2.4 RIPARIAN CONDITION

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EXECUTIVE SUMMARY

This chapter assesses the current condition of important riparian functions along the mainstem Green/Duwamish River, including:

- Bank stabilization;
- Supply of organic matter and nutrients;
- Shade;
- Large woody debris recruitment;
- Filtration of sediment;
- Channel migration zones; and
- Microclimate.

Current riparian condition was assessed based on vegetation type, size, and density, generally corresponding with the methodologies recommended by the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) and the Washington Forest Practices Board Manual (WFPB 1997). Existing data were utilized where possible. In areas where no existing riparian data were located, an original assessment was conducted specifically for this report. Criteria used to evaluate each individual riparian function for this report were developed from a number of recent, comprehensive reviews of riparian function (Wenger 1999; Knutsen and Naef 1997; FEMAT 1993; Castelle et al. 1994; Johnson and Rhyba 1992). In addition, the length of river with an "intact" riparian zone and the length of channel bordered by vegetation similar to the potential natural community was estimated. For the purposes of this report, an "intact" riparian zone was defined as a horizontal segment of the 300-foot wide analysis area extending from each bank that contained no roads, houses or buildings, yards, grass, or agricultural fields, regardless of vegetation type.

UPPER GREEN RIVER SUB-WATERSHED (RM 64.5 TO RM 93)

Currently, riparian stands along the mainstem Green River within the Upper Green River sub-watershed are composed primarily of small to medium-sized deciduous or mixed deciduous and coniferous stands. Pure stands of coniferous trees account for only 0.2 miles (<1 percent) of the total 39.5 miles of riparian habitat between RM 64.5 and 84.2. Overall, 67 percent (26.5 miles) of the riparian zone is intact and supports vegetation similar to the potential natural community. The remainder is composed of cleared fields or bare ground and emergent wetlands formed due to seasonal inundation of the mainstem Green River and its floodplain by the Howard Hanson Reservoir. Because of the relatively small size of the trees and the amount of riparian zone that is less than 300 feet wide or has been converted to other habitat types, cumulatively riparian zones along the mainstem Green River in the Upper Green River Sub-watershed is considered to be functioning at risk according to the NMFS criteria. Changes in channel morphology and the sediment transport regime that are not explicitly considered by the riparian assessment approach utilized for this report may further impair existing riparian functions in the Upper Green River sub-watershed.

MIDDLE GREEN RIVER SUB-WATERSHED (RM 32 TO RM 64.5)

Riparian conditions in the Middle Green River sub-watershed vary in direct relation to the channel types described in Chapter 2.3, (Hydromodification). The riparian zone within the reach between HHD and Tacoma's Headworks (RM 61 to RM 64.5) is forested but frequently truncated by roads or railroads, as the narrow valley bottom historically provided the easiest access route to the upper sub-watershed. The unconfined Floodplain channel segment between RM 58 and RM 61 is also forested, but the vegetation stands immediately adjacent to the channel are composed primarily of small deciduous trees that became established on formerly active bar surfaces and channel margins following initiation of flood control at HHD in 1964. Most of the riparian zone associated with the Large Contained channel type known as the Green River gorge (RM 45 to RM 57) is intact and composed of large, mixed coniferous and deciduous trees. Agricultural development and flood control structures (levees and revetments) have altered the riparian community somewhat in the wide valley associated with the Floodplain channel type between RM 32 and RM 45. However, riverside parks (including Metzler-O'Grady Park RM 38.5 to RM 40; and Flaming Geyser Park RM 43 to RM 45) and steep bluffs the river impinges on in several locations still support largely intact stands of small to medium sized deciduous trees and mixed coniferous and deciduous forest.

Cumulatively, approximately 84 percent of the riparian zone along the mainstem Green River in the Middle Green River sub-watershed still supports stands of native deciduous or coniferous forest. However, only 53 percent of the Middle Green River has an intact riparian zone at least 300 feet wide. According to the NMFS criteria for riparian function, with the exception of the Green River gorge, riparian zones in the Middle Green River sub-watershed are currently not functioning properly because most are too narrow or support non-native vegetation (bare ground, grass, shrubs or development).

LOWER GREEN RIVER SUB-WATERSHED (RM 11 TO RM 32)

Cumulatively, there is less than one mile of intact riparian zone comprised of medium to large mixed deciduous and coniferous trees along the lower mainstem Green River. Approximately 18 percent (12.4 miles) of the riparian zone in the Lower Green River sub-watershed supports native deciduous trees. However, in most cases, deciduous stands are narrow (<100 feet) or comprised of small, sparse trees mixed with patches of grass, pavement, or bare ground. Almost 50 percent of the riparian zone is comprised of forbs and grass, or shrubs, many of which are non-native. Pavement and bare ground account for approximately33 percent of the total area within 300 feet of the river in this sub-watershed. None of the mainstem riparian habitat in the Lower Green River sub-watershed is in good condition or is considered to be functioning properly based on the NMFS criteria.

