CHAPTER 6.
STREAM HABITAT

Patterson Creek (Tributary 7.0376) is a tributary of the Snoqualmie River in a rapidly urbanizing area (Haring 2002). It enters the Snoqualmie River at RM 31.2 (Williams et al. 1975). The Patterson Creek Basin is complex, with numerous tributaries that descend from the upland plateau and adjacent hillsides to the low-gradient Patterson Creek floodplain. This basin contains chinook salmon (*Oncorhynchus tshawytscha)*, coho salmon (*O. kisutch)*, steelhead/rainbow trout (*O. mykiss)*, and coastal cutthroat trout (*O. clarki clarki)* (King County SWM 1993). Although highly impacted, the basin remains biologically diverse and contributes a significant portion of the Snoqualmie River wild coho salmon fishery (King County SWM 1993).

Table 6-1 summarizes the overall habitat conditions in the Patterson Creek Basin as described in the WRIA 7 Limiting Factors Analysis report (Haring 2002). Large-scale alterations to the stream channel and riparian areas have degraded the stream habitat. Prior to the 1950s, the stream channel was straightened, channelized, and dredged to lower the water table (King County SWM 1993). Seventy-seven percent of the riparian corridor along the creek's mainstem has been cleared or consists of early seral stage plant communities with little woody riparian vegetation (SBSRTC 2002). Encroachment of non-native species has also impacted the riparian habitat (Haring 2002). Fish passage is significantly impaired, with 22 of the 38 culverts impassable, reducing the available habitat for salmonid production (Haring 2002). LWD is sparse in the basin, with fewer than 0.15-pieces per channel width (King County SWM 1993).

TABLE 6-1.
HABITAT CONDITIONS IN PATTERSON CREEK BASIN

Habitat parameter	Condition rating
Fish access	Poor
Floodplain connectivity	Poor
Large woody debris	Poor
Pools	No Data
Substrate	Poor
Riparian	Poor
Temperature/	No data
Biotic Parameter	No data except for SB 3
Dissolved Oxygen	No data
Toxics	Poor
Hydrology – Peak flow	Data gap
Low Flow	Data gap

Source: Haring 2002.

The primary surface waters in each subbasin are as follows:

- Subbasin 1 includes the headwaters of the mainstem of Patterson Creek, upstream of Redmond Fall City Road (SR 202).
- Subbasin 2 includes the floodplain of the Patterson Creek mainstem as well as two significant tributaries: Dry Creek (Tributary 0383a) and the unnamed Tributary 0383.
- Subbasin 3 is the Canyon Creek subbasin.
- Subbasin 4 is the Tributary 0377 subbasin, which also contains Tributaries 0378 and 0379.
- Subbasin 5 contains the mainstem of Patterson Creek from its confluence with the Snoqualmie River to RM 2.4 and the unnamed Tributary 0381.

6.1 STREAM HABITAT CLASSIFICATION METHODS

The stream habitat analysis was conducted for each subbasin using a modification of the Tri-County Urban Issues Study: Urban Stream Baseline Evaluation Methods (USBEM) Phase 1 method (R2 Resource Consultants 2001). The USBEM Phase I method incorporates features of several methodologies commonly used in the Pacific Northwest to characterize fish habitat using physical, biological, and chemical indicators. Since the USBEM methodology was designed for an urban setting and the Patterson Creek Basin is a rural watershed (King County SWM 1993), the methodology was adapted to better fit rural conditions. The USBEM Phase I method served as a foundation; then additional criteria were added during the scoping process for the project. The selected criteria were relevant for indicating the health of the watershed and stream habitat conditions. The criteria used in this investigation are described below.

6.1.1 General Characteristics

The general characteristics section of the evaluation provides a summary of descriptive information about each subbasin, identification of stream channel types, and the total length of each channel type in the subbasin. Lengths of each stream channel type were determined from existing mapping and aerial photographs.

The channel type was determined for each stream reach, according to the USBEM Phase I methods. The seven channel process groups described by Paustian et al. (1992) were identified by R2 Resource Consultants as representative of freshwater channel types found in northwestern Washington. The channel type descriptions presented below are from R2 Resource Consultants (2001):

- **Palustrine**—Wetland channels, beaver complexes or sloughs. Velocities are generally low, substrates are composed of fine sediment or organic matter, and channel morphology is sinuous or irregular and dominated by pools or glides. Stream gradient is very low (<1 percent).
- **Floodplain**—Low-gradient (<2 percent) depositional channel. Substrates are typically small gravel to cobble, and the bedform is typically regularly spaced pools and riffles. LWD is important for forming pools and providing

cover. These channels migrate freely across floodplains, and off-channel habitats are normally abundant.

- **Alluvial Fan**—Moderate-gradient (2 to 8 percent) depositional channels located in the transitional area between steep slopes and valley floodplains. Stream power decreases longitudinally down the fan, and deposition results in channels that migrate freely across the fan. Substrates typically range from gravel to cobble, pools are often relatively small and shallow, and off-channel habitats typically do not persist over the long-term.
- **Large Contained**—Low- to moderate-gradient (1 to 3 percent) channels that are moderately to deeply incised. Stream power is moderate to high with coarse substrates. LWD is easily transported and generally located along channel margins. These channels rarely have extensive off-channel habitats.
- **Moderate Gradient Mixed Control**—Transport-dominated channels with moderate to high stream power. Gradients range from 2 to 8 percent. LWD is important for forming pools and storing sediment; thus substrates and bedforms are highly variable. Off-channel habitats may be present, but are not abundant.
- **Moderate Gradient Contained**—Transport-dominated channels with moderate to high stream power. Gradients are typically from 2 to 4 percent, but may reach 6 percent. LWD is important for forming pools and storing sediment; thus substrates and bedforms are highly variable. Off-channel habitats are rare.
- **High Gradient Contained**—Moderately to deeply incised channels with high stream power and gradients greater than 4 percent. Most sediment is easily transported; thus gravel and small cobbles deposit only in hydraulically protected areas. Pools tend to be small and shallow, although LWD and bedrock may form large deep pools.

6.1.2 Subbasin Alteration

An analysis was performed to identify significant alterations to the basin and/or stream channel. The criteria below and in Table 6-2 are indicators of biological, physical, or chemical parameters that can affect habitat quality, and function as indicators of the overall modification of the basin from forested conditions. The level of alteration is determined using a matrix of indices.

Effective Impervious Area (EIA)

EIA is equal to the total impervious area multiplied by the effective impervious fraction (EIF), which is the fraction of actual total impervious area connected to the drainage system. This metric can indicate the relative change to a catchment by development. Values are presented in the land cover analysis portion of this report (Chapter 2), based on existing land use information supplied by King County.

Booth and Jackson (1997) studied the relationship between increased EIA and flow magnitudes in five watersheds in King County. The results indicated that an EIA of 10

percent can cause significant degradation to the aquatic system and that lower levels also can cause moderate degradation. Areas that were observed to be functioning at a high level typically had EIA values less than 3.6 percent. The following thresholds were used to classify the level of alteration to the subbasin indicated by the EIA:

- >10 percent EIA indicates a high level of alteration.
- 5 to 10 percent EIA indicates a moderate level of alteration.
- <5 percent EIA indicates a low level of alteration.

Landscape Alteration

Change to the landscape by anthropogenic activities was examined using the land cover analysis data from Chapter 2. The change to the landscape was assessed by calculating the percent of the remaining forested land cover compared to historical conditions for each subbasin. It was assumed that each subbasin was 100 percent forested prior to development. The thresholds for the low, moderate, and high levels of alteration for this criterion are presented in Table 6-2.

Impact from Culverts and Other Stream Crossings

Impacts from culverts and other stream crossings were determined for each reach from maps, aerial photos and other information. Data were also obtained from the Washington Department of Fish and Wildlife Salmon Screening, Habitat Enhancement and Restoration Section (SSHEARS) fish passage barrier database. This criterion was evaluated by determining the number of stream crossings per mile and the percentage of stream that is located within a storm drainpipe or culvert. Known passage barriers at stream crossings were also reported. Identified barriers were mapped and the length of potential habitat upstream of the barriers was estimated. Thresholds for this criterion are presented in Table 6-2.

Flow Modification

This criterion evaluated changes to the hydrology, which can be an indicator of alterations to a watershed. Hydrologic data presented in Chapter 3 were examined for significant changes to the hydrologic regime from predevelopment to existing conditions. The analysis was based on results of a study by Bledsoe and Watson (2001) on the effects of urbanization on stream channel stability. They used the ratio of 2-year flow after development to 2-year flow prior to development ($Q2_{post}/Q2_{pre}$) to compare changes in flows to effects on channel stability. The study indicated that EIAs from 10 to 20 percent could cause a two-fold increase in 2-year flow events, and result in severe destabilization of streams. Furthermore, the effects of increased EIA were more pronounced with smaller watersheds.

These results were parallel to those reported by Booth and Jackson (1997), suggesting that an EIA as low as 10 percent can have a dramatic impact on stream habitat. The $Q2_{post}/Q2_{pre}$ ratio was used to evaluate the level of hydrologic change to the Patterson Creek subbasins. The $Q2_{post}/Q2_{pre}$ ratio was calculated for each hydraulic modeling reach (RCHRES). The following thresholds were used to classify the level of alteration:

- High level of modification: $Q2_{post}/Q2_{pre}$ ratio > 1.75

- Moderate level of modification: $Q2_{post}/Q2_{pre}$ ratio 1.25-1.75
- Low level of flow modification: $Q2_{post}/Q2_{pre}$ ratio <1.25

Channel Modifications and Floodplain Connectivity

This criterion was used to indicate the relative level of alterations to the stream channel and floodplain within each segment. The level of alteration was determined by estimating the percent of stream length enclosed in storm drainage pipes, culverts, armored, channelized, diked, or constricted. This information was collected from aerial photographs and other existing data. Thresholds for this criterion are presented in Table 6-1.

