5.0 IDENTIFICATION OF EXISTING PROBLEMS

5.1 Problem Definitions

Four types of interrelated problems were identified in the Gig Harbor Basin: flooding problems, surface water quality problems, degradation of fish and wildlife habitat in stream corridors, and conflicts between land use and stream health.

Flooding occurs when surface streams overflow their banks and water spreads across the floodplain. Often water can spread out harmlessly, but if it causes damage to property, interferes with access, or threatens public safety, it becomes a flooding problem.

Water quality problems can be defined with reference to the Clean Water Act. The Clean Water Act requires that state and federal governments establish standards for surface waters that protect the beneficial uses of the waters of the United States (1). Surface waters that fail to meet these standards are problematic.

There are no precise or universally agreed upon ways to measure the quality of fish and wildlife habitat. As discussed in Section 4.5, the method used in this study was based on work by the Tri-County Urban Issues Study Group, but modified by URS to better evaluate habitat for species other than fish. For the purposes of this analysis, any stream reach that receives a "fair" or "poor" rating for fish habitat or the riparian corridor was considered to be substantially degraded, and accordingly was regarded as a problem.

A final section in this chapter examines the relationship between land use and stream health. The purpose of the analysis is to determine whether plans for future development in the Gig Harbor Basin are incompatible with healthy streams. More specifically, the analysis seeks to determine if plans for future development are compatible with maintaining streams in a "properly functioning condition" as defined by the National Marine Fisheries Service, the agency responsible for protection of salmonids listed under the Endangered Species Act.

5.2 Flooding

Most storm water runoff in the Gig Harbor Basin is routed to streams that flow to Puget Sound. Natural drainage patterns remain largely unaltered, although many culverts have been built to carry stream flow under roads and driveways. Curbs, gutters, and underground storm drains exist only in the more densely developed areas. Storm water runoff in older rural communities and suburban neighborhoods is typically routed to roadside ditches and then into natural streams. Many streams flow through fairly narrow canyons where streamside properties are generally located a considerable distance above the water level. Where the flood plain is broader, wetlands often exist, and are a deterrent to development.

Several methods were used to identify historical flooding problems in the Gig Harbor Basin. Local residents were invited to two public meetings and asked to complete a questionnaire on flooding and other problems and to locate known flooding problems on a map. The

questionnaire was also mailed to approximately 380 streamside property owners with a request that it be completed and returned. Forty-seven questionnaires were returned.

Records of past problems and complaints were also obtained from Pierce County's files. The County records any incidents of flooding reported by its own staff or citizens and has done so for the last ten years. The files contained 135 reports of water-related problems in the Gig Harbor Basin. One hundred of the reports related to flooding or drainage problems in the Gig Harbor Basin. The remaining 35 reports addressed water quality, erosion, safety, and maintenance problems.

Earlier storm drainage studies of the Gig Harbor area were also examined to determine whether they contained records of historical flooding. The earlier storm drainage studies are the countywide storm drainage master plan prepared by James M. Montgomery Consulting Engineers in 1991 and an analysis of storm drainage in the Wollochet Creek watershed by Economic and Engineering Services, Inc., conducted in 1995. No records of historical flooding were found in these reports.

Reported flooding problems are listed in a table contained in Appendix D. Almost all of the flooding problems that occur under existing conditions are localized and relatively minor. There is only one report of flooding that caused serious damage. It occurred when a hillside above several homes was logged and no measures were taken to control storm runoff from the denuded slope. The problem was corrected by the installation of a detention basin. Several individuals noted that water from Crescent Creek overflows on to Crescent Valley Road at times. But, in general, the existing system appears to have sufficient capacity to carry storm water away from structures at the current level of urban development. Most of the reported problems are probably the result of debris accumulating in culverts and ditches and probably could be solved by improved maintenance. A few problems may be the result of deficiencies in the engineered drainage system in some residential subdivisions.