GREEN/DUWAMISH ESTUARY SUB-WATERSHED (RM 0 TO RM 11)

Areas of riparian vegetation are limited in extent in the Green/Duwamish Estuary and Elliott Bay and are composed primarily of deciduous trees and non-native shrubs, such as blackberries. Stands of riparian vegetation are found in only three areas in the estuary and bay: between RM 5.3 and 11.0 on the upper estuary, on and near Kellogg Island on the lower estuary, and along Magnolia Bluff on Elliott Bay. These areas represent a relatively small percentage of the total shoreline of the estuary and bay. Between 0 and 7.4 percent of the estuary and bay shorelines support riparian stands that provide some riparian functions (shade, organic matter recruitment, sediment filtration, large woody debris [LWD] recruitment). (Note that categorizations of riparian functions in the estuary and nearshore as good, fair, or poor are based on criteria provided in Table RIP-3 for the upper subbasins; these criteria may not be fully relevant in the estuary and nearshore, as discussed below.) Similar percentages of existing riparian stands are expected to provide fair riparian function. However, up to 35 percent of shorelines in the upper estuary have narrow vegetated zones that provide fair riparian function. The remaining areas of the estuary and bay are dominated by overwater structures, seawalls, and riprap that are sparsely vegetated with grasses or shrubbery and consequently provide poor riparian function.

MAJOR TRIBUTARIES (SOOS AND NEWAUKUM CREEKS)

Little mature native vegetation remains in the riparian zone along mainstem Soos Creek. There is still an intact riparian zone supporting native tree species between RM 1.5 and 2.8, and patches of native deciduous trees also occur elsewhere along the lower six miles of the creek. However, these trees are generally small. The remainder of the riparian zone is composed primarily of shrubs or grass. Development and roads limit the riparian zone width in many cases.

The riparian assessment of Newaukum Creek covered only the areas downstream of RM 10. Much of the middle portion of the watershed has been developed for agriculture. Little mature native vegetation remains along the middle reaches of Newaukum Creek. There is an intact riparian zone supporting native trees from RM 3 to the confluence with the Green River. None of the riparian zone along Newaukum Creek is currently considered to be good or functioning properly according to the NMFS criteria, primarily because the trees that are present are small or medium sized. However, there is approximately 6.8 miles of habitat that is currently in fair condition, and that will develop into good riparian habitat if allowed to mature. Most of this habitat is located in the canyon between RM 0 and RM 3. There also are stands of dense young deciduous trees between RM 6.7 and 7 and along the left bank from RM 7.5 to RM 8.2 that could develop into good riparian habitat in the future.

KEY FINDINGS

UPPER GREEN

- At least 33 percent of the riparian zone has conditions that would be expected to result in poor bank stability because riparian communities there are currently composed of small trees or shrubs. Watershed analysis channel assessments indicate that bank stability may be further compromised by increased sediment delivery and in-channel storage

- Almost 50 percent of the channel length is currently bordered by a riparian zone that is classified as providing poor shade because riparian communities there are currently composed of small trees or shrubs. None of the riparian zone along the mainstem Green River is sufficient to provide good shade conditions.

- The ability to supply organic matter and filter sediments is rated poor along approximately 35 percent of the channel where roads, railroads, or other land uses extend to within 75 feet of the channel.

- Because streamside trees are currently small to medium size, large woody debris (LWD) recruitment is currently rated poor along almost 50 percent of the river. LWD recruitment is not considered to be good anywhere along the mainstem Green River in the Upper Green River sub-watershed.

- Overall, 67 percent (26.5 miles) of the riparian zone in the Upper sub-watershed is intact and supports vegetation similar to the potential natural community.

- Seasonal inundation by Howard Hanson Dam and the permanent presence of roads and railroads within the riparian zone will prevent recovery of riparian functions along approximately 12 miles of the mainstem Green River (approximately 28 percent of the total length).

MIDDLE GREEN

- Cumulatively, approximately 84 percent of the riparian zone along the mainstem Green River in the Middle Green River sub-watershed still supports stands of native deciduous or coniferous forest. However, only 53 percent of the Middle Green River has an intact riparian zone.

- Riparian conditions within the Middle Green River sub-watershed vary according to channel type and adjacent land use.

- Agriculture or rural residential land uses have cleared riparian communities to within 75 feet of the bank in almost 25 percent of the riparian zone, resulting in conditions that would be expected to result in poor bank stability.

- Due to the small size of existing riparian trees or the truncated width of the riparian zone, almost 30 percent of the channel length in the Middle Green River is currently classified as providing poor shade. Of the 45 miles of riparian zone currently classified as providing fair to good shade, 65 percent is located within the undeveloped Green River gorge. Due to the large size of the mainstem Green River in the Middle Green sub-watershed, shade conditions may never achieve levels classified as good according the criteria utilized for this evaluation.

- The ability to supply organic matter and filter sediments is rated poor along approximately 27 percent of the channel because of small trees or a narrow riparian zone.