Riparian Alteration

Riparian areas are one of the most complex ecological systems and are an essential component to healthy stream habitat conditions (Naiman et al. 2000). The riparian area provides thermal insulation for the stream, prevents streambank erosion, traps sediment from runoff, provides overhead cover for fish, and is a significant source of LWD to the stream (Wenger 1999). Riparian vegetation also contributes to the food web of the stream by depositing leaves and other debris as well as providing habitat for terrestrial insects, which can be a significant source of food for fish (Rondorf et al. 1990). Throughout the Pacific Northwest, riparian forests historically formed a continuous corridor of vegetation along a stream channel (Naiman et al. 1992), but human impacts have altered these conditions (Naiman et al. 2000).

Two methods were used to analyze riparian habitat. The first method calculated the percent of the total riparian area for each land cover type using data from the land cover analysis section of this report. These data provide a relative comparison of the land cover types within the 200-foot riparian corridor. It was assumed that prior to development the riparian corridor was 100 percent forested. The ratio of existing forested land cover to predevelopment conditions was used to indicate the magnitude of alteration. Thresholds for this analysis are presented in Table 6-2.

In the second method, the frequency of riparian breaks was used as an indicator of the longitudinal integrity of the riparian corridor. Riparian breaks included road crossings, pipelines, or other areas where the riparian vegetation was removed. For this, the number of riparian breaks per mile of stream was calculated. Thresholds for this analysis are shown in Table 6-2.

Subbasin Alteration Matrix

The subbasin alteration matrix (Table 6-2) was used to indicate the overall level of alteration and classification of existing habitat conditions, and to identify the most significant factors for habitat degradation in each subbasin. Criteria indicating higher levels of alteration are a guide for prioritizing habitat improvement projects.

TABLE 6-2.
SUBBASIN ALTERATION MATRIX.

Criteria	Level of Alteration		
	High: Two or more of the following	Moderate: One or more of the following	Low: All of the following
Effective Impervious Area	>10%	5-10%	<5%
Landscape Alteration	<60% of subbasin forested	60-75% of subbasin forested	>75% of subbasin forested
Impact from Culverts and Other Stream Crossings	>5 per mile	2-5 per mile	<2 per mile
Flow Modification (Q2post/Q2pre ratio)	$Q2_{post}/Q2_{pre} > 1.75$	$Q2_{post}/Q2_{pre} = 1.25 - 1.75$	$Q2_{post}/Q2_{pre} < 1.25$
Channel Modifications and Floodplain Connectivity	>25 % of the stream length is modified	10-25% of stream length is modified	<10% of stream length is modified
Riparian Alteration	<60% of corridor forested or >5 riparian breaks/mile	60-80% of corridor forested or 2-5 breaks/mile	>80% of corridor forested and <2 breaks/mile

6.1.3 Benthic Index of Biotic Integrity

Indices of biotic integrity use biological data to numerically depict a basins relative health. The benthic index of biotic integrity (B-IBI) used by King County (King County 2002) accomplishes this by comparing the existing abundance of invertebrate taxa to what would be expected under pristine conditions. Taxa of particular interest are the aquatic insect families Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddis flies). Members of these taxa are associated with healthy or pristine systems. Therefore, reduced diversity can indicate impacts such as sedimentation, water pollution, or increased water temperatures. The B-IBI methodology used by the King County Road Services Division was developed specifically for Western Washington. These B-IBI data were not available for all of the Patterson Creek subbasins. Also, the data may be biased because the samples were collected only at road crossings.

The King County Roads Division used a 5-metric scoring method in 1999 and a 10-metric method in 2000 and 2001. Although the number of metrics used was different, the interpretation of the scores is the same (see Table 6-3). The individual metric scores are also indicators of stream health; values of "5" represent a range of results indicative of an undisturbed site, "3" indicates a somewhat degraded site, and "1" indicates severely degraded sites (Table 6-4).

TABLE 6-3.
INTERPRETATION OF B-IBI TOTAL SCORES.

10-Metric Score	5-Metric Score	Stream Condition
46-50	23-25	Excellent
38-44	19-22	Good
28-36	14-18	Fair
18-26	9-13	Poor
10-16	5-8	Very Poor

TABLE 6-4.
THE B-IBI SCORING METHOD (FROM KING COUNTY 2002).

	Score[a]		
Metric	1	3	5
Taxa richness and composition			
Total number of taxa[b]	0-14	15-28	≥29
Number of Ephemeroptera species	0-4	5-8	≥9
Number of Plecoptera species	0-3	4-7	≥8
Number of Trichoptera species	0-4	5-9	≥10
Number of long-lived taxa	0-2	3-4	≥5
Tolerance			
Number of intolerant taxa[b]	0-2	3	≥4
% of individuals in tolerant taxa[b]	≥50	20-49	0-19
Feeding ecology			
% of predator individuals	0-9	10-19	≥20
Number of clinger taxa	0-8	9-18	≥19
Population attributes			
% Dominance (3 taxa)[b]	≥80	60-79	0-59

a. Metrics are scored as 1 (severely degraded), 3 (somewhat degraded), or 5 (undisturbed) depending on the range of values indicated for each metric.
b. Chironomids were not included in these metrics.

6.1.4 Subbasin Summary

Field Investigation and Verification

A field investigation was conducted to verify the results of the above analysis using a modification of Phase II of the USBEM methodology (R2 Resources 2001). The habitat condition of each subbasin was evaluated near road crossings or other easy access points.

Criteria used to classify the habitat included fish passage, riparian condition and embeddedness, substrate composition in spawning areas, streambank condition, pool frequency, channel pattern/bedform, and LWD abundance. At each evaluation site, these criteria were classified as good, fair, or poor according to Table 5-7 of the USBEM methodology (R2 Resources 2001), which provides ranges of values for each criterion according to the channel types. The "good" condition rating represents values that are within the range known to support salmonid production; a "fair" rating indicates that salmonid production could be diminished; and the "poor" rating represents unsuitable conditions for sustaining salmonid populations or life stages due to degraded conditions. The thresholds for these criteria are provided in Table 6-5. Evaluation of these criteria was based on professional judgment. These data were collected to provide representative information for each subbasin based on observations made at major access points and under the assumption that conditions at these locations were representative of the subbasin.

Habitat Value and Rating

A qualitative assessment of each subbasin was conducted based on stream classification, complexity (number and size of the tributaries), and habitat potential (amount of spawning or rearing habitat). The value of each subbasin was classified as low, moderate, or high, depending on the amount of potential spawning and rearing habitat.

The habitat condition of each subbasin was rated as good, fair, or poor based on the existing conditions compared to what is described as natural conditions for the channel types described by the USBEM methodology Appendix E. Stream reaches that provided highly suitable habitat were rated as "good;" reaches that have been degraded but still provided habitat use were rated as "fair;" and reaches with negligible habitat use or a portion of the salmonid life history habitat requirements that are significantly impaired were rated as "poor."

State of the Subbasin

This "state of the subbasin" is a summary of the existing conditions and impairments to the habitat in each subbasin and identifies potential areas for habitat improvement projects and remaining high quality habitat areas suitable for preservation.

TABLE 6-5.
FIELD ASSESSMENT CRITERIA AND THRESHOLDS (FROM R2 RESOURCES 2001).

Habitat Parameter	Habitat Condition		
	Good	Fair	Poor
All Streams			
Passage barriers	Upstream and downstream movement by species of concern is not restricted by barriers	Upstream and downstream movement by species of concern is restricted by barriers at some flows	Upstream and downstream movement by species of concern is restricted by barriers at most flows.
Water Temperature	50-57°F For bull trout: 39-48°F (spawning); 36-41°F (incubation); 39-54°F (rearing); <59°F (adult migration)	57-60°F (spawning) 57-64°F (migration and rearing) For bull trout: <39 or 50°F (spawning); <36 or 43°F (incubation); <39 or 55-59°F (rearing); sometimes >59°F (adult migration)	>60°F (spawning) >64°F (migration and rearing) For bull trout: <39 or >50°F (spawning); <34 or >43°F (incubation); >59°F (rearing); regularly >59°F (adult migration)
Palustrine Channels			
Riparian condition	Riparian vegetation is continuous and dominated by native species typical of the channel type.	Riparian vegetation is discontinuous or <50% are native species typical of the channel type.	Riparian area is dominated by land use alterations or invasive non-native vegetation.
Substrate composition in spawning areas	N/A	N/A	N/A
Embeddedness	N/A	N/A	N/A
Bank condition	N/A	N/A	N/A
Pool frequency	N/A	N/A	N/A
Channel pattern/ bedform	Sinuous pattern with intact connections to adjacent wetlands or side-channels	Sinuous pattern with few connections to adjacent wetlands or side-channels	Straightened pattern; channel is disconnected from adjacent wetlands or side-channels
Large woody debris	N/A	N/A	N/A

TABLE 6-5 (continued).
FIELD ASSESSMENT CRITERIA AND THRESHOLDS (FROM R2 RESOURCES 2001).

