additional 39% of the remaining dry wells need maintenance.

WL6 - Quinault Drive/Queets Drive Frequent flooding occurs on Quinault Drive NE between Marvin Road and Queets Drive because approximately 6 dry wells are not functioning properly. The city of Lacey recently installed additional dry wells in this area.

WL7 - 15th Avenue NE/Enterprise The intersection of 15th Avenue NE and Enterprise Drive floods periodically because all of the runoff from the development between 6th Avenue NE and 15th Avenue NE drains into an undersized ditch on 15th Ave NE. The culvert under Enterprise Drive is also too small and frequently becomes clogged with debris. The roadside ditch conveys the water along with debris, garbage, and lawn clippings to another ditch that runs south along a property line next to an undeveloped tract across from Judd Street NE, and drains into Woodland Creek near the culvert under Interstate-5 (see figure 7-3). Runoff from the north also drains to this location through a culvert under 15th Avenue.

WL8 - Long Lake North When Long Lake rises in the winter, high flows downstream flood the yards and septic systems of a few homes near Woodland Creek in the Pacific Park subdivision.

WL9 - 35th Ave\36th Ave\Ida Jane Way SE In a neighborhood southeast of Hicks Lake, low spots on 35th Avenue SE and 36th Avenue SE near Ida Jane Drive flood frequently because the old drywell infiltration systems are not functioning properly.

WL10 - Homann Drive Homann Drive floods frequently in several locations, especially near the intersections of 13th, 15th, 16th and 17th Avenues. The flooding restricts access to homes in the neighborhood. The drywells that comprise the storm drain system are too small to infiltrate the volume of runoff draining into them from the surrounding area.

WL11 - 1703 Alder Street SE The neighborhood in the vicinity of Alder Street and Gemini Street SE has a history of chronic flooding. The terrain is flat and the soils are poor for infiltration. Lacey maintenance crews have recently installed additional infiltration trenches and dry wells in most of the flooding spots. However, one dry well in front of 1703 Alder Street SE has failed, and stormwater continues to pond across the road there.

WL12 - 49th Avenue SE\Lakemont Drive SE Flooding frequently occurs on the road and homes at 49th Avenue SE and Lakemont Drive. Both streets drain to the intersection, where there are three failed dry wells which overflow to Pattison Lake. When these dry wells fill up, untreated runoff discharges to Pattison Lake.

WL13 - Failing drainage systems In addition to the drainage systems described above, approximately 256 infiltration systems in Woodland basin have failed or do not function properly. The problem sites described above include only those sites with a documented history of flooding. There are probably numerous other flooding sites which the jurisdictions do not know about. Also, sites with marginal facilities are likely to cause flooding in the future as they deteriorate.

4.2.2 Water Quality Problems in Woodland Creek Basin

The *Woodland and Woodard Creek Basins Stormwater Quality Survey* (Davis and Coots 1989) identified specific water quality problems at several outfalls, described below. The study prioritized all the problem outfalls without regard to basin. Some of the problem outfalls have already been treated or have treatment designs under development. The remaining outfalls were reorganized by basin and reprioritized for remedial action, reflecting the actions that have occurred since the study was completed. The sampling results are summarized in more detail in appendix B. The City of Lacey conducted a water quality survey in the Woodland and Woodard Creek basins in 1991-1992. (Lacey Stormwater Monitoring Program 1992). These studies identified the presence of fecal coliform, phosphorous, oil and grease, and total petroleum hydrocarbons as chronic pollutants found in runoff, often exceeding water quality standards.

WL14 - Ruddell Road near Ruddell Loop Woodland Creek Outfall Priority #1. This site had 4 problem chemicals identified. Total pthalates levels in one stormwater sample exceeded chronic freshwater criteria, lead and zinc levels exceeded sediment criteria, and phosphorous exceeded EPA recommended criteria. Fecal coliform levels in stormwater exceeded state standards for receiving waters. The stormwater flows through a series of small ponds and a wetland that drains to Hicks Lake. Complaints regarding poor water quality in the ponds have been investigated by the Thurston County Health Department in the past. The City of Lacey has prepared preliminary designs for a constructed wetland treatment system to address this problem.