- Large woody debris recruitment is currently rated poor along almost 38 percent of the river where the riparian zone is less than 150 feet wide or is dominated by small trees. The 22.6 miles of riparian zone considered to have good LWD recruitment is located almost entirely within the Green River gorge.

- A number of riverside parks (including Metzler-O'Grady Park RM 38.5 to RM 40; and Flaming Geyser Park RM 43 to RM 45) still support largely intact stands of small to medium sized deciduous trees and mixed coniferous and deciduous forest that could develop good riparian function if undisturbed by future landuse activities.

LOWER GREEN

- Levees and revetments have fixed the channel into place and effectively prevent bank erosion even where gradual channel migration would occur naturally, effectively halting an important mechanism of large woody debris recruitment to the lower mainstem Green River.

- There is less than one mile of intact riparian zone comprised of medium to large mixed deciduous and coniferous trees along the lower mainstem Green. Approximately 18 percent (12.4 miles) of the riparian zone in the lower Green River sub-watershed supports native deciduous trees; however in most cases deciduous stands are narrow (<100 feet) or comprised of small, sparse trees mixed with patches of grass, pavement or bare ground.

- Almost 50 percent of the riparian zone is comprised of forbs and grass, or shrubs, many of which are non-native.

- Over 80 percent of the riparian zone is currently considered to provide poor shade, organic matter recruitment, and sediment filtration because native vegetation communities have largely been converted to grass or shrubs and because development often extends to within 75 feet of the channel.

- Ninety seven percent of the riparian zone is considered to have poor LWD recruitment potential and microclimate conditions because native vegetation communities have largely been converted to grass or shrubs, and because development often extends to within 75 feet of the channel. None of the riparian zone along the lower Green River is considered to have good LWD recruitment potential.

- Pavement and bare ground account for approximately 33 percent of the total area within 300 feet of the river in the lower Green River sub-watershed.

GREEN/DUWAMISH ESTUARY

- The majority of the upper intertidal zones in both the estuary and in Elliott Bay are supplanted with riprap, seawalls, and overwater structures.

- The upper estuary between RM 5.3 to RM 11.0 supports the largest proportion of riparian vegetation, although these stands are not wide enough to provide high quality riparian functions.

- Riparian vegetation is sparse in the lower estuary (RM 5.3 to the mouth).

- Functional riparian stands on Elliott Bay are limited to Magnolia Bluff and represent less than 14 percent of the bay shoreline.

- The remaining riparian areas of the lower estuary and bay are dominated by overwater and inwater structures.

MAJOR TRIBUTARIES: SOOS CREEK (RM 0.0 –13.0) AND NEWAUKUM CREEK (RM 0.0-10.0)

- Sections of intact riparian zone that currently support small to medium sized deciduous and mixed conifer and deciduous trees are concentrated in the canyon sections of both Soos and Newaukum Creeks from around RM 0 to RM 3.

- Bank stability, shade, and organic matter recruitment is considered poor along approximately 65 percent to 80 percent of Soos Creek and 53 percent of Newaukum Creek because of development that extends to within 75 feet of the channel or because trees are currently small.

- None of the riparian zone along Soos Creek is currently considered to provide good LWD recruitment because of development that extends to within 75 feet of the channel or because trees are currently small.

- Sixty percent of the riparian zone along Newaukum Creek currently provides poor LWD recruitment. The remaining 40 percent of the riparian zone analyzed currently has fair LWD recruitment and may develop good conditions if left undisturbed.

- Impairment of riparian functions along mainstem Soos Creek occur primarily as a result of industrial (including powerline corridors) or residential development adjacent to the stream.

- Impairment of riparian functions along mainstem Newaukum Creek occur primarily as a result of agricultural or residential development adjacent to the stream.

DATA GAPS

- A field reconnaissance of riparian conditions using a consistent methodology designed for application at the appropriate stream/river scales has not been conducted for most of the watershed.

- Information on riparian conditions between RM 77 and RM 88 in the Upper Green River sub-watershed is based primarily on watershed analyses that considered only riparian conditions within 100 feet on each side of the river.

- Information on riparian conditions between RM 64.5 and RM 77 were derived from USFS GIS layers constructed from LandSat imagery, which is known to have a high rate of inaccuracy.

- None of the remote sensing data utilized for this assessment was validated in the field by the author.

- The current analysis of bank stability is not based on a field data and therefore may be highly inaccurate where site-specific conditions influence this riparian function.

- The analysis of shade conducted for this report does not consider topographic shading.

- Assumptions of riparian functional conditions based on tree size were developed for use in smaller rivers and may not accurately reflect conditions relative to the mainstem Green River.

- Knowledge of the functions of riparian vegetation in the estuary and nearshore areas is limited and largely extrapolated from information on riparian functions along streams in upper watersheds, lowland streams, and studies of marine riparian vegetation functions in marine and estuarine environments elsewhere.