Habitat Parameter	Habitat Condition		
	Good	Fair	Poor
Floodplains			
Riparian condition	High recruitment potential	Medium recruitment potential	Low recruitment potential
Substrate composition in spawning areas	Gravel or cobble is dominant	Gravel or cobble is subdominant	Sand or silt is dominant
Embeddedness	<20% in riffle and pool tailout units	20-40% in riffle and pool tailout units	>40% in riffle and pool tailout units
Bank condition	Perennial vegetation exists along 80% of banks; <20% of banks are exposed soil or artificially hardened	Perennial vegetation exists along 50% of banks; 20-50% of banks are exposed soil or artificially hardened	>50% of banks are exposed soil or artificially hardened
Pool frequency	If Channel Width (CW)>60 feet, <5 CW/ pool; if CW<60 feet, <2 CW/pool	If CW>60 feet, 5-7 CW/ pool; if CW<60 feet, 2-4 CW/pool	If CW>60 feet, >7 CW/pool; if CW<60 feet, >4 CW/pool
Channel pattern and connectivity	Sinuous pattern with intact connections to adjacent wetlands or side-channels	Sinuous pattern with few connections to adjacent wetlands or side-channels	Straightened pattern; channel is disconnected from adjacent wetlands or side-channels
Large woody debris	If CW is >66 ft, accumulations with at least one key piece are frequent at the outside of meander bends, side-channel inlets, and bar apexes. If CW is 33 to 66 feet, >0.50 key pieces/CW; If CW<33 feet, >0.30 key pieces/CW and >2 total pieces/CW	If CW is >66 ft, accumulations with at least one key piece are scarce at the outside of meander bends, side-channel inlets, and bar apexes. If CW is 33 to 66 feet, 0.20 to 0.50 key pieces/CW; If CW<33 feet, 0.15 to 0.30 key pieces/CW and 1-2 total pieces/CW	If CW is >66 ft, accumulations with at least one key piece are not present at the outside of meander bends, side channel inlets, and bar apexes. If CW is 33 to 66 feet, <0.20 key pieces/CW; If CW<33 feet, <0.15 key pieces/CW and <1 total piece/CW

TABLE 6-5 (continued).
FIELD ASSESSMENT CRITERIA AND THRESHOLDS (FROM R2 RESOURCES 2001).

Habitat Parameter	Habitat Condition		
	Good	Fair	Poor
Alluvial Fan			
Riparian condition	High recruitment potential	Medium recruitment potential	Low recruitment potential
Substrate composition in spawning areas	Gravel or cobble dominant	Gravel or cobble subdominant	Silt or sand dominant
Embeddedness	<20%	20-40%	>40%
Bank condition	Perennial vegetation exists along 80% of banks; <20% of banks are exposed soil or artificially hardened	Perennial vegetation exists along 50% of banks; 20-50% of banks are exposed soil or artificially hardened	>50% of banks are exposed soil or artificially hardened
Pool frequency	<2 CW/pool	2-4 CW/pool	>4 CW/pool
Channel pattern and connectivity	N/A	N/A	N/A
Large woody debris	If CW is 33 to 66 feet, >0.50 pieces/CW	If CW is 33 to 66 feet, 0.20 to 0.50 pieces/CW	If CW is 33 to 66 feet, <0.20 pieces/CW
	If CW<33 feet, >0.30 key pieces/CW and >2 total pieces/CW	If CW<33 feet, 0.15 to 0.30 key pieces/CW and 1-2 total pieces/CW	If CW<33 feet, <0.15 key pieces/CW and <1 total piece/CW
Large Contained Streams			
Riparian condition	High recruitment potential	Medium recruitment potential	Low recruitment potential
Substrate composition in spawning areas	Gravel or cobble dominant	Gravel or cobble subdominant	Bedrock, boulder, sand or silt is dominant
Embeddedness	<20% in riffle and pool tailouts	20-40% in riffle and pool tailouts	>40% in riffle and pool tailouts
Bank condition	Few side slope failures; where present, revegetation is well established	Few side slope failures; where present, <50% revegetated	Side slope failures are common and actively eroding
Pool frequency	If CW>60 feet, <5 CW/pool; if CW<60 feet, <2 CW/pool	If CW>60 feet, 5 -7 CW/ pool; if CW<60 feet, 2-4 CW/pool	If CW>60 feet, >7 CW/ pool; if CW<60 feet, >4 CW/pool
Channel pattern and connectivity	N/A	N/A	N/A

TABLE 6-5 (continued).
FIELD ASSESSMENT CRITERIA AND THRESHOLDS (FROM R2 RESOURCES 2001).

Habitat Parameter	Habitat Condition		
	Good	Fair	Poor
Large Contained Stream (continued)			
Large woody debris	If CW is 33 to 66 feet, >0.50 key pieces/CW If CW<33 feet, >0.30 key pieces/CW and >2 total pieces/CW	If CW is 33 to 66 feet, 0.20 to 0.50 key pieces/CW If CW<33 feet, 0.15 to 0.30 key pieces/CW and 1-2 total pieces/CW	If CW is 33 to 66 feet, <0.20 key pieces/CW If CW<33 feet, <0.15 key pieces/CW and <1 total piece/CW
Moderate Gradient Mixed Control and Moderate Gradient Contained Streams			
Riparian condition	High recruitment potential	Medium recruitment potential	Low recruitment potential
Substrate composition in spawning areas	Gravel or cobble dominant	Gravel or cobble subdominant	Bedrock, boulder, sand or silt is dominant
Embeddedness	<20% in riffle and pool tailouts	20-40% in riffle and pool tailouts	>40% in riffle and pool tailouts
Bank condition	>80% of banks are vegetated and not artificially hardened Few side slope failures; where present, revegetation is well established	50-80% of banks are vegetated and not artificially hardened Side slope failures scarce, or if present, >50% are revegetated	>50% of banks are exposed soil or artificially hardened Side slope failures are common and actively eroding
Pool frequency	<2 CW/pool	2-4 CW/pool	>4 CW/pool
Channel pattern/bedform	Sinuous pattern with well developed step-pool or pool-riffle bedform	Sinuous pattern with irregular or poorly defined step-pool or pool-riffle bedform	Straightened pattern, plane-bed
Large woody debris	If CW is 33 to 66 feet, >0.50 key pieces/CW If CW<33 feet, >0.30 key pieces/CW and >2 total pieces/CW	If CW is 33 to 66 feet, 0.20 to 0.50 key pieces/CW If CW<33 feet, 0.15 to 0.30 pieces/CW and 1-2 total pieces/CW	If CW is 33 to 66 feet, <0.20 key pieces/CW If CW<33 feet, <0.15 key pieces/CW and <1 total piece/CW

TABLE 6-5 (continued).
FIELD ASSESSMENT CRITERIA AND THRESHOLDS (FROM R2 RESOURCES 2001).

Habitat Parameter	Habitat Condition		
	Good	Fair	Poor
High Gradient Streams			
Riparian condition	High recruitment potential	Medium recruitment potential	Low recruitment potential
Substrate composition in spawning areas	Gravel or cobble dominant	Gravel or cobble subdominant	Bedrock or boulder dominant
Embeddedness	N/A	N/A	N/A
Bank condition	Few side slope failures; where present, revegetation is well established	Side slope failures scarce, or if present, <50% are revegetated	Side slope failures are common and actively eroding
Pool frequency	<2 CW/pool	2-4 CW/pool	>4 CW/pool
Channel pattern/bedform	Well developed step-stool bedform	Irregularly spaced or poorly defined step-pool bedform separated by cascades	Cascade bedform
Large woody debris	If CW is 33 to 66 feet, >0.50 key pieces/CW If CW<33 feet, >0.30 key pieces/CW and >2 total pieces/CW	If CW is 33 to 66 feet, 0.20 to 0.50 key pieces/CW If CW<33 feet, 0.15 to 0.30 pieces/CW and 1-2 total pieces/CW	If CW is 33 to 66 feet, <0.20 key pieces/CW If CW<33 feet, <0.15 key pieces/CW and <1 total piece/CW

Note: CW = Channel Width

6.2 SUBBASIN 1 STREAM HABITAT CLASSIFICATION RESULTS

6.2.1 General Characteristics

Subbasin 1 originates in a broad, low-gradient catchment on the upland plateau and descends through a steep ravine to the floodplain reach of Subbasin 2 (see Figure 6-1). The stream habitat has been described as in fair condition despite channel incision up to 1 foot in depth, localized scour occurring down to the underlying silty sand substrate, embedded substrates, and sparse LWD (King County SWM 1993). Subbasin 1 has a mix of moderate gradient mixed control, palustrine, moderate gradient contained, and alluvial fan channel types (see Figure 6-1). The total length of these channel types in the subbasin is presented in Table 6-6. Subbasin 1 is the smallest of the Patterson Creek subbasins in terms of stream length, with approximately 2.5 miles of stream.

TABLE 6-6.
LENGTH OF EACH CHANNEL TYPE ALONG PATTERSON CREEK IN SUBBASIN 1

	Length (feet)	
Stream Type	Patterson Creek	Tributary at RM 10.0
Alluvial Fan	1,242	—
Floodplain	0	—
High Gradient Contained	0	—
Mod. Gradient Contained	5,710	—
Moderate Gradient Mixed Control	3,682	—
Palustrine	1,194	—
Total	**11,828**	**1,350***

***** Represents length of tributary at RM 10.0

6.2.2 Subbasin Alteration

Effective Impervious Area

Subbasin 1 is 1,156 acres in size and has 29 acres of EIA, yielding a 3 percent EIA, a low level of alteration. This level of alteration probably has a limited impact on the hydrologic regime of the stream in this subbasin.