WL15 - Martin Way @ Woodland Creek Woodland Creek Outfall Priority #2. This site had 6 problem chemicals identified. Total phthalate levels in one stormwater sample exceeded chronic freshwater criteria, and lead, copper, zinc and a PCB compound exceeded sediment criteria. The system discharges runoff from the Tanglewilde subdivision, through a series of ditches that traverse dense vegetation alongside Martin Way, and into Woodland Creek. The Lacey stormwater study (City of Lacey 1992) found elevated fecal coliform levels, phosphates, the banned pesticide DDT in concentrations exceeding the highest apparent effects threshold, and a PCB compound which exceeded sediment criteria by an order of magnitude. Thurston County recently completed an engineering study to prepare preliminary designs for treating this discharge.

WL16 - St. Martins' Campus @ College Creek Woodland Creek Outfall Priority #3. This site had 5 problem chemicals identified. Total pthalates in two stormwater samples exceeded chronic freshwater criteria, and lead and zinc exceeded sediment criteria. The stormwater from this outfall flows through an extensive ditch and wetland system before emptying into College Creek, a short tributary of Woodland Creek. Lacey has prepared preliminary designs for a constructed wetland treatment system to address this problem.

Lacey conducted intensive sampling of four storm drains which contribute to this storm system (City of Lacey 1992). The study detected elevated fecal coliform levels throughout the system, two stations which exceeded Total Petroleum Hydrocarbon criteria, three stations which exceeded lead criteria, and one station which exceeded lead criteria.

WL17 - Direct discharges Many stormwater systems in Woodland basin discharge directly to a stream or lake, in addition to those monitored by the county for water quality (Entranco 1981). Sampling of each outfall exceeded the scope of this basin plan. Most of the direct discharges drain from older developments, constructed before the local jurisdictions had adopted drainage standards. Some of the discharges drain from major roads, including Pacific Avenue and Interstate 5. Most stormwater studies have shown urban runoff to contain pollutants, usually including heavy metals and petroleum by-products. Studies in the south Puget Sound area have all confirmed that runoff from urban and suburban neighborhoods is usually highly contaminated. Therefore, many of the unmonitored direct discharges are likely to contain contaminants that degrade the quality of the receiving waters. Table 4-3 shows all the known stormwater outfalls discharging to surface water in Woodland basin.

Table 4-3 Woodland Creek Basin Outfalls Discharging to Surface Water

Problem #	Location	Receiving waterbody	Jurisdiction[2]
WL14	Ruddell Road near Ruddell Loop	Hicks Lake	L
WL15	Martin Way @ Woodland Creek	Woodland Creek	L
WL16	St. Martins Campus @ College Creek	College Creek	L
WL17[1]	Pacific Avenue @ Woodland Creek	Woodland Creek	TC
	I-5 & Martin Way @ College Creek	College Creek	L
	I-5 @ Woodland Creek	Woodland Creek	L
	I-5 @ College Creek	College Creek	L
	6th Ave NE & College St @ College Cr	College Creek	L
	15th Ave NE across from Judd Street	Woodland Creek	L,TC,O
	Mullen Road RR overpass	Woodland Creek	TC
	South Bay Rd & Johnson Point Rd	Woodland Creek	TC
	Draham Road	Woodland Creek	TC,L
	21st Court	Woodland Creek	TC
	Pleasant Glade Road	Woodland Creek	TC
	26th Avenue on Jorgenson Creek	Jorgenson Creek	TC
	Hawks Prairie Road on Fox Creek	Fox Creek	TC
	Hawks Prairie Road (includes Foxhall)	Woodland Creek	TC
	Marvin Road @ Eagle Creek	Eagle Creek	TC
	Carpenter Road @ Eagle Creek	Eagle Creek	TC
	Eagle Drive @ Eagle Creek	Eagle Creek	TC
	Timberlake Drive SE	Long Lake	TC
	Timberlake Dr SE & Timberlake Ct SE	Long Lake	TC
	Mill Drive SE & Sierra Drive SE	Long Lake	TC
	Patricia Court	Long Lake	TC
	Carpenter Road	Lake Lois	L
	Shady Lane & Sierra Drive	Hicks Lake	L
	Carpenter Loop	Long Lake	TC
	Hilmes Court	Long Lake	L
	Long Lake Drive SE	Long Lake	L
	Long Lake Drive & Long Lake Court	Long Lake	TC
	41st Avenue SE	Long Lake	L
	Lorna Court	Long Lake	TC
	Woodland Elementary School	Long Lake	L
	Private Road 20th SE Extension	Long Lake	TC
	Lakemont St SE & 49th Ave SE	N. Pattison Lake	TC
	Ridgemont Drive	N. Pattison Lake	TC
	Mullen Road & Glen Terra Drive	N. Pattison Lake	TC
	58th Avenue SE & Hollis Drive	S. Pattison Lake	TC