INTRODUCTION

Riparian ecosystems are complex assemblages of organisms and their environment existing adjacent to and near water (Lowrance et al.1985). Along riverine systems, riparian zones connect mountainous headwater streams with lowland floodplains and estuaries, providing avenues for the transfer of water, sediment, wood and organic matter, nutrients, and aquatic organisms. Riparian zones are corridors of disturbance, occupying a complex mosaic of landforms that support biological communities that are often more heterogeneous and diverse than upslope landscapes (Agee 1988; Gregory et al. 1991). In pristine mountainous environments, natural disturbance of riparian zones along small, steep headwater channels is most often the result of landslides and debris flows that occur on an infrequent basis. Streams that have not experienced a recent mass-wasting event frequently support forest vegetation communities similar to those of the surrounding uplands, while recently impacted channels are initially recolonized with fast growing early successional species such as red alder (Gecy and Wilson 1990). Moving downstream, the size of the river increases and low gradient alluvial landforms become more prevalent. Along mainstem rivers, riparian disturbance is most often caused by flooding, which erodes banks and creates new landforms through the variable scour and deposition of sediment (Agee 1988). The alluvial landforms formed by the river as a result of a series of disturbances support a variety of even-aged stands composed of species such as red alder, willow, or cottonwood that rapidly colonize disturbed sites. Young forests established following disturbances often exist within a matrix of older forests composed of later successional species such as western redcedar, Sitka spruce, and western hemlock that persist on landforms not affected by recent floods (Abbe and Montgomery 1996; Bayley 1995).

Riparian zones perform many functions that are essential to the survival and productivity of salmonids and other aquatic organisms. The effects of riparian vegetation on streams decrease with increasing distance from the stream, and the rate of this decrease varies between the different functions (Figure RIP-1). A number of excellent reviews have been published recently on the subject of riparian function, the influence of land use and management activities on riparian function, and the buffer widths necessary to maintain properly functioning riparian habitats including Wenger 1999; Knutsen and Naef 1997; FEMAT 1993; Castelle et al. 1994; Johnson and Rhyba 1992. The reader is referred to those documents for an in-depth discussion of those topics.

Although extensive research has been done on freshwater riparian functions, very little research has been conducted to identify riparian functions in estuarine or marine systems. Brennan and Culverwell (in prep.) hypothesize that marine riparian zones provide functions similar to those provided by freshwater riparian zones and that marine riparian zones are likely to provide additional functions unique to nearshore systems.

The following text briefly reviews important riparian functions relevant to the Green River and their effects on salmonids, including:

- Bank stabilization;
- Supply of organic matter and nutrients;
- Shade;
- Large woody debris recruitment;
- Filtration of sediment;
- Channel migration zones; and
- Microclimate.

Based on the literature reviews cited above, the width of riparian zone sufficient to maintain each individual function on each bank is identified (Table RIP-1). The widths cited are not intended to be used as a recommendation for required riparian buffer widths but simply to facilitate an evaluation of the current status of individual functions at various locations along the Green River. As noted above, disturbances influence riparian zones even in unmanaged watersheds. Consequently, conditions naturally vary throughout the stream network over both space and time and realistically could never be expected to be in good condition throughout an entire watershed at any given time. The distribution of riparian habitat conditions necessary to provide for fish needs cannot be specified, but restoring or maintaining the distribution, diversity, and complexity of the various disturbance patterns should result in properly functioning riparian ecosystems.

BANK STABILITY

One of the most important functions of riparian vegetation is bank stabilization (bank stabilization for the purposes of this discussion refers only to the active contribution of roots at resisting lateral bank erosion and does not address resistance to channel avulsion, long-term channel migration, or concerns about slope stability). The roots of streamside vegetation bind unconsolidated soil particles together, increasing the bank's resistance to erosive forces. Stream-adjacent riparian vegetation and root systems also increase surface roughness, decreasing flow velocity and dissipating the erosive energy of high flows. In a study of 748 stream bends on rivers located in southern British Columbia, 67 percent of the unvegetated bends experienced erosion during a storm, while only 14 percent of the vegetated bends eroded (Beeson and Doyle 1995). Non-vegetated bends were more than 30 times as likely to suffer exceptionally severe erosion as fully vegetated bends (Beeson and Doyle 1995). Erosion of channel bends is a natural process and occurs whether mature riparian vegetation is present or not. However, mature trees with intact root masses slow the rate of erosion. They protect the bank from further erosion or serve as a source of large woody debris when they are undercut and topple into the river.

The extent of the root system of an individual tree is roughly equivalent to its crown diameter. Consequently, trees located more than ½ crown diameter from the channel exert little influence on bank stability (Burroughs and Thomas 1977). The average maximum crown diameter for deciduous species commonly found along the Green River, including red alder, bigleaf maple and cottonwood, is 88 feet; maximum crown diameters for coniferous species are somewhat smaller, averaging 68 feet for western redcedar, western hemlock, Douglas-fir, and Sitka spruce (Thomas 1999). Thus, riparian zones with a horizontal width of at least 44 feet wide should be sufficient to provide effective bank stability (Table RIP-1). Small trees and shrubs presumably have shallower, smaller root systems. Small trees or shrubs may provide adequate bank stability in small streams. In the case of the mainstem Green River, it is assumed that medium to large trees are required for optimum bank stabilization.