Landscape Alteration

Prior to development, 1,120 acres of forested land cover were present in Subbasin 1. Under existing conditions, 764 acres of forested land cover remain, 68 percent of the historical area, indicating a moderate level of landscape alteration.

Impact from Culverts and other Crossings

In the 2.5 miles of stream, there are seven stream crossings, yielding 2.8 stream crossings per mile. Passage barriers are a major impairment in the subbasin. The SSHEARS database indicates that a barrier on a private road adjacent to SR 202 potentially prevents fish passage into the entire subbasin, 11,800 feet of potential habitat. The culvert at NE 52nd Place is perched and is a passage barrier. The 18-inch culvert at NE 67th Place is undersized and should be replaced. The level of impact from culverts and stream crossings in Subbasin 1 is high since fish passage barriers prevent access to the subbasin. Locations of the passage barriers are shown in Figure 6-2.

Flow Modification

The hydrologic analysis indicates a low level of flow modification ($Q2_{post}/Q2_{pre}$ <1.25) in Subbasin 1 (Table 6-7).

TABLE 6-7. PRE-DEVELOPED AND POST-DEVELOPED 2-YEAR FLOWS AND RATIO; RCHRES SEGMENT 100 IN SUBBASIN 1	
$Q2_{pre}$	65 cfs
$Q2_{post}$	72 cfs
$Q2_{post}/Q2_{pre}$ ratio	1.11

Channel Modifications and Floodplain Connectivity

In Subbasin 1, alteration to the stream channel and floodplain was most evident in the alluvial channel type reach on the Stevlingson Property, immediately upstream of SR 202. At this site, the stream channel has been channelized and diverted from the natural alignment. Approximately a quarter-mile of stream channel has been altered, which is 10 percent of the length of stream in Subbasin 1. In addition, the stream channel is altered by the seven road crossings in the subbasin. This length of modified stream channel represents a moderate level of alteration, although near the threshold between low and moderate levels of alteration.

Riparian Alteration

In Subbasin 1, 77 percent (89 of the 115 acres) of the riparian corridor is forested, a moderate level of alteration. There are 10 riparian breaks, or 4.0 riparian breaks/mile, which is a moderate level of alteration to the longitudinal integrity of the riparian corridor. The overall riparian alteration rating was moderate due to the moderate level of alteration indicated by both metrics.

Subbasin Alteration Matrix

A moderate level of watershed alteration has occurred in Subbasin 1 (Table 6-8). All of the criteria were rated at a moderate level of alteration except for EIA (low), flow modification (low) and the impact from culverts (high). These results suggest that the fish passage barriers are the most significant impairment to habitat in this subbasin.

6.2.3 Benthic Biodiversity

No B-IBI data exist for Subbasin 1.

6.2.4 Subbasin 1 Summary

Field Assessment

The field assessment of Subbasin 1 was performed at RM 9.2, at NE 52nd Place, and at NE 67th Place.

TABLE 6-8.
SUBBASIN ALTERATION MATRIX FOR SUBBASIN 1

Criteria	Level of Alteration		
	High	Moderate	Low
Effective Impervious Area			3% EIA
Landscape Alteration		68% of the historical area	
Impact from Culverts and Other Stream Crossings	Fish passage barriers		
Flow Modification ($Q2_{post}/Q2_{pre}$ ratio)			1.11
Channel Modifications and Floodplain Connectivity		10% of the stream length modified	
Riparian Alteration		77% forested, 4.0 breaks/mile	

At RM 9.2, no fish passage barriers were seen. However, in the late 1990s, a culvert at an old logging road that crossed the stream approximately a quarter-mile upstream from this site had plugged and caused the road to fail (Kirk Anderson, King County Stream Basin Steward, personal communication, 2003). This released a large volume of water and debris that scoured the stream channel and severely degraded the habitat. However, the stream is now recovering and in fair condition. The riparian habitat in this reach is dominated by a mixed conifer and deciduous forest and is in good condition. Substrate composition in spawning areas was in good condition and dominated by gravel substrates, and embeddedness was fair (approximately 30 percent embedded). The stream banks were in fair condition, with infrequent nick point erosion areas, but otherwise stable. Pool frequency was poor, as none were seen. The channel pattern/bedform was in fair condition, with some step-pool formation developing. LWD abundance was fair and contributing to channel morphology.

At NE 52nd Place, fish passage is poor due to a perched culvert. King County is currently working to replace this culvert (Kirk Anderson, King County Stream Basin Steward, personal communication, 2003). At this site the riparian habitat, substrate composition in spawning areas, embeddedness, and bank condition were in good condition. Pool frequency was poor, as none were seen. The channel pattern/bedform was in fair condition with limited step-pool features. The abundance of LWD was fair, and moderately contributing to channel complexity.

At the NE 67th Place stream crossing, fish passage is in fair condition due to an 18-inch culvert that is undersized. However, the NE 52nd Place culvert prevents fish passage to this area. The riparian habitat is in good condition and dominated by deciduous and coniferous forest trees. The substrate composition in spawning areas was fair, with gravel and sand as the dominant substrate, but substrate quality was low due to a poor embeddedness condition. Stream banks were well vegetated and in good condition. Channel pattern/bedform was in fair condition with a moderate level of sinuosity. Pool frequency

was fair due to infrequent pools. The abundance of LWD was fair, with sporadic occurrence of small accumulations.

Habitat Value

Subbasin 1 of Patterson Creek provides moderate habitat value to the Patterson Creek Basin. This reach is primarily a spawning habitat reach with limited rearing habitat. It is not a complex subbasin since there are limited tributaries and channel and habitat complexity is moderate. The moderate gradients, lack of channel complexity, and low pool frequency limit rearing habitat. Although the stream habitat of this subbasin has been moderately altered, this subbasin still provides a significant amount of potential spawning habitat.

Rating

Although development in the subbasin has impacted conditions, the stream habitat in Subbasin 1 is in fair condition, because the stream still supports salmonid production. Stream habitat complexity is limited and pools are infrequent, which impairs the amount of potential spawning and rearing habitat. Furthermore, culverts block fish access to the subbasin.

State of the Subbasin

Subbasin 1 has been slightly impacted by residential development. Fish passage barriers are the most significant limitation to salmonid production in Subbasin 1 and prevent access to approximately 2.5 miles of spawning and rearing habitat. Elimination of these passage barriers would open up substantial spawning habitat for salmonids and should be a high priority restoration measure. The stream channel and riparian alterations at the Stevlingson property are significant impairments to habitat conditions in the subbasin and provide an area of opportunity for habitat improvement projects. Restoration of habitat on the property could produce a valuable segment of spawning and rearing habitat. Aside from these specific areas of impairment, Subbasin 1 remains relatively intact; therefore, measures to maintain the hydrologic and riparian integrity of this subbasin should be implemented.

6.3 SUBBASIN 2 STREAM HABITAT CLASSIFICATION RESULTS

6.3.1 General Characteristics

Subbasin 2 is the largest of the five subbasins in terms of stream miles, with 11.2 miles of stream. It includes the mainstem of Patterson Creek from RM 2.7 to RM 8.3 and numerous lateral tributaries, including five Class 2 streams (see Figure 6-1). Table 6-9 lists the length of each of these streams. In this reach, Patterson Creek is a low-gradient, floodplain channel that has been highly impacted by land use practices. The once Sitka spruce, western red cedar, and hemlock dominated floodplain has been largely converted to agricultural land, leaving the riparian habitat in poor condition (King County SWM 1993). The stream has been channelized and dredged, altering the channel morphology and condition, as well as the floodplain connectivity. Habitat complexity is limited by the lack of LWD. Since this reach of Patterson Creek has a very low gradient (0.1 percent), LWD was

likely important for stream channel dynamics, the development of macro- and microhabitats, and providing cover.

TABLE 6-9.
STREAM LENGTHS IN SUBBASIN 2

Stream/Tributary	Stream Length (feet)
Patterson Creek	29,430
Tributary 0376A	4,912
Tributary 0376B	1,375
Tributary 0376C	3,725
Tributary at RM 6.5	1,410
Tributary 0383	7715
Dry Creek	10,500

The lateral tributaries are steep streams that flow off the surrounding slopes of the watershed, are susceptible to erosion, and contribute fine sediment to the main stem of Patterson Creek (King County SWM 1993). The most significant tributaries to Patterson Creek in Subbasin 2 in terms of fish production are Dry Creek and Tributary 0383. Dry Creek is a moderate gradient, moderately confined channel in the upstream reaches that flows into a moderate gradient, contained reach adjacent to Ames Lake Road. Tributary 0383 is a moderate gradient, moderately contained channel. The habitat in the Tributary 0383 watershed is relatively intact, but the Dry Creek basin has been significantly impacted by development (King County SWM 1993). Table 6-10 summarizes the channel types in Subbasin 2.

TABLE 6-10.
CHANNEL TYPES IN SUBBASIN 2 BY LENGTH

Stream/Tributary	Length (feet)
Alluvial Fan	1,826
Floodplain	5,653
High Gradient Contained	11,845
Moderate Gradient Contained	13,156
Moderate Gradient Mixed Control	0
Palustrine	26,610

6.3.2 Subbasin Alteration

Effective Impervious Area

Subbasin 2 is 5,356 acres in size and has 217 acres of impervious area, yielding a 4-percent EIA, a low level of alteration that likely has a limited impact on the hydrologic regime of the stream in this subbasin.