5.3 Water Quality Problems

Rain falling on urban and suburban areas washes litter and other pollutants that have accumulated on roofs, buildings, streets, landscaped areas, and parking lots into storm drains and natural channels. Although runoff is usually only lightly polluted compared to municipal sewage, it still has considerable potential to harm aquatic life. Urban runoff typically contains total suspended solids, oxygen demanding material, bacteria, pesticides, toxic metals, and nutrients in concentrations that are higher than those found in runoff from undeveloped forest or grassland. In addition, development in urban and suburban areas often results in the loss of the tree canopy that shades streams and keeps water temperatures low. As a result, streams in urban and suburban areas are subject to higher pollutant loads and higher water temperatures than streams in undeveloped areas.

Several methods were used to identify water quality problems. A questionnaire was sent to streamside residents with a request that they report any water quality problems that they may have observed. County records and earlier studies by the U.S. Geological Survey and others

were examined for reports of poor water quality conditions. Also, URS and Pierce County staff made measurements and observations of water quality as part of this study.

The only serious water quality problem reported by residents occurs at Sylvia Lake. Sylvia Lake, which is located on a tributary of Mark Dickson Creek, suffers from excessive growth of algae in the summer months.

Almost all of the available data indicate that water quality in streams in the Gig Harbor Basin is good. Waters are generally well oxygenated, and water temperature and turbidity are low. As discussed in Chapter 4, all water temperature measurements made with the continuously reading thermographs from May 2000 through December 2001 were in compliance with water temperature standards.

A few of the dissolved oxygen measurements made in June 2000 were slightly below the standard of 8 mg/L. Nutrient concentrations in streams were generally higher than in natural streams that are unaffected by human activities but not by a wide margin, except for in Goodnough Creek. Previous measurements of nitrate concentration by others have indicated that nitrate concentrations are often elevated in Goodnough Creek. Nitrate concentrations were also elevated in the samples taken in June 2000, July 2001, and October 2002. In June 2000, July 2001, March 2002, and June 2002 fecal coliform concentrations in many of the streams exceeded the standard of 100 CFU/100ml, but in no case did they exceed 1,000 CFU/100ml. These results are higher than would be expected absent human influences. They suggest that there are no major discharges of untreated human waste or domestic animal waste to the creeks but that some contamination is occurring, possibly as a result of failing septic tanks, small private fish hatchery operations, and/or domestic animals in or near the creeks. However, two samples taken in October 2002 did exceed 1,000 CFU/100ml. Both samples were taken from the tributaries to the southeast corner of Sylvia Lake. Potential sources are being investigated by Pierce County.

The conclusion that water quality in the Gig Harbor Basin is generally good should be viewed as provisional. Most of the data available are from sampling locations near the mouths of the creeks. Water quality could be worse at locations upstream in the watershed. A stream survey conducted by volunteers in 1998 indicated that there is no flow or very little flow in some reaches of Artondale and Crescent Creeks during the late summer. When streams are reduced to disconnected pools, water temperature increases and dissolved oxygen concentration falls.

It is increasingly recognized that collection of grab samples for water quality analysis provides useful but limited information on the condition of streams. Grab samples provide information on water quality conditions at an instant in time. Events that have a transitory effect on water quality, for example a chemical spill or the sudden collapse of a stream bank, are unlikely to be detected by grab sampling. The characteristics of the macroinvertebrate community provide a better indicator of long-term stream health than the characteristics of individual water samples because they serve as a continuous monitor of water quality. The effects of a chemical spill that may only last for a few hours will be reflected by the macroinvertebrate community but would be missed by water sampling programs that employ only grab sampling.

As discussed in Section 4.20, the macroinvertebrate samples taken in May 2000 and September 2000 indicate that while streams have been adversely affected by human activities, many pollution-sensitive macroinvertebrate species are present. This suggests that the streams of the basin are relatively free of toxic substances. Few pollution-sensitive species were found in the September 2000 sampling episode but this is probably attributable to the use of a less advanced sampling device that may have excluded some of the organisms present.