Channel bank vegetation, including roots, sod, and leaf mats is less effective in controlling the rate of bank erosion and channel migration in estuaries than in smaller streams because of the generally greater flow volumes and because of the nature of the underlying soils. In the estuary, stream bank soils consist of sands and silts that have been deposited by river action over the recent geologic history. Such soils are often highly erosive and the root structure of riparian vegetation is easily undermined, especially given the fluctuations in tidal and flow elevations that occur.

In certain situations, however, vegetation can form an effective deterrent to erosion. For example, much of the shoreline of tidal portions of lower river systems is vegetated with marsh plants (rushes, cattails, grasses, shrubs) below ordinary high water (OHW). These plants tend to trap river-born sediments and form near-horizontal benches; the benches, in turn are stabilized by the root mats of the marsh plants. In such areas, the vegetated riparian zone function of bank stabilization is provided by plants that extend well below the OHW line.

The great majority of shoreline in the Duwamish estuary is contained by levees, dikes, or revetments, constructed early in the last century to allow flood plain development and agriculture (see Chapter 2.3, Hydromodification). In these areas, the role of vegetation in bank stabilization has been largely pre-empted by artificial structures. Nonetheless, riparian vegetation, especially emergent marsh and scrub shrub, is important in maintaining the stability of some of these earthen structures.

SHADE

Canopy cover that provides shade is an important factor governing stream heating and cooling. On small streams, shade is one of the most important determinants of water temperature. Both daily and annual fluctuations in water temperature are moderated by the shade of streamside vegetation (Beschta et al. 1987). In forested watersheds, mid-day summer water temperatures rise only 1-2 ^{o}C above year-round average water temperatures (Beschta et al. 1987). In contrast, water in streams where the riparian canopy has been removed may experience temperature increases of 7 to 16 ^{o}C (Beschta et al. 1987). In the winter, riparian vegetation prevents the rapid and excessive cooling of the stream (Knutsen and Naef 1997). In general, stream surfaces should have 60 to 80 percent shade throughout the day to maintain water temperature (Budd et al. 1987). In western Washington, stream temperatures are also strongly influenced by elevation; at elevations above 3,600 feet, environmental conditions are such that streams are not likely to exceed 16^{o}C even if there is no canopy cover (Sullivan et al. 1990).

Studies reviewed by Knutsen and Naef (1997) suggest that buffers 90 feet wide or greater are required to maintain recommended shade levels (Table RIP-1). However, most of the studies reviewed by Knutsen and Naef (1997) relate specifically to small (1st through 3rd order) streams. Wide streams are less likely to be completely shaded by stream-adjacent vegetation even with intact native riparian communities (WFPB 1997). Given a solar angle of 60 degrees (typical for western Washington in June through August), the height of vegetation required to provide shade to the middle of the stream nearly equals the stream width (Figure RIP-2). Thus, a stand of 150 foot tall mature Douglas-fir would shade a 173 foot wide stream. In addition, both the direction of flow and topography can also influence shade. Steep sideslopes or canyon walls can provide significant amounts of topographic shade.

As noted above, potential direct influence of shading on air and water temperatures over and in larger order streams is limited. Even with a densely forested riparian zone of one potential tree height in width, shading will only cover the margins of the stream during mid-day hours when insolation is greatest. Greater water depths only allow a small fraction of the water column to be influenced by solar heating or shading. Tidal circulation and mixing of marine waters with stream flow in the lower estuary and nearshore areas further limits the influence of shading on water temperatures. The influence of riparian zone shading is also limited during low water periods when water volumes are at a minimum; under these conditions shading may only fall on exposed mudflats, not on the water surface.

Shading remains an important factor in moderating temperatures in certain cut-off sloughs and small tributaries to the larger tidal waters; juvenile salmonids may venture into these areas during their estuarine residence. Smaller distributary channels, such as the area behind Kellogg Island, may carry such a low flow volume that some influence of shading might be measured in water temperature.

In nearshore areas of Puget Sound, shading of the upper intertidal beach plays a critical role in limiting the upward distribution of intertidal plants and animals (e.g., Foster et al. 1986). Typically the upper elevation at which intertidal biota can live is dictated by the degree of desiccation experienced during low tides. Rate of desiccation is clearly reduced on shorelines with a forested riparian zone; the influence of shading is dependent on the orientation of the shoreline with maximum shade on beaches with northern exposure. Shading is especially important in the nearshore in areas of surf smelt or sand lance spawning. These species spawn in the upper intertidal zone of sandy or sand and gravel beaches. In some areas of Puget Sound, surf smelt spawning occurs year round and Pentilla (D. Pentilla, WDFW, personal communications, 2000) reports that this spawning behavior occurs primarily on well-shaded beaches. In otherwise suitable spawning areas that lack shade, spawning only occurs during the fall through spring months and egg survival may be reduced. Pentilla has also shown that surf smelt egg survival from summer spawning is higher on shaded versus unshaded beaches.