Landscape Alteration

Prior to development conditions, 4,684 acres of forested land cover were present in Subbasin 2. Under existing conditions, 3,031 acres of forested land cover remain in the subbasin, 65 percent of the historical area. This represents a moderate level of alteration to the landscape.

Impact from Culverts and other Crossings

In the 11.2 miles of stream, there are 15 stream crossings, or 1.3 stream crossings per mile. Fish passage barriers are present in Dry Creek at NE 40th Street and NE 45th Street (WDFW 2002). A barrier on a private road also blocks fish passage in the tributary entering Patterson Creek on the left bank at RM 6.95 (Haring 2002). These barriers prevent anadromous fish access to 1,100 feet of potential habitat. The level of impact from stream crossings was rated as high due to the fish passage barriers.

Flow Modification

In Subbasin 2, the Q2post/Q2pre ratio ranges from 1.10 to 1.20 for the four RCHRES segments (Table 6-11), representing a low level of modification to the hydrologic regime.

TABLE 6-11.
PRE-DEVELOPED AND POST-DEVELOPED 2-YEAR AND RATIO; RCHRES SEGMENTS 200, 210, 220 AND 230 IN SUBBASIN 2

	RCHRES 200	RCHRES 210	RCHRES 220	RCHRES 230
$Q2_{pre}$	78 cfs	68 cfs	111 cfs	156 cfs
$Q2_{post}$	86 cfs	76 cfs	133 cfs	187 cfs
$Q2_{post}/Q2_{pre}$ ratio	1.10	1.12	1.20	1.20

Channel Modifications and Floodplain Connectivity

This reach of Patterson Creek is a low-gradient, wetland-dominated system with the stream flowing though intermittent forested and agricultural/residential areas. Nearly all of the stream channel in Subbasin 2 has been highly altered by straightening, channelization, and dredging through the 1950s (King County SWM 1993). These alterations affected floodplain connectivity. Dry Creek has been channelized and confined adjacent to Ames Lake Road, causing straightening of the channel and localized erosion. These abundant alterations to the stream channel and floodplain connectivity represent a high level of alteration.

Riparian Alteration

In Subbasin 2, 51 percent (277 of the 542 acres) of the riparian corridor is forested, a high level of alteration. There are 20 riparian breaks, or 1.8 riparian breaks per mile, which is a low level of alteration to the longitudinal integrity of the riparian corridor. However, the actual number of riparian breaks is misleading since many of the breaks are areas where agricultural and grazing practices have removed significant tracts of riparian vegetation.

The overall riparian alteration rating is high due to the low percentage of forested riparian corridor.

Subbasin Alteration Matrix

The subbasin alteration matrix indicates a high level of alteration in Subbasin 2 (Table 6-12). The major impairments to the habitat are from removal of the riparian vegetation from the majority of the reach, channelization, deepening, and dredging of the stream channel, and fish passage barriers.

TABLE 6-12.
SUBBASIN ALTERATION MATRIX FOR SUBBASIN 2

Criteria	Level of Alteration		
	High	Moderate	Low
Effective Impervious Area			4% EIA
Landscape Alteration		65% of the historical area	
Impact from Culverts and Other Stream Crossings	Fish passage barriers		
Flow Modification ($Q2_{post}/Q2_{pre}$ ratio)			1.10 - 1.20
Channel Modifications and Floodplain Connectivity	>90% of the channel has been altered		
Riparian Alteration	51% forested		1.8 breaks/mile

6.3.3 Benthic Biodiversity

No B-IBI data exist for Subbasin 2.

6.3.4 Subbasin Summary

Field Assessment

The field assessment of Subbasin 2 was performed at four locations; one on the mainstem Patterson Creek; one on the right bank Tributary 0383; and two on Dry Creek.

Fish passage was in good condition on the mainstem Patterson Creek. The riparian zone is in poor condition in this reach. Riparian forest has been removed from much of the streamside and the riparian zone now dominated by reed canary grass. This portion of the mainstem provides limited to no spawning habitat, as the substrate is dominated by fines and organic sediments, and LWD is absent from the stream. Stream banks are in fair condition since reed canary grass is maintaining some bank stability. The stream pattern/bedform has been altered, but is in fair condition since moderate sinuosity has been maintained.

All of the criteria examined were rated as good in Tributary 0383, except for pool frequency and LWD abundance, which were rated poor. The riparian habitat was dominated by coniferous trees, which provide substantial potential LWD recruitment to the stream. Gravels dominated the substrate, and there was a low level of embeddedness of the gravels. A lack of LWD appeared to contribute to the lack of pools in this reach. The stream channel/bedform was moderately sinuous and in good condition.

Dry Creek has been significantly degraded where it is adjacent to Ames Lake Road. Fish passage was the only criterion in good condition. The riparian habitat was in fair condition and heavily encroached on by the roadway. Substrate composition and quality in spawning areas were in poor condition, since gravel was subdominant to sand and embeddedness was high. A substantial amount of sand has been deposited in this area from an upstream source. Bank conditions were fair, with nick-point erosion occurring due to channel confinement by Ames Lake Road. Pool frequency was fair as a result of man-made log weir pools. Channel/bedform condition was poor due to confinement by the road.

Dry Creek at NE 36th Place is in relatively good condition. Fish passage, riparian condition, substrate composition, embeddedness, and bank condition were all rated as good. Channel pattern/bedform and pool frequency were in fair condition. Large woody debris abundance was poor, and likely contributed to the poor channel complexity and infrequent pools.

Habitat Value

Subbasin 2 is a complex and highly valuable subbasin. The slow, meandering, mainstem of Patterson Creek provides critical juvenile rearing habitat not only to the Patterson Creek Basin, but also to the Snoqualmie River. In addition, the numerous tributaries in this subbasin contribute a substantial amount of spawning habitat.

Rating

Although the stream channel and riparian habitat of the mainstem of Patterson Creek in Subbasin 2 have been highly altered, this reach is still in fair condition and provides rearing habitat. Tributary 0383 is in good condition, but pool habitat is limited. The lower Dry Creek stream channel adjacent to Ames Lake Road is in poor condition, but the mid-watershed is suitable for salmonid spawning.

State of the Subbasin

The mainstem of Patterson Creek has been highly altered in Subbasin 2. The subbasin alteration matrix indicates that passage barriers, channel alterations, and riparian alteration are the significant impairments to habitat function. Specific improvements to Patterson Creek should focus on restoring riparian habitat and floodplain connectivity, and increasing habitat complexity in the channel. These improvements would likely restore juvenile rearing habitat and increase the potential salmonid production. Culverts limit access to 1,137 feet of potential spawning habitat in the subbasin and should be replaced. The middle portion of Dry Creek is potentially important spawning habitat and should be preserved. Tributary 0383 provides quality salmonid habitat that should also be preserved.

6.4 SUBBASIN 3 STREAM HABITAT CLASSIFICATION RESULTS

6.4.1 General Characteristics

Subbasin 3 is the Canyon Creek watershed. Canyon Creek is a significant tributary for salmonid production in the Patterson Creek Basin. Its drainage area is a forested watershed that originates on Grand Ridge and has some of the best moderate-gradient channel stability and fish habitat in the Patterson Creek Basin (King County SWM 1993). The stream habitat is in relatively good condition, with clean gravel substrate, abundant woody debris, and high habitat complexity. The reach below RM 0.7 is the only significantly degraded portion of the subbasin, with degradation similar to other floodplain reaches in the Patterson Creek Basin. Canyon Creek is primarily a moderate gradient, moderately contained channel type, with intermittent areas of palustrine channels (see Figure 6-1). Subbasin 3 has 5.8 miles of stream. Table 6-13 summarizes the channel types.

TABLE 6-13.
LENGTH OF EACH CHANNEL TYPE ALONG BEAVER CREEK IN SUBBASIN 3

Stream Type	Length (feet)
Alluvial Fan	0
Floodplain	0
High Gradient Contained	0
Moderate Gradient Contained	529
Moderate Gradient Mixed Control	21,232
Palustrine	4,639
Total	**26,400**

6.4.2 Subbasin Alteration

Effective Impervious Area

Subbasin 3 is 2,038 acres in size and has 93 acres of impervious area, a 5-percent EIA. This moderate level of alteration may be enough to cause significant increases in the intensity of high flow events and potentially degrade habitat conditions.

Landscape Alteration

Under predeveloped conditions, 1,951 acres of forested land cover were present in Subbasin 3. Under existing conditions, 1,254 acres of forested land cover remain, 64 percent of the historical area. This represents a moderate level of landscape alteration.

Impact from Culverts and other Crossings

In the 5.9 miles of stream, there are 17 road-stream crossings, or 2.9 stream crossings per mile, a moderate level of alteration. However, Haring (2002) indicated that six culverts are barriers to fish migration in an unnamed tributary to Canyon Creek at RM 2.0. Locations of

the passage barriers are shown in Figure 6-2. These culverts may prevent access to 2,750 feet of potential habitat.

Flow Modification

In Subbasin 3, the Q2post/Q2pre ratio is 1.17 (Table 6-14), representing a low level of flow modification.