5.4 Fish and Wildlife Habitat Degradation

Human activity in the Gig Harbor Basin has degraded the quality of fish and wildlife habitat within stream corridors. The causes of habitat degradation are several and interrelated. They include changes in basin hydrology, loss of riparian vegetation, and creation of barriers to fish passage.

Streamside and In-stream Habitat

Human activities in the Gig Harbor Basin have often resulted in the loss of streamside or riparian vegetation. When the basin was first settled by Euro-Americans, lands along streams were attractive to loggers because large trees often grew there, and stream corridors provided a convenient route for skidding and/or floating logs to waiting ships. Later, farmers valued the productive soils of streamside lands and easily available year-round water supplies. Today, many residents choose to site their homes near streams for aesthetic reasons.

As described in detail in Chapter 4, a team of technical specialists assessed the condition of fish habitat and the riparian corridor along the streams of the Gig Harbor Basin. The results of the assessment are summarized in Tables 5-1 and 5-2. Approximately 19 miles (100,000 feet) of stream were examined. Fish habitat in 44% of the stream miles was rated as in good condition, 46% was rated as in fair condition, and 10% was rated as in poor condition. Overall, the riparian corridor is in better condition than the in-stream fish habitat. The riparian corridor in 72% of the stream miles examined was rated as in good condition, 21% was rated as in fair condition, and 7% was rated as in poor condition. The condition of the riparian corridor provides an indication of the value of streamside habitat for amphibians, birds, and mammals.

Stream survey field teams noted that wherever the riparian corridor is in fair or poor condition, fish habitat is also degraded. Even where the riparian corridor is in good condition, fish habitat may be in only fair or poor condition because fish habitat is affected not only by its immediate surroundings but also by upstream conditions. Embeddedness was judged to be fair or poor in almost all the stream reaches examined. The interstices in streambed gravel were typically found to be full of silt and sand. This may be a result of natural factors, glacial till being common in the basin, but it is undoubtedly made worse by human-caused soil erosion. Stream survey teams noted erosion of streambeds and banks and soil erosion at construction sites near streams. Alterations in hydrology produced by urban development are also a probable cause of streambed instability, as discussed later in this chapter.

Of the creeks examined, Warren Creek is in the overall best condition with more than 90% of fish habitat and the riparian corridor rated as in good condition. Other creeks in good condition

include McCormick Creek, with more than 80% of fish habitat and the riparian corridor rated as in good condition; Doc Weathers, with more than 70% of fish habitat and the riparian corridor rated as in good condition; and Crescent Creek, with 65% of fish habitat and the riparian corridor rated as in good condition. Crescent Creek has more linear feet of fish habitat in good condition than any other stream in the basin. Wollochet Creek has the greatest number of linear feet of riparian corridor in good condition.

Barriers to Fish Passage

There are many man-made barriers to fish passage on streams in the Gig Harbor Basin. Prior to the 1990s, fish passage on small streams was given little consideration. Public and private parties typically used culverts to convey small streams under highway and driveway fills because they were less expensive than fish–friendly bridges would be. Today, many existing road and driveway culverts prevent or hinder the movement of fish from salt water to freshwater and from one stream reach to another. These culverts form barriers to fish passage due both to aspects of the design of the culverts (slope, outfall conditions, water velocity, water depth, etc.) and to aspects of the maintenance of the culverts (debris blocking the culvert, sediment build-up within the culvert, etc.). In addition to culverts, some Gig Harbor streams also contain barriers to fish passage in the form of small dams and weirs for on-line lakes and ponds.

Barriers are particularly damaging to anadromous or migratory fish, which spend most of their life in the ocean, but return to spawn in their native freshwater streams. Anadromous fish that use small streams, principally coho salmon, steelhead, and sea-run cutthroat trout, may be denied access to reaches of streams that provide suitable spawning and rearing habitat when they encounter these barriers. The free movement from reach to reach of the streams by resident species such as cutthroat trout may also be prevented by fish passage barriers. The salmonid species that inhabit small streams in the Gig Harbor Basin are in decline and may, in the future, be listed as threatened pursuant to the Endangered Species Act.