ORGANIC MATTER AND TERRESTRIAL INVERTEBRATE RECRUITMENT

Riparian zones are the dominant contributors to the aquatic food chain, particularly in smaller streams (Vannote et al. 1980). Leaves, wood, insects, and other materials fall into the stream from overhanging vegetation. Some species (e.g., aquatic invertebrates, whitefish) feed directly on vegetative detritus; these species in turn serve as a food source for anadromous and resident salmonids. The distance away from the stream from which organic matter and terrestrial inputs originates depends on site-specific conditions, but it generally declines at a distance equal to about one-half tree height (FEMAT 1993). This distance will range from 50 to 75 feet depending on the potential height of native vegetation and the slope of land adjacent to the channel (Table RIP-1). Because they are shorter, small trees or shrubs are assumed to provide less organic matter and terrestrial insect inputs than medium to large size trees.

In larger streams, the cumulative material transported downstream from upstream reaches becomes a more important source of organic matter than that produced locally. In addition, in reaches with extensive floodplains, large amounts of organic matter are recruited to the channel by overland flows during floods. Finally, salmonids themselves were historically an important source of nutrients to both riverine and riparian ecosystems. Carcasses deposited on the floodplain during overbank flows or caught on large woody debris in the channel provide nutrients that benefit many different species, ranging from salmonids and other aquatic fishes, to bears, to riparian vegetation itself (WDFW 2000).

Riparian vegetation along estuarine channels and in marshes plays well-recognized roles in production of organic litter for local detritus based food webs and for export to other ecosystems (e.g., Simenstad and Thom 1996) and production of insect prey for local consumption by juvenile salmonids (e.g., Simenstad and Cordell 2000). Marsh vegetation (below Ordinary High Water) in broad brackish and salt marshes and in linear marsh fringes along tidal channels can provide much of the organic litter and invertebrate prey production functions that riparian vegetation above OHW does along freshwater streams and rivers. Where it occurs, marsh vegetation is likely to be more important in the production of prey for juvenile salmonids than scrub-shrub or forest vegetation that may border the marsh above OHW; the marsh vegetation is simply closer to (or in) the water more of the time so that associated insects are more likely to be transported into the water.

SEDIMENT FILTRATION

As noted in earlier chapters, when erosion and sedimentation delivery exceed natural rates, fish and other aquatic biota may be negatively impacted. One of the most important functions of riparian vegetation is to inhibit sediment from entering streams. Intact riparian buffers also keep soil disturbing activities away from streams, preventing erosion and delivery of sediment from exposed soils. Although overland flow is rare in fully forested areas, in developed watersheds, densely-vegetated riparian zones reduce the velocity of overland flow from nearby exposed soils or impervious surfaces, enhancing infiltration of the water and deposition of the sediment. The numerous obstructions and storage sites formed by the roots, stems, and abundant litter associated with intact riparian zones trap and retain sediment before it is delivered to the stream channel. Riparian vegetation also is important for trapping sediment transported downstream by overbank flows during large floods. That latter function was not assessed for this report.

Numerous studies have documented the effectiveness of vegetated buffers at trapping sediment transported by surface runoff. According to Knutsen and Naef (1997), the results of eight separate studies conducted in forested areas suggest that buffer widths effective at controlling fine sediment range from 26 to 300 feet (Table RIP-1). Wenger (1999) reports that studies from agricultural and urban landscapes indicate grass buffers as narrow as 15 feet wide can reduce total suspended sediment loads by over 80 percent. Based on the studies Wenger (1999) reviewed, buffer widths of 82 feet are the most efficient at removing sediment; beyond that large increases in width resulted in small reductions in sediment. Wenger (1999) further notes, however, that researchers in forested landscapes typically found that buffers at least 98 feet wide were needed to prevent impacts to aquatic habitats. In addition, a number of researchers have noted that for controlling delivery of fine sediment, riparian buffers are especially important along smaller headwater streams that make up the majority of the stream network miles in any watershed (Osborne and Kovavic 1993; Lowrance et al. 1997).

Riparian vegetation along tidal waters is likely to be as effective at trapping finer sediments being carried to the shoreline from upland sources as is riparian vegetation along streams. In estuarine areas with limited circulation (e.g., cut-off sloughs) silt carried to the surface water can increase water turbidity significantly and in such areas the role of riparian vegetation in controlling overland sediment movement is similar to that in freshwater areas.

Storm drains and ephemeral streams can also deliver larger volumes of water from an entire shoreline drainage basin through a point source of flow onto the beach. In these cases, riparian conditions along the course of the stormwater flow from the uplands are important in dictating water quality upon entering the tidal water body. Marsh vegetation (below Ordinary High Water) in broad brackish and salt marshes and in linear marsh fringes along tidal channels provides the same sediment retention function that riparian vegetation above OHW does along freshwater streams and rivers.