[1] There is little or no water quality data for outfalls listed under WL17, so they have been listed in priority order for monitoring and remediation, if needed, based on the level of traffic and the type and density of surrounding development.
[2] L=Lacey, TC=Thurston County, O=Olympia

4.2.3 Fish Habitat Problems in Woodland Creek Basin

This section describes stream habitat problem sites on Woodland Creek, in order from mouth to headwaters. County staff inspected the creek and evaluated the habitat with several stream and fisheries specialists, including staff from the Department of Fisheries, Department of Ecology, WSU Cooperative Extension and private consultants. The results of this inspection and analysis indicate that changes to the stream hydrology pose the greatest threat to fish habitat in the stream.

Chapter 3 describes the hydrologic changes which have resulted from development in the basin. Generally, winter high flows have become more frequent and more intense, and summer low flows have declined dramatically. These hydrologic changes have damaged fish habitat throughout the stream, and seriously hampered the ability of fish to move up and down the system during critical spawning, emergence and rearing periods of their lifecycles.

WL18 - Pleasant Glade Road Culverts Two 4′ diameter culverts under Pleasant Glade Road block fish passage during high flows. The culverts are too small, so they cause velocities which scour out pools at the outlets and prevent fish from passing through. Debris accumulates periodically at the inlets, further blocking fish passage. The culverts also cause sediments to settle in the stream bed at the inlets. Stream velocities in these culverts exceed Department of Fisheries guidelines for coho and chinook by 52%, and exceed chum guidelines by 90%.

Table 4-4 Existing Flow Velocities of Problem Culverts on Woodland Creek

Culvert length & velocity for the 2-year flood			WDF allowable velocities (fps)[1]			Jurisdiction[2]
Location	Length (ft)	Velocity (fps)	Chinook/Coho	Chum	Meets criteria?	
Pleasant Glade Rd	60	7.6	5.0	5.0	No	TC
21st Court NE	Unknown	Unknown			Unknown	TC
Interstate 5	240	6.7	3.0	2.0	No	L
Martin Way	120	6.8	4.0	3.0	No	L

[1] From Washington Department of Fisheries, 1991.
[2] TC=Thurston County, L=Lacey

WL19 - Woodland Creek Subdivision Approximately nine homes abutting the creek within the Woodland Creek subdivision, in the vicinity of Mark Street and Covington Court, have little or no vegetation along the shoreline, and debris has accumulated on the banks and in the stream channel. Three homes have been built recently and most of the land was cleared within 25′ of the shoreline. Rain has washed most of the unprotected top-soil into the creek, silting the nearby spawning beds. Construction debris in the creek has created blockages in this area.

WL20 - 21st Court NE Culverts Twin culverts of 3′ and 3.5′ diameter were installed under 21st Court NE in 1990. The culverts were installed to meet fisheries guidelines but the flow velocities were not checked and could present the potential to block fish passage under future flows.

WL21 - Draham Road to 21st Court NE An analysis of stream habitat was performed on a portion of Woodland Creek between Pleasant Glade Road and Draham Road in autumn of 1991 and is included as appendix H. The analysis found a significant lack of pools and slow water habitat in the urbanized reach from Draham Road to 21st Court NE. Field inspection revealed that the reach contains very little large woody debris, probably because the channel has been cleared by adjacent property owners. Much of the natural riparian vegetation had also been removed. These problems probably occur throughout the urbanized reaches of Woodland Creek.

WL22 - Woodland Creek downstream of Martin Way Uncontrolled runoff from the Tanglewilde subdivision discharges through ditches into Woodland Creek at Martin Way, where it has deposited significant sediment loads into the stream bed and seriously degraded spawning habitat.

WL23 - Martin Way Culvert The 4′ by 4′ box culvert under Martin Way blocks fish passage during low flows, because the stream flow in the wide, flat bottom is too shallow for fish to negotiate. Stream velocities in this culvert exceed Department of Fisheries guidelines for coho and chinook by 70%, and exceed chum guidelines by 127%.