TABLE 6-14.
PRE-DEVELOPED AND POST-DEVELOPED 2-YEAR AND RATIO; RCHRES SEGMENT 300 IN SUBBASIN 3

$Q2_{pre}$	269 cfs
$Q2_{post}$	314 cfs
$Q2_{post}/Q2_{pre}$ ratio	1.17

Channel Modifications and Floodplain Connectivity

The Canyon Creek stream channel remains in good condition, although storm-induced erosion has occurred in localized areas (King County SWM 1993). The channel is not significantly altered with the exception of the floodplain reach, where approximately 0.5 miles (8 percent of the total stream length) has been channelized and floodplain connectivity is impaired. Upstream of RM 0.5 the floodplain function was rated as good (Haring 2002). The level of channel and floodplain modification is low since only 8 percent of the length of stream in Subbasin 3 has been altered.

Riparian Alteration

In Subbasin 3, 73 percent (172 of the 236 acres) of the riparian corridor is forested, a moderate level of alteration. There are 15 riparian breaks, or 2.6 riparian breaks per mile, a moderate level of alteration to the longitudinal integrity of the riparian corridor. Aside from the riparian breaks, riparian habitat is relatively intact except for the lower reach, which is surrounded by agricultural area where the riparian vegetation has been removed. However, the overall riparian alteration rating is moderate due to the moderate level of alteration indicated by both metrics.

Subbasin Alteration Matrix

A moderate level of watershed alteration has occurred in Subbasin 3 (Table 6-15). The subbasin remains in relatively good condition and provides high quality habitat despite the moderate level of impact in four of the criteria. Development in this subbasin may be reducing the integrity of the subbasin. Further development could have damaging repercussions on habitat conditions.

TABLE 6-15.
SUBBASIN ALTERATION MATRIX FOR SUBBASIN 3

Criteria	Level of Alteration		
	High	Moderate	Low
Effective Impervious Area		5% EIA	
Landscape Alteration		64% of the historical area	
Impact from Culverts and Other Stream Crossings		2.9-stream crossings/mile	
Flow Modification ($Q2_{post}/Q2_{pre}$ ratio)			1.17
Channel Modifications and Floodplain Connectivity			8% of stream length altered
Riparian Alteration		73% forested	

6.4.3 Benthic Biodiversity

King County collected B-IBI data in 1999 and 2000 at Water Quality Sampling Location E949, at the SE Issaquah-Fall City Road Bridge, which crosses Canyon Creek in the headwaters of Subbasin 3. The low values for all of the parameters suggest that Canyon Creek is in poor condition (Table 6-16). These results do not correspond with the other criteria in this investigation, which suggest that Subbasin 3 has only been moderately altered and contains quality habitat. The collected B-IBI data may not be representative of actual conditions because of the influence by the road crossing.

TABLE 6-16.
B-IBI METRIC SCORES FOR CANYON CREEK
AT SE ISSAQUAH FALL CITY ROAD

	1999	2000
Total No. Taxa	2	1
E Richness	3	1
P Richness	3	1
T Richness	3	1
% Dominance	1	5
Site Score	12	20

Note: Scores from 1999 are based on the 5-metric method; scores from 2000 are based on the 10-metric method

6.4.4 Summary

Field Assessment

The field assessment was conducted on Canyon Creek at the Issaquah-Fall City Road crossing and on the right bank tributary to Canyon Creek that flows adjacent to Issaquah-Fall City Road near the confluence of the tributary and Canyon Creek.

In this reach of Canyon Creek, all of the habitat criteria examined were in good condition. The riparian habitat was dominated by deciduous and coniferous forest, the substrate was dominated by gravels with low embeddedness, banks were stable, pools were abundant, the channel was sinuous, and LWD was abundant.

Fish passage in the right bank tributary to Canyon Creek at this location was in poor condition due to a perched culvert on SE 41st Street that blocks fish passage. The reach adjacent to Issaquah-Fall City Road has been significantly altered. The riparian habitat is severely encroached on by the road, but is in fair condition since there is a moderate level of LWD recruitment to the stream in this reach. The substrate was in good condition, as it was dominated by gravels with low embeddedness. Stream banks were in poor condition due to erosive and non-vegetated banks in the channelized reach along the road. The stream pattern/bedform was in poor condition due to a high level of confinement by the road, which has straightened and steepened the channel and reduced the size and availability of the floodplain. LWD abundance is poor and may be contributing to the poor pool frequency. Although this reach is degraded, the stream is in good condition and resembles Canyon Creek downstream of Issaquah-Fall City Road.

Habitat Value

The Canyon Creek subbasin is a highly complex and valuable watershed with abundant tributaries with high habitat complexity. This subbasin provides essential spawning and rearing habitat to the Patterson Creek Basin, and is one of the most significant salmonid producing streams in the Snoqualmie River Basin (King County SWM 1993). .

Rating

The results of the habitat assessment indicate that a moderate level of watershed alteration has occurred from agricultural and/or residential uses, but Subbasin 3 remains in fair condition. The riparian vegetation has been removed or heavily encroached on in the lower reaches of the lower watershed and may be impacting in-stream conditions in this reach. The upper watershed has been impacted by residential development.

State of the Subbasin

Further development in Subbasin 3 poses a threat to its habitat conditions. The subbasin alteration matrix indicates that the riparian habitat, fish access (impact from culverts), and the landscape have been moderately altered. Results from this analysis are similar to those in the King County SWM report (1993) indicating that development in the upper watershed has altered the hydrology and negatively impacted the stream channel. Habitat projects in this subbasin should focus on preserving the existing conditions and reducing the level of

impact on these habitat parameters. Projects should include working with private landowners to improve the riparian habitat on their property, replacing problem culverts, and maintaining the natural hydrology. It is also important to verify that none of the culverts are barriers or are failing. Canyon Creek would also benefit from improvement of the riparian condition and increased LWD in the lower agricultural reaches.

6.5 SUBBASIN 4 STREAM HABITAT CLASSIFICATION RESULTS

6.5.1 General Characteristics

Subbasin 4 includes Tributary 0377, a right bank tributary to Patterson Creek at RM 1.2, and Tributaries 0378 and 0379, which are tributaries to 0377 and drain the northeast slopes of Mitchell Hill. Table 6-17 lists the length of each of these streams. Subbasin 4 is the second largest of the five subbasins in terms of stream miles, with 10.8 miles of stream. The upper stream channels are in good condition with abundant cover and LWD, but the lower reaches pass through livestock pastures and have been degraded, similarly to other floodplain channel type reaches in the Patterson Creek Basin (King County SWM 1993). The streams in Subbasin 4 are primarily moderate gradient, mixed control and moderate gradient contained channel types (see Figure 6-1 and Table 6-18).

TABLE 6-17.
STREAM LENGTHS IN SUBBASIN 4

Stream/Tributary	Stream Length
Tributary 0377	21,100
Tributary 0378	28,330
Tributary 0379	7,810

TABLE 6-18.
CHANNEL TYPES IN SUBBASIN 4 BY LENGTH

Stream/Tributary	Length (feet)
Alluvial Fan	0
Floodplain	881
High Gradient Contained	0
Moderate Gradient Contained	33,157
Moderate Gradient Mixed Control	22,129
Palustrine	5,004

6.5.2 Subbasin Alteration

Effective Impervious Area

Subbasin 4 is 2,908 acres in size and has 49 acres of impervious area, yielding a 2-percent EIA. This low level of alteration probably has a minimal impact on the hydrologic regime of the stream in this subbasin.

Landscape Alteration

Under predeveloped conditions Subbasin 4 had 2,754 acres of forested land cover. Under existing conditions, 1,411 acres of forested land cover remains, 51 percent of the historical area. This represents a high level of landscape alteration.

Impact from Culverts and Other Crossings

In the 10.8 miles of stream, there are 26 stream crossings, or 2.4 stream crossings per mile. Six culverts are known barriers to fish passage (three on Tributary 0377 and three on Tributary 0379), which significantly impairs the production of salmonids in the subbasin (Haring 2002). The locations of these barriers are shown in Figure 6-2. These barriers prevent access to 30,600 feet of stream. The six barriers result in a high level of impact on the subbasin.

Flow Modification

In Subbasin 4, the Q2post/Q2pre ratio of 0.95 (see Table 6-19) suggests that the 2-year flow has actually decreased. However, as Chapter 3 explains, this is likely due to lack of precision in the model and the inability of the model to detect the small changes in EIA in the subbasin.

TABLE 6-19.
PRE-DEVELOPED AND POST-DEVELOPED 2-YEAR AND RATIO; RCHRES SEGMENT 400 IN SUBBASIN 4

$Q2_{pre}$	213 cfs
$Q2_{post}$	203 cfs
$Q2_{post}/Q2_{pre}$ ratio	0.95

Channel Modifications and Floodplain Connectivity

In Subbasin 4, the stream channel has not been significantly altered, with the exception of a quarter-mile reach (2 percent of the total stream length) upstream from the confluence with Patterson Creek and the frequent road crossings. Areas where floodplain connectivity has been altered only occur in the same areas as the channel alterations. Therefore, the alteration to stream channel and floodplain connectivity was rated as low.

Riparian Alterations

In Subbasin 4, 62 percent (357 of the 570 acres) of the riparian corridor is forested, a moderate level of alteration. There are 58 riparian breaks, or 5.4 riparian breaks per mile, which is a high level of alteration to the longitudinal integrity of the riparian corridor. The overall riparian alteration rating is high due to the high level of riparian breaks. This rating is reflective of the frequent narrowing or complete removal of the significant lengths of the riparian corridor in Subbasin 4.