LARGE WOODY DEBRIS RECRUITMENT

Large woody debris (LWD) serves many important functions in stream channels. Wood creates pools, captures, sorts and stores sediment, stabilizes the stream bed and banks, provides cover from predators and high flows, and retains nutrients and organic matter. Large logs of decay-resistant coniferous species such as western redcedar, Douglas-fir, and western hemlock are the most valuable because they form features that may persist in the streambed for over 100 years (Franklin et al. 1981). Large deciduous trees such as bigleaf maple or black cottonwood can also serve as key pieces of large woody debris, although they generally decay more rapidly than coniferous logs (Harmon et al. 1986). Large logs with attached rootwads are particularly important as “key pieces” in large rivers (Abbe and Montgomery 1996). For a river 50 to 65 feet wide, a key piece would consist of a log with a total volume of 318 cubic feet (at least 2 feet in diameter and up to 100-feet long) (Schuett-Hames et al. 1999).

Seven studies reviewed by Knutsen and Naef (1997) indicated that most wood is recruited to streams from within 150 feet of the channel (Table RIP-1). In general, smaller wood is stable and functional in smaller streams, while large streams require large logs or accumulations of woody debris (jams) to maintain desired aquatic habitat attributes (Perkins 1999). Riparian vegetation along undisturbed small, mountainous headwater streams is generally composed of species similar to the surrounding uplands (Doughty 1996). Although deciduous trees may colonize channels disturbed by debris flows and rapidly reach the minimum “functional” size, medium to large size coniferous trees are generally required to supply long-lasting LWD and to serve as barriers to the propagation of future debris flows or dam break floods (Coho 1993). Thus, optimum riparian habitat conditions in small mountainous streams are composed of medium to large confers or mixed coniferous and deciduous stands.

In marshes, LWD may play a role in the formation of channels or deeper pockets that retain water during low tide. LWD stranded in marsh areas also provides a substrate for the establishment of vegetation, including marsh plants or even trees (Brennan and Culverwell, in prep.; J. Houghton, Pentec Environmental, pers. obs.). In areas of broad marsh habitat, directly recruited LWD will fall onto upper marsh terraces where it is seldom and incompletely inundated. Unless the marsh is crossed by channels, fish may never have access to the area of the LWD. Relatively smaller sizes of LWD can be retained in lower energy, off-channel estuarine habitats and thus provide the same functions as larger LWD in more active channels. Consequently, relatively young stands of alder and cottonwood can provide functioning LWD in estuaries and nearshore areas. Even if the trees decay in 20 or 30 years, they may be continually replaced with other 20- to 30-year old trees. Mature trees considered for this purpose are those with diameter at breast height (dbh) of > 0.3 m. Trees that recruit directly to the estuary or nearshore from the adjacent riparian zone are assumed to have limbs and rootwads attached, thus adding to their function as refuge, despite a smaller size. Large wood also provides for organic contributions to the estuary and nearshore and thereby supplements the detrital base (Maser and Sedell 1994).

LWD anchored or buried in the beach plays a role in stabilizing beach sediments by limiting shoreline erosion and long-shore sediment transport (Brennan and Culverwell, in prep.). Little LWD is retained along areas with a hardened shoreline (bulkhead or riprap) although occasional logs may lodge in riprap or be deposited at the top of riprapped slopes by high tides.

CHANNEL MIGRATION ZONE

In unconfined streams where the channel migrates back and forth across the floodplain over time, wood may be recruited to the channel from throughout the channel migration zone (CMZ). The channel migration zone is defined as the lateral extent of likely movement along a stream reach with evidence of active channel migration or avulsions over the past 100 years (WFPB 2000). Vegetation in the channel migration zone of large rivers is typically patchy, ranging from young early successional vegetation that colonizes recently active bar surfaces to large old growth coniferous or deciduous trees on stable floodplain terraces (Abbe and Montgomery 1996; Bayley 1995). Although riparian habitat conditions characteristic of large meandering rivers typically consist of multiple stands of varying age and species, large coniferous or deciduous trees are required to provide functional and key sized LWD. Consequently, upstream reaches or stands of older trees located within or immediately adjacent to the CMZ are particularly important sources of wood.

Conditions within the channel migration zone also have the potential to influence the future effectiveness of the various riparian functions described above. For example, a 200 foot wide band of large mixed conifer and deciduous trees may maintain sufficient shading, bank stability, and sediment filtration under current conditions. However, if the channel migrates laterally over time and the remainder of the channel migration zone has been cleared and converted to farm fields, future riparian conditions are likely to deteriorate as the channel moves across the CMZ. Intact native vegetation communities within the channel migration zone are also important for maintaining natural rates of lateral channel migration and the frequency of channel avulsions.

In the Duwamish estuary, the CMZ is limited to the top of the existing hardened shorelines.