WL24 - Woodland Creek between Lake Lois and Martin Way High peak flows from stormwater systems discharging into the creek have caused major stream bank erosion on this stretch of Woodland Creek through St. Martin's College property. The city of Lacey's Woodland Creek Stormwater Treatment Facility has reduced damaging peak flows from small events, but existing eroding stream banks continue to contribute sediment to the stream bed. During recent summers, this reach has dried up completely for periods of 6 months or longer, cutting off all access to the upper stream, lakes and wetlands. Most of the native stream side vegetation has been removed in the residential area on the south side of the creek below Lake Lois along 7th Avenue SE, contributing to bank erosion. Debris accumulation in this reach is also a problem.

WL25 - Interstate 5 Woodland Creek Culvert The culvert under Interstate 5 blocks fish passage during high flows. Stream velocities in these culverts exceed Department of Fisheries guidelines for coho and chinook by 123%, and exceed chum guidelines by 235%.

WL26 - Woodland Creek Peak Flows The basin hydrologic modeling shows that peak flows have increased substantially over the natural, pre-development stream flows (see Figures 4-1 and 4-2). Although this is presented ias a habitat problem, it affects all water resources.

Extreme peak flows cause flooding, erosion, turbidity, sedimentation, wash pollutants into estuaries, and destroy habitat features. Modeling shows that peak flows will increase in the future, despite recent drainage design measures.

Field surveys of habitat in Woodland Creek revealed that long reaches of the creek contain little woody debris and few pools, and several stream banks are eroding (Johnson and Caldwell 1992). Stream flow gauging indicates that stream peak flows in the rainy season are extremely high, while summer flows are low or nonexistent.

Conversion of forested lands to pavement, buildings and lawns has dramatically increased the volume of runoff and the rate at which it enters the creek. The short, intense peak flows have damaged fish habitat in the creek by washing out spawning beds, removing woody debris, filling in pools, eroding stream banks and creating velocities too high for fish to tolerate. Conversely, the developed landscape prevents rainfall from infiltrating into the ground, which causes the creek to dry up in the summer. This altered hydrology is the most significant source of habitat degradation in the basin.

Thurston County implemented drainage design standards in 1991 and revised them in 1994, in order to reduce the level of impact due to new development (Thurston County 1994). The design standards are intended to retain as much stormwater as possible on the site of new development, to prevent increased runoff. However, many areas in the basin have poorly drained soils where on-site infiltration is not feasible. These sites are required to detain runoff in ponds and discharge it slowly to the creek or other receiving water body. Nevertheless, the current design standards permit some increases in runoff for these poor soils.

Local drainage standards specify the minimum size for detention ponds and the maximum rate that water can be released from the ponds. The minimum standards are based on soil types and a "design event", which is an empirically-derived 24 hour storm. Soils and rainstorms in the real world rarely behave like the design event. Rain falls for several consecutive days, "well-drained" soils become saturated, and groundwater tables rise and fall. Under some conditions, stormwater facilities no longer detain the storm events for which they were designed. When the facilities reach capacity, stormwater overflows through them as if they were not there. Compounding the problem, developments under a certain size do not have to meet the design standards.

Aqua-Terra Consultants modeled the impacts of future growth on Woodland Creek. Chapter 5 describes the modeling assumptions, and appendix C describes the model in greater detail. The modeling shows that future growth will cause substantial increases in peak flows, even with the new drainage design standards. The peak flows from the 2-year storm are predicted to increase by 15% at Martin Way, and by 37% downstream at the mouth. The predicted increases in flow are greater downstream because several tributaries enter between Martin

Way and the mouth. The peak flows from the 100-year storm are predicted to increase by 10% at Martin Way and by 60% at the mouth. Recent studies indicate that the smaller, more frequent events have a greater influence on channel morphology and stream habitat than large infrequent events such as the 100-year flows (Washington Department of Fisheries 1991). Figures 4-1 and 4-2, below, show the predicted increases in future flows at several locations along the creek.