Subbasin Alteration Matrix

The subbasin alteration matrix (Table 6-20) indicates a high level of alteration to Subbasin 4. Habitat conditions are significantly impaired by landscape alteration, impacts from culverts, and riparian alteration. These impairments are caused by the abundant road crossings and the agricultural/grazing practices in the subbasin. Habitat improvement actions in the subbasin should be focused on implementing agricultural best management practices (BMPs), removing or replacing culverts, and revegetating riparian corridors with native plants.

TABLE 6-20.
SUBBASIN ALTERATION MATRIX FOR SUBBASIN 4

Criteria	Level of Alteration		
	High	Moderate	Low
Effective Impervious Area			2% EIA
Landscape Alteration	51% of the historical area		
Impact from Culverts and Other Stream Crossings	6 passage barriers		
Flow Modification ($Q2_{post}/Q2_{pre}$ ratio)			0.95
Channel Modifications and Floodplain Connectivity			2% of the stream length modified
Riparian Alteration	62% forested 5.4 breaks/mile		

6.5.3 Benthic Biodiversity

No B-IBI data exist for Subbasin 4.

6.5.4 Summary

Field Assessment

Habitat conditions in Subbasin 4 were assessed at four locations: the Redmond-Fall City Road crossing of Tributary 0377; the right bank tributary to Tributary 0377 that crosses SE 48th Street near 319th Place SE; Tributary 0378 at SE 40th Street; and Tributary 0377 at SE 40th Street.

Fish passage in Tributary 0377 at Redmond-Fall City Road was good. In this reach, the riparian habitat is in fair condition with moderate LWD recruitment potential, but a private road on the right bank and downstream of the road encroach heavily on the riparian habitat. No spawning habitat was seen in this reach; the substrate was highly embedded and dominated by sand and fines. Upstream of the road, the stream banks are well vegetated and in good condition, but the limited vegetation along the right bank at the private residence downstream of SE 48th Street reduced the conditions to fair. The channel pattern/bedform is in fair condition since the sinuosity has been maintained. The LWD abundance was fair upstream of the road and poor downstream. Pools are infrequent, likely due to the limited LWD.

The right bank tributary to Tributary 0377 is a Class 2 stream with poor fish passage due to an impassable perched culvert at SE 48th Street. The riparian habitat in this reach is in good condition, maintaining good bank stability. The substrate in the spawning area was dominated by gravels in good condition, with low embeddedness. Pool frequency was fair, as was the channel pattern/bedform, and LWD abundance.

The habitat of Tributary 0378 at SE 40th Street was in fair condition. Fish passage, riparian condition, bank condition, pool frequency, channel pattern/bedform, and LWD were all in good condition. However, the substrate in spawning areas was in poor condition and dominated by sands, which caused a high level of embeddedness. The source of these fine sediments was not evident.

The stream habitat of Tributary 0377 was in fair condition with good fish passage. The riparian habitat provided medium LWD recruitment potential, but was encroached on by a road downstream of SE 40th Street and dominated by Himalayan blackberry. The substrate in spawning areas was dominated by cobbles and gravels and in fair condition, with a fair level of embeddedness. The streambank condition was fair, with stable and well vegetated banks upstream of the SE 40th Street, but poorly vegetated and unstable on the right bank downstream of the road. The stream channel was moderately sinuous and in fair condition, with poor LWD abundance and pool frequency.

Habitat Value

Subbasin 4 is a diverse and high value watershed with a complex network of tributaries that provide both spawning and rearing habitat to the Patterson Creek Basin. The complex network of tributaries in this subbasin provides miles of spawning and rearing habitat.

Rating

The stream habitat in Subbasin 4 is in fair condition and provides suitable spawning and rearing habitat, but has been degraded by rural residential development and agricultural land use. Together, fish passage barriers and riparian degradation significantly impair the stream habitat quality and limit the potential salmonid production of the subbasin.

State of the Subbasin

Subbasin 4 is an important subbasin of the Patterson Creek Basin. It contains 10.8 miles of spawning and rearing habitat. However, the integrity of the habitat has been impaired by

fish passage barriers and degradation of the riparian habitat. These impairments are the most significant limiting factors to salmonid production in Subbasin 4 and should be addressed. Improvement of the riparian habitat in degraded areas is necessary for restoration of the stream to a healthy condition. Removal of passage barriers is also necessary so that the entire potential stream habitat area in the subbasin can be used by salmonids.

6.6 SUBBASIN 5 STREAM HABITAT CLASSIFICATION RESULTS

6.6.1 General Characteristics

Subbasin 5 includes Patterson Creek from its confluence with Canyon Creek to the Snoqualmie River (a length of 13,770 feet) as well as Tributary 0381 (with a stream length of 6,600 feet). Subbasin 5 is the fourth largest (total length of stream) of the Patterson Creek subbasins, with approximately 3.8 miles of stream. The stream banks of Patterson Creek in this reach are dominated by agriculture and pastureland, with little or no riparian vegetation (King County SWM 1993). Channelization, deepening, dredging, and livestock trampling have severely degraded the channel and stream banks through this reach. The low abundance of LWD contributes to low habitat complexity and poor channel conditions. Tributary 0381's drainage area remains forested, but fish passage barriers limit the use of habitat (Haring 2002).

In Subbasin 5, the mainstem Patterson Creek is a floodplain channel type, and Tributary 0381 is a moderate gradient, mixed control channel type (see Figure 6-1 and Table 6-21).

TABLE 6-21.
CHANNEL TYPES IN SUBBASIN 2 BY LENGTH

Stream/Tributary	Length (feet)
Alluvial Fan	0
Floodplain	15,908
High Gradient Contained	0
Moderate Gradient Contained	1,868
Moderate Gradient Mixed Control	2,539
Palustrine	0

6.6.2 Subbasin Alteration

Effective Impervious Area

Subbasin 5 is 1,253 acres in size and has 25 acres of impervious area, yielding a 2-percent EIA, a low level of alteration.

Landscape Alteration

Under predeveloped conditions, Subbasin 5 had 1,205 acres of forested land cover. Under existing conditions, 425 acres of forested land cover remains, 35 percent of the historical area, a high level of landscape alteration.

Impact from Culverts and Other Crossings

In the 3.8 miles of stream, there are six stream crossings, or 1.5 stream crossings per mile. Two culverts on Tributary 0381 are barriers to fish migration (Haring 2002), preventing access to 3,600 feet of potential habitat. Due to the passage barriers on Tributary 0381, a high level of impact from stream crossings has occurred in Subbasin 5.

Flow Modification

The Q2post/Q2pre ratio ranges from 1.03 to 1.17 for RCHRES segments 500, 510 and 300 (Table 6-22), a low level of flow modification.

TABLE 6-22.
PRE-DEVELOPED AND POST-DEVELOPED 2-YEAR AND RATIO; RCHRES SEGMENTS 500, 510 AND 300 IN SUBBASIN 5

	RCHRES 500	RCHRES 510	RCHRES 300
$Q2_{pre}$	321 cfs	498 cfs	269 cfs
$Q2_{post}$	349 cfs	515 cfs	314 cfs
$Q2_{post}/Q2_{pre}$ ratio	1.09	1.03	1.17

Channel Alterations and Floodplain Connectivity

In Subbasin 5, the entire 2.6 miles of the mainstem of Patterson Creek flow through pastures and other agricultural lands where the stream has been channelized and deepened. Many of the stream banks have been trampled by livestock and have collapsed. Deepening and channelization of the stream has significantly reduced the floodplain connectivity of Patterson Creek from the confluence with the Snoqualmie River to SR 202 (Haring 2002). From SR 202 upstream to Canyon Creek, floodplain connectivity is more natural. Tributary 0381 has received little alteration with the exception of two culverts limiting fish passage. The 2.6 miles of altered stream channel in this subbasin make up 68 percent of the total length of stream, a high level of alteration.

Riparian Alterations

In Subbasin 5, 77 percent (89 of the 115 acres) of the riparian corridor is forested, a high level of alteration. There are only five riparian breaks in the subbasin, but this number is misleading since most of the breaks are extensive tracts where the riparian vegetation has been completely or nearly completely removed. Reed canary grass and Himalayan blackberry dominate the stream banks in these areas. The riparian habitat along Tributary 0381 is in good condition except for two short (approximately 400 feet long) areas

where it is impaired. However, the overall riparian alteration rating is high due to the extremely low amount of forested land cover in the riparian corridor for the entire subbasin.

Subbasin Alteration Matrix

Landscape alteration, fish passage, channel modifications, floodplain connectivity, and riparian alteration were rated at a high level of alteration in Subbasin 5 (see Table 6-23). This reach of Patterson Creek is extremely degraded, especially downstream of SR 202. The impairments identified in the subbasin alteration matrix significantly degrade the integrity and function of Subbasin 5.

TABLE 6-23.
SUBBASIN ALTERATION MATRIX FOR SUBBASIN 5

Criteria	Level of Alteration		
	High	Moderate	Low
Effective Impervious Area			2% EIA
Landscape Alteration	35% of the historical area		
Impact from Culverts and Other Stream Crossings	2 passage barriers		
Flow Modification ($Q2_{post}/Q2_{pre}$ ratio)			1.03 - 1.17
Channel Modifications and Floodplain Connectivity	68% of stream length modified		
Riparian Alteration	27% forested		

6.6.3 Benthic Biodiversity

No B-IBI data exist for Subbasin 5.

6.6.4 Summary

Field Assessment

The field assessment of Subbasin 5 was performed on Patterson Creek at SE 24th Street and on Tributary 0381 at SE 40th Street.