As discussed in Chapter 4, barriers to fish passage in the Gig Harbor Basin were identified by URS stream survey teams and by Pierce Conservation District. Information on barriers to fish passage is summarized in Table 5-3. Table 5-3 lists the number of "Full" and "Level B" barriers on each stream, as identified by Pierce Conservation District and URS stream surveyors. "Level B" barriers are barriers that have been identified by Pierce Conservation District as potential barriers that need further analysis to determine if they are full barriers or not. Many of the Level B barriers have slope breaks within the pipe or are located in tidally influenced areas, conditions which require a more lengthy modeling process to determine the barrier status. Culverts in tidally influenced areas are particularly time-consuming to analyze, and it may be some time before it is known whether those in question are full fish passage barriers or not.

Some creeks in the basin are relatively free of fish passage barriers. Approximately 11,400 feet of Crescent Creek extending upstream from its mouth is free of barriers. Migrating salmonids can access about 3,700 feet of McCormick Creek before encountering a barrier to upstream movement. Approximately 2,150 feet of Artondale Creek extending upstream from its mouth is free of barriers to fish passage. In all other creeks surveyed, barriers prevent fish obtaining access to any more than the most downstream reaches.

Changes in Basin Hydrology

As noted elsewhere in this report, the clearing of vegetation for agriculture and urban development alters watershed hydrology. The volume and peak flow rates of storm water runoff increase as permeable surfaces are replaced by impermeable or less permeable surfaces, and the drainage network is simplified by the filling of wetlands and construction of ditches and storm drains. Under pre-development conditions, the characteristics of a watershed and those of the stream channel that drains the watershed are in a state of dynamic equilibrium. Development, and the hydrologic changes that accompany it, disturbs this equilibrium. The stream channel must adjust its geometry to reestablish equilibrium with the altered watershed characteristics. As a result, stream banks become destabilized and erosion accelerates. If urban development continues, the stream channels often remain in an unstable condition until several decades after build out.

In the Gig Harbor Basin, destabilization of stream channels probably began when the area was first logged and has continued as wood lots and farms have been converted to urban land uses. Because much of the development planned for the Gig Harbor Basin has already taken place, much of the development-related hydrologic change, and thus damage to streams, has already occurred. The percentage of impermeable surface in a watershed provides a rough indicator of the degree of hydrologic change that has occurred, because undeveloped watersheds generally contain little or no impermeable surfaces. Currently, the impermeable surface percentage in the subbasins in the Gig Harbor basin ranges from 8% to 34%. The average value is 16%.

5.5 Land Use and Stream Health

Stream health is largely a function of land use in the watershed that the stream drains. Although all human use of watersheds adversely affects stream health to a degree, some land use types and land use practices are more damaging than others are. It was important, therefore, as part of the basin planning process, to examine whether planned future development in the Gig Harbor Basin is compatible with healthy streams. And more specifically, to determine whether plans for future development are compatible with maintaining streams in a “properly functioning condition” as defined by the National Marine Fisheries Service, the agency responsible for protection of salmonids listed under the Endangered Species Act. The discussion of land use practices in the Gig Harbor Basin is prefaced by a summary of what is known about the relationship between land use and stream health.

Land Use/Stream Health Relationship

Scientists have conducted numerous studies to try to identify a quantitative relationship between land use and stream health and a qualitative cause-and-effect relationship between urban development and the degradation of stream conditions. James Karr, of the University of Washington, describes the relationship qualitatively as follows. "Because rivers integrate all that happens in their landscapes, their condition, especially their biological condition, tells much about the consequences of human actions. Human actions jeopardize the biological integrity of

water resources by altering physical habitat, modifying seasonal flow of water, changing the food base of the system, changing interactions within the stream biota, and polluting water with chemical contaminants" (2).