Figure 4-1 Impact of future development on Woodland Creek 2-year peak flows

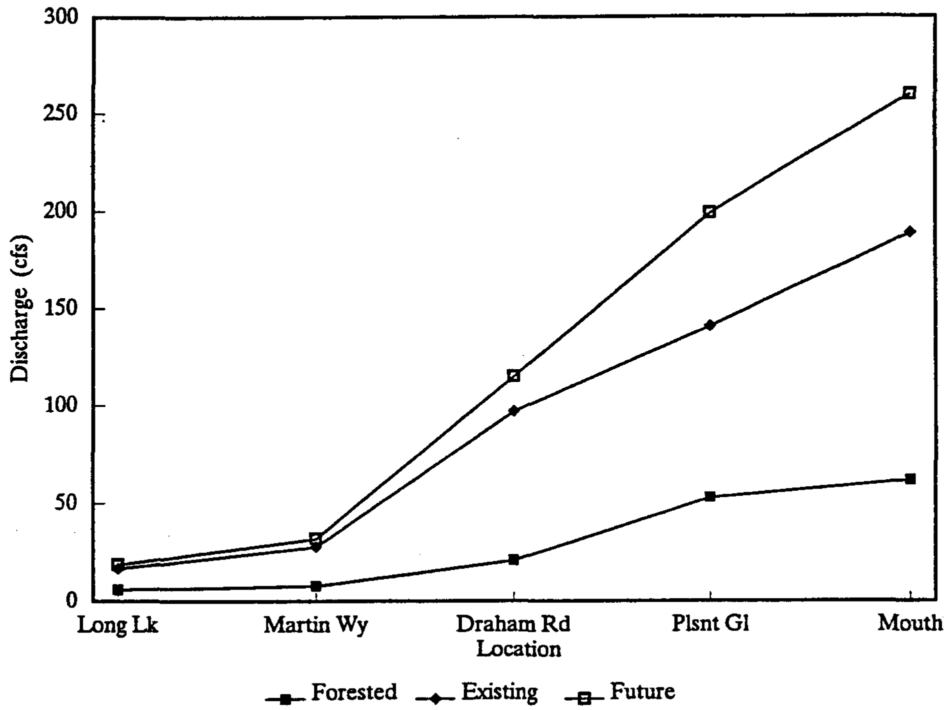
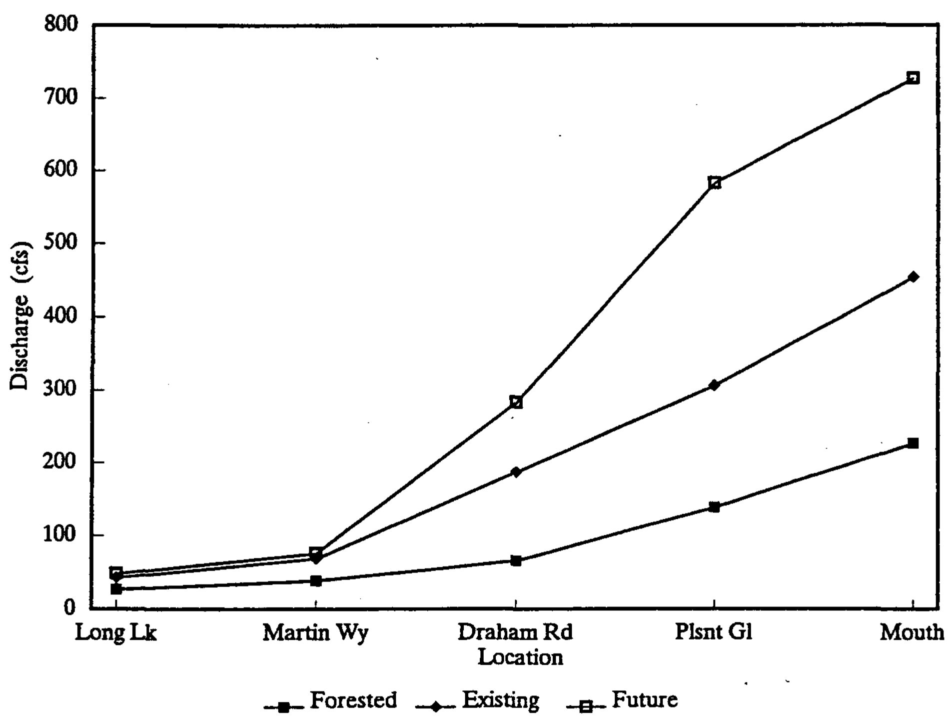


Figure 4-2 Impact of future development on Woodland Creek 100-year peak flows



4.3 PROBLEMS IN WOODARD CREEK BASIN

Most of the problems identified in Woodard Creek basin relate to water quality degradation from untreated stormwater discharges, especially in the urban portion of the basin. All of the frequent local flooding or ponding problems identified in this study are due to lack of maintenance. The fish habitat in Woodard Creek is generally best in the northern, rural reaches, but the urban reaches show signs of degradation. Some problems listed are on private property, not in the existing public right-of-way.