All of the habitat criteria were in poor condition on Patterson Creek at SE 24th Street except fish passage, which was good. The riparian forest has been removed from much of the reach and is dominated by Himalayan blackberry; the substrate was dominated by sand and fines, and was heavily embedded; and the stream banks were eroding in much of the reach. The channel had been severely channelized and lacked LWD and pools.

Tributary 0381 at SE 40th Street was moderately impacted and had fair fish passage due to an improperly functioning culvert that was half-filled with sediment. The riparian habitat was in fair condition; upstream of the road it was dominated by coniferous forest, but downstream of the road the vegetation had been removed from a section of the stream. The

substrate in spawning areas was fair, and primarily made up of gravel. However, a fair level of embeddedness occurred in the spawning areas. Stream banks were in good condition upstream of the road, but may be impaired downstream due to the lack of vegetation at the private residence. No pools were observed. The channel pattern/bedform was in fair condition with moderate sinuosity. LWD abundance was fair upstream of SE 40th Street, but poor downstream of the road.

Habitat Value

Subbasin 5 is a moderate value subbasin with limited juvenile rearing habitat in the Patterson Creek mainstem, and spawning habitat in Tributary 0381. In this subbasin, Patterson Creek primarily provides access between the Patterson Creek Basin and the Snoqualmie River. In pristine conditions, this reach would provide substantial rearing habitat, and potentially spawning habitat. However, since the reach has been significantly degraded, the contribution of this reach to salmonid production in the Patterson Creek has been reduced. Improvement of the habitat conditions should increase the value of the subbasin to the Patterson Creek fishery.

Rating

The Patterson Creek mainstem in Subbasin 5 is highly degraded and provides limited salmonid habitat. This reach has been channelized and has little structure, habitat diversity, or cover, and a poor riparian habitat. These impairments limit salmonid production within this reach. Tributary 0381 is in fair condition since it has been moderately impacted by land use, but it still provides a moderate amount of spawning and rearing habitat to the Patterson Creek Basin.

State of the Subbasin

The Patterson Creek mainstem in Subbasin 5 is heavily degraded and would benefit from improvement of the riparian habitat and increased LWD abundance. These improvements would increase stream channel and habitat complexity and enhance the quantity and quality of juvenile salmonid habitat in the reach. Projects in this subbasin should be directed toward restoring natural stream and floodplain function. Tributary 0381 contains over a mile of habitat, of which a large portion is in good condition although inaccessible due to a passage barrier. Removal of this barrier should be a priority action for this subbasin and would quickly increase the amount of habitat accessible to salmonids.

6.7 BASIN SUMMARY

The Patterson Creek Basin is complex and contributes significantly to the Snoqualmie Basin fishery. However, rural residential, grazing, and agricultural land use practices have significantly altered the integrity of the basin, resulting in aquatic habitat degradation. In particular, the integrity of the riparian habitat is a significant impairment to overall habitat quality. Since the riparian habitat is an essential component of a healthy stream (Naiman et al. 2000), it is reasonable to suggest that the poor riparian habitat conditions consistently found in the Patterson Creek Basin are a significant habitat limiting factor. Although much of the basin has been degraded, areas of suitable habitat remain. However, passage barriers at road crossings limit access to some of these areas, substantially

reducing the amount of available habitat in the basin. The stream channel in the Patterson Creek floodplain has been significantly altered, but it remains a functioning element of the system and provides key juvenile habitat to the basin. The valuable habitat reaches and degraded areas are shown in Figure 6-3.

6.8 RECOMMENDATIONS

Since the WRIA 7 Limiting Factors Assessment report (Haring 2002) was the best available habitat information for the Patterson Creek Basin, the recommended habitat improvement actions identified by this analysis parallel those in the report. The following habitat restoration actions are recommended to restore and enhance fisheries and aquatic habitats in the basin.

- **Fish Passage Barriers**—Improving fish passage conditions in the basin is critical to restoring fisheries habitat and making the available salmon spawning habitat in the basin accessible. The WRIA 7 Limiting Factors Assessment report (Haring 2002) indicated that 22 of 38 culverts in the basin are impassable. Replacing these culverts would increase the accessibility of spawning habitat in the watershed and broaden salmonid distribution in the basin. Known high priority barriers that should be removed include the following:
  - The NE 52nd Place culvert on Patterson Creek is a barrier to fish passage and blocks approximately a mile of spawning and rearing habitat.
  - The NE 67th Place culvert is undersized and partially filled with debris. This culvert should be replaced to maintain both upstream and downstream fish access.
  - In the Dry Creek basin, the culverts at NE 40th Street and NE 45th Street are fish passage barriers and block a quarter-mile of stream habitat.
  - A perched culvert at 31728 SE Issaquah-Fall City Road blocks fish access to over a mile of spawning and rearing habitat.
  - Tributary 0381 barriers identified in the WRIA 7 Limiting Factors Assessment report block three-quarters of a mile of potential habitat.
- **Riparian Habitat Restoration**—Improving the riparian habitat of the Patterson Creek Basin would directly improve the salmonid habitat by providing cover, streambank stability, stream temperature control, production of fish prey (terrestrial insects), and long-term LWD recruitment. Since riparian habitat impairment is widespread in the basin, the following restoration activities should be implemented where applicable:
  - Reed canary grass and blackberry removal and revegetation with native plants
  - Riparian plantings with native trees and shrubs

– Working with landowners to implement agricultural BMPs, including restricting livestock access to stream channels, wetlands, and riparian areas.

These actions are most applicable in Subbasins 2 and 5, where long expanses of riparian habitat have been removed. Implementing agricultural/grazing BMPs would also benefit Subbasin 4.

- **Protection and Restoration of Natural Hydrology**—The findings of this report indicate that maintaining forest cover and limiting effective impervious surface are of crucial importance for maintaining healthy stream systems and maintaining groundwater recharge. These can be protected to a limited extent through acquisition projects but in order to protect this basin, a regulatory strategy can be far more effective. The county is currently refining a comprehensive code revision proposal (the Draft Critical Areas Ordinance) that would limit clearing and effective impervious cover on rural-zoned properties. The proposed code revision would limit clearing to 35% of the parcel area on larger rural-zoned parcels and would limit the effective impervious area to 10%. Enactment of this code would provide a large measure of protection to Patterson Creek aquatic resources.

- **Habitat Preservation and Acquisition**—The Patterson Creek Basin is a complex basin with a diversity of habitats that are essential for salmonid spawning and rearing that vary from good to poor condition. Due to the continual threat of development, property acquisition may be necessary to protect areas of existing quality habitat and improve degraded reaches. The following are high priority acquisition areas:

  – Canyon Creek Subbasin—The Canyon Creek subbasin has some of the highest quality habitat in the Patterson Creek Basin, principally due to the large portion of the upper watershed that is publicly owned or protected by conservation easements. Further acquisition of land in this subbasin would ensure that the integrity of the Canyon Creek subbasin is maintained.

  – Dry Creek Subbasin—The upper reaches of Dry Creek contain important spawning habitats. Portions of this watershed have already been protected by conservation easements; further acquisition or development of conservation easements would ensure preservation of the habitat along this reach.

  – Upper Patterson Creek Subbasin—Subbasin 1 of the Patterson Creek Basin contains valuable spawning and rearing habitat. Portions of this reach are already protected by conservation easements; further acquisition or development of conservation easements would ensure the preservation of these habitats.

  – Tributary 0383—Tributary 0383 contains approximately 1.5 miles of spawning and rearing habitat. Most of this watershed is still forested and in good condition. Since this reach provides valuable habitat, it is a high priority area for acquisition or development of conservation easements to protect the integrity of the watershed.

  - Stevlingson Property—The Stevlingson property is directly upstream of SR 202 in Subbasin 1. The reach of Patterson Creek on this property is a transition area from moderate-gradient, confined stream channel to floodplain channel. Because of the change in gradient, the stream deposits large quantities of gravel, which creates high quality spawning habitat. Habitat conditions in this reach have been significantly degraded. Acquisition of this reach to limit the increase in EIA and reduction of forest cover could be the first step to recovery of its habitat. Further habitat improvement projects could transpire after acquisition of the land to expedite the recovery process.

- **Addition of LWD**—LWD is an important component of fish habitat and stream function (Reeves et al. 1991). Much of the Patterson Creek Basin is deficient in or void of LWD. Therefore, LWD should be added to Patterson Creek and its tributaries where appropriate and feasible (private land ownership will limit where this activity may occur). The addition of LWD will provide rearing and refuge habitat for juvenile salmonids while the newly planted riparian vegetation grows to a sufficient age to allow natural recruitment of LWD into Patterson Creek and its tributaries.
- **Dry Creek Nick Point Erosion**—Dry Creek has been severely confined where it flows adjacent to Ames Lake Road. Alteration of stream hydraulics and steep, poorly vegetated, and unstable stream banks have caused nick-point erosion on both banks in this reach. Stabilization of this stream channel is necessary to prevent further erosion of this reach and transport of fine sediments to downstream habitats.
- **Canyon Creek Right Bank Tributary at Issaquah-Fall City Road**—The right bank tributary to Canyon Creek at Issaquah-Fall City Road has been degraded and channelized to the extent of being restricted to a roadside ditch. Stream banks in much of this reach are unstable and eroding. The eroded materials are transported downstream and may have negatively affected substrate conditions in Canyon Creek. Restoration of this reach should include realignment or reconstruction of the stream channel, riparian plantings, and placement of LWD.