Major changes in streams associated with urban development include modified hydrologic regime, the loss of instream structural complexity, and the alteration of channel morphological characteristics. Horner and May conducted a study in the Puget Sound lowland ecoregion and noted that "at very low levels of development there appears to be a rapid decline in biological integrity as well as the physical habitat conditions necessary to support natural biological diversity and complexity. This decline continues as watershed development increases, with no threshold indicated. These results suggest that resource managers should place a high priority on preservation and protection of high-quality stream ecosystems that currently support natural salmonid populations. A wide and near-continuous riparian zone appears to be necessary, although not wholly sufficient condition for a natural level of ecological integrity. Although recovery to near-pristine conditions cannot be expected in all developed stream basins, innovative mitigation efforts should nevertheless continue in an effort to improve stream quality to a level supportive of natural biota" (3).

Horner and May's conclusions are not new. In the early 1990's Booth and Reinelt determined that "urbanization imposes a variety of watershed changes that profoundly affect runoff processes and the downstream surface-water drainage system. These changes include not only the most obvious manifestation of urban development, namely impervious surfaces that cover the land, but also the associated vegetation clearing, soil compaction, water-conveyance modifications, riparian-corridor alterations, human intrusion, and import of chemical contaminants that invariably accompany such development. In aggregate, the physical changes imposed by urban development on the landscape result in a decline in function of aquatic systems" (4). This study, supporting findings from more recent investigations, demonstrates that there is a causal relationship between development and the degradation of stream health.

In an effort to quantify the decline in function and identify its relationship with upstream urbanization, technical experts are relying on biological indicators. Integrative multimetric biological indexes, such as the index of biological integrity (IBI) developed by James Karr of the University of Washington, examine the influences of humans on fish, invertebrate, and algal assemblages (2). Some studies indicate that a marked degradation of the biological condition of aquatic systems occurs when development causes the proportion of impervious surface in a watershed to reach 8 to 10% (4). Others report that this quantitative relationship does not always hold (5).

Booth and Reinelt note that an absence of significant riparian vegetation virtually assures degraded in-stream habitat quality (4). Observations made by stream surveyors as part of the Gig Harbor Basin study support this assertion. Booth and Reinelt regard the area of land adjacent to a stream or other water body as an important component of the watershed. However, in the past, these land areas have often been developed and degraded without regard to be the effect such degradation has on the adjacent water body.

Watershed managers concur that the riparian area or riparian corridor is part of the properly functioning condition of the water body (as defined by the National Marine Fisheries Service), and should be protected along with the water body itself. The processes or functions associated with the riparian area include:

- Shade and temperature regulation
- Large woody debris recruitment
- Source of allochthonous organic material
- Streambank stabilization
- Channel migration zone and floodplain interactions
- Nutrient and non point source pollutant filtration
- Wildlife habitat

In order for a riparian area to be considered in a properly functioning condition, it is necessary for all of these processes to be in effect (5). To enable all of these processes to be in effect simultaneously, an extensive riparian area is needed. Urbanization often encroaches upon riparian corridors, decreasing their integrity. Therefore, streamside buffer zones are needed to help protect riparian corridors and streams.

Potential Land Use/Stream Health Conflicts in the Gig Harbor Basin

Existing land use in the Gig Harbor Basin is predominantly low-density residential development, as shown in Table 3-6. The Gig Harbor Peninsula Community Plan estimates that on average there is one single-family dwelling unit per acre. Vacant land is the next largest land use, which is significant because in spite of the fact that Gig Harbor Basin is estimated to be at 80 percent of build out, there are approximately 4,423 parcels available for residential development on the Gig Harbor Peninsula (6). Expected future land use is also shown in Table 3-6. Most of currently vacant land is planned to be converted to low-density residential development, consisting primarily of single-family residences.