4.3.1 Local Flooding Problems In Woodard Creek Basin

The frequent local flooding or ponding problems identified in this study are due to lack of maintenance or inadequate facilities that could be resolved through remedial maintenance.

WD1 - 12th Avenue SE/Boone Street The roads flood frequently in this area because the storm drainage facilities are inadequate.

WD2 - Failing drainage systems In addition to the drainage system described above, approximately 14 infiltration systems in Woodard basin have failed or do not function properly. Some of these systems probably also cause flooding problems for which the jurisdictions have no records. Sites with marginal facilities are likely to cause flooding in the future as they deteriorate.

4.3.2 Water Quality Problems In Woodard Creek Basin

The *Woodland and Woodard Creek Basins Stormwater Quality Survey* (Davis and Coots 1989) identified specific water quality problems at several of these outfalls. The section below describes the outfalls identified for high priority remedial action. The sampling results are summarized in more detail in appendix B. Lacey conducted a water quality survey in the Woodland and Woodard Creek basins in 1991-92 (Lacey Stormwater Monitoring Program 1992). The studies identified the presence of fecal coliform, phosphorous, oil and grease, and total petroleum hydrocarbons as chronic pollutants found in runoff often exceeding water quality standards.

WD3 - Fones Road Woodard Creek Outfall Priority #1. This site had 23 problem contaminants identified. This was the most contaminated outfall of all the sites sampled in both basins. Total phthalate levels in one stormwater sample exceeded chronic freshwater criteria, and PCBs, lead and zinc exceeded sediment criteria. The South Sound Center stormwater discharges to an open ditch that conveys water past the Fones Road site to the wetland at the head of Woodard Creek. The ditch flows adjacent to a residential mobile home park for part of its length, and is readily accessible to the public. Lacey and Olympia recently completed construction of a stormwater facility to address this problem, based on a design developed jointly by Olympia, Lacey, Thurston County and the U.S. Environmental Protection Agency.

Lacey conducted intensive monitoring of seven stormdrains that discharge to the Fones Road ditch (City of Lacey 1992). The study found elevated fecal coliform levels at all seven storm drains, and seven different chlorinated pesticides including the banned insecticides Aldrin and DDT. DDT levels exceeded highest apparent effect thresholds. Lead and zinc levels exceeded lowest apparent effects thresholds at six of the sampling sites, and the area had the highest copper and chromium levels detected in the study. Three stations exceeded criteria for Total Petroleum Hydrocarbons (TPH).

WD4 - Martin Way Woodard Creek Outfall Priority #2. This site had 7 problem chemicals identified. Total phthalate levels in two stormwater samples exceeded chronic freshwater criteria, and PCBs, cadmium, lead and zinc exceeded sediment criteria. The outfall discharges into a riparian wetland next to the creek. Elevated metals concentrations just downstream at Ensign Road may indicate cumulative impacts from stormwater discharges from South Sound Center, I-5 and Martin Way.

WD5 - Direct discharges Many stormwater systems in Woodard basin discharge directly to a stream or lake, in addition to those monitored by the county for water quality. Sampling of each outfall exceeded the scope of this basin plan. Most of the direct discharges drain from older developments, constructed before the local jurisdictions had adopted drainage standards. Some of the discharges drain from major roads, including Pacific Avenue and South Bay Road.

Most stormwater studies have shown urban runoff to contain pollutants, usually including heavy metals and petroleum by-products. Studies in the south Puget Sound area have all confirmed that runoff from urban and suburban neighborhoods is usually highly contaminated. Therefore, many of the unmonitored direct discharges are likely to contain contaminants that degrade the quality of the receiving waters. Table 4-5 shows all the known stormwater outfalls discharging to surface water in Woodard basin.

Table 4-5 Woodard Creek Basin Outfalls Discharging to Surface Water

Problem #	Location	Receiving waterbody	Jurisdiction[1]
WD3	Fones Road	Woodard Creek wetland	O,L
WD4	Martin Way	Woodard Creek	O
WD5[2]	I-5/Pacific Ave Interchange	Woodard Creek	O
	Pacific Avenue @ Woodard Creek	Woodard Creek	O
	Martin Way at Drainage District Ditch	Woodard Creek	O
	Ensign Road	Woodard Creek	O
	Lindell Road	Woodard Creek	TC
	South Bay Road	Woodard Creek	TC
	South Bay Road @ Kegley Creek	Kegley Creek	TC
	26th Ave @ Birdie Creek	Birdie Creek	TC
	46th Ave & Libby Road @ Libby Creek	Libby Creek	TC
	Libby Road @ Furlong Creek	Furlong Creek	TC

[1] O=Olympia, TC=Thurston County, L=Lacey

[2] There is no water quality data for outfalls listed under WD5, so they have been listed in priority order for monitoring and remediation, if needed, based on the level of traffic and the density and type of development in the surrounding area.

4.5.3 Fish Habitat Problems in Woodard Creek Basin

This section describes fish habitat problem sites on Woodard Creek. County staff inspected the creek and evaluated the habitat with several stream and fisheries specialists, including staff from the Department of Fisheries, Department of Ecology, WSU Cooperative Extension and private consultants. The inspection and analysis found that changes to the stream hydrology have been slightly less severe than in Woodland Creek, due to less urban development. Future development threatens to cause more habitat damage.

WD6 - Libby Road Numerous single family residences on large lots occupy the land between the creek and Libby Road. Several landowners have cleared the riparian vegetation down to the edge of the creek. Stream bank erosion occurs sporadically throughout the reach, as a result of vegetation clearing. Channel clearing by stream side property owners has probably reduced in-stream habitat.

WD7 - 40th Avenue NE Culverts 40th Avenue NE is a private road leading across Woodard Creek from Libby Road. The two 3′ diameter metal culverts under the road do not appear to block fish passage currently, but their flow velocities were not checked and they may block fish passage in the future from increased high flows.

Table 4-6 Existing Flow Velocities of Problem Culverts on Woodard Creek

Culvert length & velocity for the 2-year flood			WDF allowable velocities (fps)			Juris-diction[1]
Location	Length (ft)	Velocity (fps)	Chinook/Coho	Chum	Meets criteria?	
40th Avenue NE	60	Unknown			Unknown	TC
36th Avenue NE	60	7.3	5.0	4.0	No	TC
South Bay Road	50	6.5	5.0	4.0	No	TC
Ensign Road NE	75	3.8	5.0	4.0	Yes	O
Martin Way	130	Unknown	4.0	3.0	Unknown	O
Pacific Avenue	Unknown	Unknown			Unknown	O
I-5 and Railroad	Unknown	Unknown			Unknown	O

[1] TC=Thurston County, O=Olympia

WD8 - 36th Avenue NE Culvert The 4′ diameter culvert under 36th Avenue is too small for the stream flow, and causes high velocity that scours out a pool at the outlet and prevent fish from passing through. Debris accumulates periodically at the inlet, further blocking passage.

Stream velocity in the culvert exceeds Department of Fisheries guidelines for coho and chinook by 46%, and exceed chum guidelines by 83%.

WD9 - South Bay Road Culvert The 4' diameter culvert under South Bay Road is too small for the stream flow, and causes high velocity that scours out a pool at the outlet and prevent fish from passing through. Debris accumulates periodically at the inlet, further blocking passage. High amounts of sediment have accumulated at the inlet because the constriction created by the culvert causes water to pool upstream. Stream velocity in the culvert exceeds Department of Fisheries guidelines for coho and chinook by 30%, and exceed chum guidelines by 63%.

WD10 - Side channels below Pacific Avenue The creek channel immediately downstream from Pacific Avenue is bordered by several isolated depressions and side channels that do not connect to the main creek. When the creek overtops and then recedes back into the main channel, juvenile fish can die by becoming stranded in these isolated depressions.

WD11 - Pacific Avenue Culverts A series of culverts under the I-5/Pacific Avenue interchange and the adjacent bike path and railroad right-of-way connect Woodard Creek to the north with its headwaters to the south (see figure 7-9). The culverts prevent fish from passing through. The wetland south of the culverts could offer good rearing habitat for juvenile coho salmon. The culvert velocities were not checked here, but Department of Fish and Wildlife staff found fish at the mouth of the Pacific Avenue culvert and no fish upstream of Interstate-5.