The Gig Harbor Peninsula Community Plan proposes an increase in residential density within the urban growth area to an average of 4 dwelling units per acre. It also proposes the establishment of an urban resource zoning overlay consisting of the remaining open space/green belts that create habitat for wildlife species native to Gig Harbor Peninsula. The Urban Sensitive Resource Overlay designates open space corridors within the Urban Growth Area of the Gig Harbor Peninsula. Fifteen to 50 percent of each site that is proposed for development in the overlay zone shall be retained in a natural, undisturbed condition. Referred to as the open space tract, this part of the site shall be located on each site plan in such a manner that the potential for wildlife movement is maintained through corridors (Objective 5, Principle 1, Standard 5.1.1). The proposed plan designates 616 acres within the Urban Sensitive Resource overlay zone. Low impact development techniques would be required in the overlay zone to protect the remaining wildlife habitat from fragmentation.

As noted earlier, Booth and Reinelt postulate that a steep decline in stream health begins when the impermeable surface percentage in a watershed exceeds 8 to 10 percent. Table 5-4 compares the current impermeable percentages for certain subbasins in the Gig Harbor Basin with the

percentages of instream habitat that is in good condition (7). The information in the table does not support the conclusion that the quality of fish habitat declines proportionally to the increase in impermeable surface. There are a number of reasons for this. Several subbasins that have a relatively low impermeable percentage have little or no good habitat because agricultural activities and development have destroyed the riparian corridor. Also, agricultural activities often produce high sediment loads to streams. Too much fine sediment in streams degrades salmon habitat. In the more urban subbasins, habitat quality is influenced by the location of development within a basin. The Goodnough and McCormick subbasins have about the same impermeable percentage but widely differing amounts of good instream habitat. Goodnough has no good instream habitat whereas McCormick has a considerable amount. This is attributable to the fact that several long reaches of McCormick Creek are in deep undeveloped canyons. Development in Goodnough subbasin, on the other hand, tends to follow the stream and has consequently resulted in a greater level of degradation of stream health in the subbasin.

It is clear that defining potential land use/stream health conflicts in the Gig Harbor Basin is not a task that can be wholly undertaken utilizing the broad generalizations some research has suggested may be applicable. Land use/stream health relationships are complex and dynamic, and the relationships are sensitive to and dependent upon a number of factors unique to individual subbasins and stream reaches. Existing land use in the Gig Harbor Basin currently impacts stream health, and future land use decisions will continue to impact stream health. Pierce County should continue to incorporate what is known about land use/stream health relationships into planning decisions to reduce the negative impacts that land uses may have on the health of streams in the Gig Harbor Basin.

NOTES:

(1) A discussion of the Clean Water Act and its provisions can be found in *Guidelines for Basin Planning*, *Pierce County, 2000*.

(2) Karr, James R., 1996, "Rivers as Sentinels: Using the Biology of Rivers to Guide Landscape Management" www.salmonweb.org/salmonweb/pubs/pacnwfin.html, January 14, 2001.

(3) Horner, Richard R., and Christopher W. May, "Watershed Urbanization and the Decline of Salmon in Puget Sound Streams," 2000.

(4) Booth, Derek B., and Lorin E. Reinelt, "Consequences of Urbanization on Aquatic Systems--Measured Effects, Degradation Thresholds, and Corrective Strategies." Watershed '93.

(5) May, Chris, University of Washington, "Assessment of Riparian Conditions." Presentation at the Willamette Urban Watershed Network workshop on Managing Urban Riparian Areas for Salmonid Protection and Recovery, www.wuw-net.org, October 19, 2001.

(6) Gig Harbor Peninsula Community Plan Update, "Draft Community Plan and Draft Supplemental Environmental Impact Statement" http://www.co.pierce.wa.us/services/home/property/pals/disclaim/landuse/ghplan.htm accessed August 24, 2001.

(7) Most investigators use the Index of Biological Integrity as an indicator of stream health. The comparison described here was based on a partially qualitative assessment of stream health by URS surveyors using the Tri-County evaluation method.

Table 5-1
Summary of Habitat Condition by Linear Feet of Stream

Creek	Fish Habitat (ft)			Riparian Corridor (ft)		
	Good	Fair	Poor	Good	Fair	Poor
Goodnough	0	5,300	450	5,300	0	450
McCormick	7,900	600	1,350	8,300	700	850
Nelyaly	800	4,000	3,200	4,550	2,750	700
Rosedale	0	4,700	100	500	4,200	100
Mark Dickson	0	4,600	1,300	3,100	2,800	0
Warren	6,300	500	0	6,800	0	0
Artondale	5,050	4,900	1,100	8,900	250	1,900
Wollochet	6,950	8,600	0	13,000	2,550	0
Sullivan Gulch	3,500	4,600	0	4,100	4,000	0
Doc Weathers	2,000	0	800	2,000	800	0
Donkey	1,300	4,100	0	5,100	300	0
Crescent	8,850	2,900	1,800	8,850	1,800	2,900
Total	42,650	44,800	10,100	70,500	20,150	6,900
Percent of Total	44%	46%	10%	72%	21%	7%

Table 5-2
Summary of Habitat Condition by Percentage of Linear Feet

Creek	Fish Habitat			Riparian Corridor		
	Good	Fair	Poor	Good	Fair	Poor
Goodnough	0	92	8	92	0	8
McCormick	80	6	14	84	7	9
Nelyaly	10	59	31	57	34	9
Rosedale	0	98	2	10	88	2
Mark Dickson	0	78	22	53	47	0
Warren	93	7	0	100	0	0
Artondale	46	44	10	81	2	17
Wollochet	45	55	0	84	16	0
Sullivan Gulch	43	57	0	51	49	0
Doc Weathers	71	0	29	71	29	0
Donkey	24	76	0	94	6	0
Crescent	65	21	14	65	14	21

Table 5-3
Barriers to Fish Passage

Creek	Number of Reported Full Barriers	Number of Reported Level B (Partial) Barriers	Downstream Full Barrier Location	Unimpeded Length[a] (feet)	Total Length (feet)
Goodnough	5	2	Culvert under State Route 302	450	7,750
McCormick	6	0	Culvert under Woodhill Drive	3,700	13,850
Nelyaly	4	0	Culvert under 82nd Avenue	1,000	8,000
Rosedale	2	0	Culvert under Rosedale Street	100	4,800
Mark Dickson	3	2	Culvert under private driveway	1,300	5,900
Warren	1	0	Culvert under Warren Drive	1,500	6,800
Muri	1	1	Culvert under private garage built over creek	300	500+
Artondale	2	1	Culvert under Artondale Drive **(Note: This barrier was removed in 2004)**	2,150	11,050
Wollochet	8	0	Double culvert under East Bay Drive	250	15,500
Sullivan Gulch	2	1	Culvert under East Bay Drive	600	8,100
Murphy	1	0	Culvert under East Bay Drive	300	400+
Doc Weathers	2	0	Culvert under County Park	100	2,800
Donkey	2	1	Culvert under Harborview Drive	600	5,400
Crescent	1	0	Culvert under private driveway	11,400	17,600

[a]Unimpeded length means the length of the stream from the mouth to the first full fish passage barrier.

Table 5-4
Percent Impermeable and Habitat Quality Comparison

Subbasin	Current Percent Impermeable	Percent Good Instream Fish Habitat
Artondale	9%	46%
Crescent	9%	65%
Doc Weathers[1]	34%	71%
Donkey	20%	24%
Goodnough	19%	0%
Mark Dickson	9%	0%
McCormick	17%	80%
Nelyaly	8%	10%
Rosedale	10%	0%
Sullivan Gulch	29%	43%
Warren	12%	93%
Wollochet	19%	45%

Notes:

[1] Doc Weathers drains a small portion of the large Point Evans subbasin. The percent impermeable shown for Doc Weathers is based on the entire Point Evans subbasin, and may overstate the percent impermeable of the land contributing runoff to Doc Weathers Creek.