WD12 - Woodard Creek Peak Flows Woodard Creek shows the same peak flow problems as Woodland Creek. Refer to Problem WL26, earlier in this chapter, for a more detailed description of the mechanics of peak flow increases. Increased peak flows are causing erosion, water quality degradation and loss of fish habitat in Woodard Creek. Contributors to the basic problem include:

- Future development will increase impervious areas and reduce the forested areas that mitigate runoff and peak flows in the creek.
- Stormwater facilities designed to existing standards will cause future peak flow increases.
- Small developments that fall below existing drainage design thresholds will exacerbate the problem.

Field surveys of habitat in Woodard Creek show that some reaches of the creek contain little woody debris and few pools, and several stream banks are eroding. Stream flow gauging indicates that peak flows in the rainy season are high, while summer flows are low. The basin hydrologic model confirms that peak flows have increased significantly over the natural, pre-development stream flows.

Aqua-Terra Consultants modeled the impacts of future growth on Woodard Creek. Chapter 5 describes the modeling assumptions and appendix C describes the model in greater detail. The modeling indicates that future growth will cause increases in peak flows, even with the new drainage design standards. The peak flows from the 2-year storm are predicted to increase slightly at Ensign Road, and increase by 36% downstream at the mouth. The predicted increases in flow are greater downstream because of tributaries which enter between Ensign Road and the mouth. The peak flows from the 100-year storm are predicted to increase by 40% at Ensign Road and increase by 24% at the mouth. The peak flow increases from the 100-year events are greater upstream because runoff from the commercial/industrial drainage systems at the headwaters overwhelms the creek.

Recent studies indicate that the smaller, more frequent events have a greater influence on channel morphology and stream habitat than large infrequent events such as the 100-year flows (Powers, Washington Department of Fisheries 1991). Figures 4-3 and 4-4 show the predicted increases in future flows at several locations along the creek.

Figure 4-3 Impact of future development on Woodard Creek 2-year peak flows

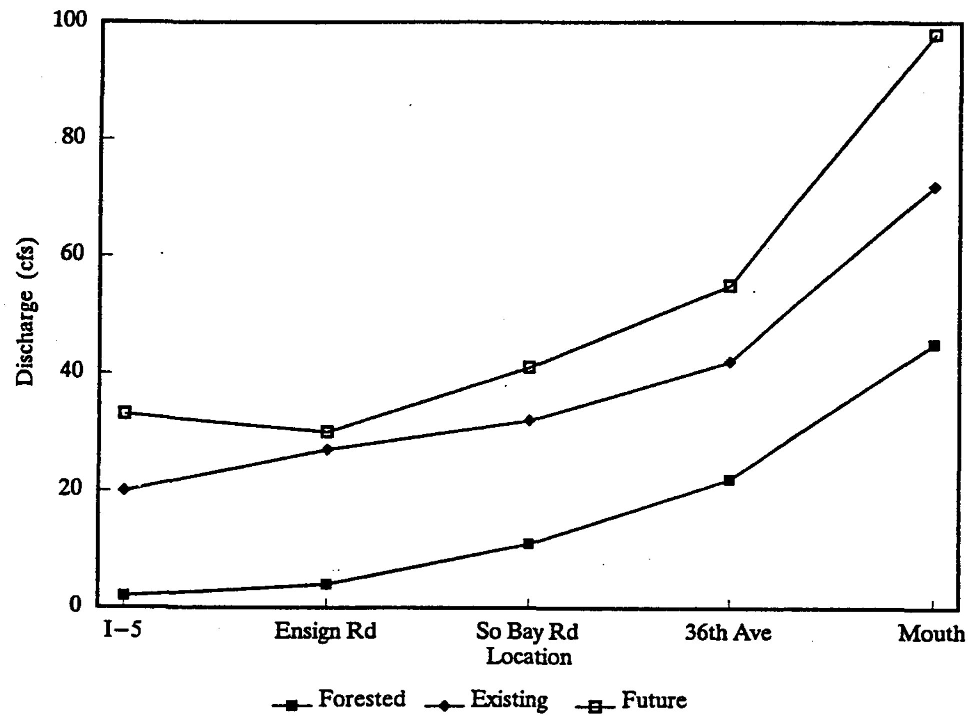


Figure 4-4 Impact of future development on Woodard Creek 100-year peak flows