MICROCLIMATE

The presence of surface and sub-surface water and abundant vegetation in riparian zones results in a microclimate that is moister and more moderate (cooler in summer and warmer in winter) than the surrounding areas (Knutsen and Naef 1997). These conditions provide an environment that is desirable to many species, particularly amphibians (Knutsen and Naef 1997). Microclimate is believed to be influenced by the width of both the stream channel and the riparian zone. Although there are no reported specific field investigations of the extent of riparian microclimate (FEMAT 1993), general ecological theory and observations suggest that riparian microclimate effects may extend two to three tree heights (up to 525 feet) into the surrounding forest (Table RIP-1) (Harris 1984; Franklin and Forman 1987). For the purpose of this report, it is assumed that dense stands of large trees (deciduous, coniferous, or mixed) would provide optimal microclimate conditions.

The presence of intact riparian stands along estuarine and nearshore areas provide an important microclimate for wildlife and may influence prey production and salmonid feeding and refuge habitat.

OTHER FUNCTIONS

In addition to the functions evaluated for fish and aquatic habitat, riparian zones also play an important role as wildlife habitat. Riparian zones have a higher species diversity than any other habitat type (Oakley et al. 1985). Terrestrial wildlife and many bird species rely on riparian zones because the habitat provided is structurally diverse, contains abundant sources of water and food, and serves as travel corridors to and from other ecosystems (Knutsen and Naef 1997). Amphibians are particularly abundant in riparian zones because of the abundant water and moist and moderate microclimate (Bury et al. 1991).

ANALYSIS METHODS

Historic riparian conditions were inferred based on early descriptions of the vegetation of the Green River watershed or similar nearby areas (Pence 1946; Smalley 1883). For the lower Green River and Green/Duwamish estuary, a vegetation map produced by the USGS in 1894 provides some information on pre-settlement riparian and floodplain vegetation patterns. Even at that early date, much of the lower Green River valley had already been subjected to forest harvest or agricultural development.

Current riparian condition was assessed based on vegetation type, size, and density, generally corresponding with the methodologies recommended by the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) and the Washington Forest Practices Board Manual (WFPB 1997) (Table RIP-2). Existing data were utilized where possible. In the Upper Green River sub-watershed, Plum Creek Timber Company has completed draft or final riparian assessment reports for the Lester, Upper Green, and Sunday Creek Watershed Administrative Units (WAUs) using the Washington Department of Natural Resources Methodology. In addition, the U.S. Forest Service compiled GIS data on vegetation types and stand ages within 300-foot wide "riparian reserves" on each side of the mainstem Green River for a federal watershed analysis of the entire Upper Green River sub-watershed (USFS 1996). The USFS watershed analysis did not specifically evaluate riparian conditions. However, the GIS data were used to assess current riparian conditions for this report. For portions of the Middle and Lower Green River sub-watersheds, King County compiled a map of riparian cover types within a 300-foot wide band on each side of the low flow channel of the mainstem Green River between RM 0 and RM 45.7 based on analyses of aerial photos dating from 1994. No independent field validation was conducted of any of the data obtained from these sources.

In areas where no existing riparian data were located (RM 45 to RM 64.5 of the mainstem Green River; Soos and Newaukum Creeks), an original assessment was conducted specifically for this report using 1:12,000 black and white orthophoto quads flown in 1999 and 1:12,000 scale color aerial photos flown in 1996. To maintain consistency with the USFS and King County data sets, original analyses conducted for this report covered the area within 300 feet on each side of the stream channel. The predominant cover type within this zone was identified, and stands of trees were further classified by size and density (Table RIP-2). The width of the vegetation community immediately adjacent to the channel was recorded (to the nearest 25 feet) and other vegetation or cover types occurring within the 300-foot wide analysis area were noted (if present). The presence of roads, buildings, or developments within the riparian zone was recorded. No field validation was conducted in any of the areas for which an original analysis was conducted for this report.

The current status of each of the riparian functions described above was assessed based on the riparian cover type and density. Criteria used to evaluate each individual riparian function for this report were developed based on the width of existing streamside shrub or tree community and on the vegetation size and age, in general accordance with the approach employed by Washington Watershed Analysis riparian function assessment module (WFPB 1997). Specific criteria used to determine the current status of each individual function considered by this report are summarized in Table RIP-3. Although tidal estuarine habitats predominate in the Duwamish River and Elliott Bay, the same criteria were used to assess those areas. As reported, very little research has been conducted to identify riparian functions specific to estuarine systems.

At a minimum, a riparian zone in good condition had to meet the width requirements for that condition category. Once the current width of the riparian zone was established, the existing condition evaluation was modified based on vegetation type. For example, a riparian zone that was 75 feet wide but that consisted predominantly of shrubs would be classified poor in terms of bank stability. Similarly, a riparian zone that was 75 feet wide and supported large dense coniferous would be in good condition in terms of bank stability but in poor condition in terms of LWD recruitment, because it did not meet the minimum width requirement (≥150 feet) for sufficient LWD recruitment. Riparian condition was assessed separately for each bank of the river.

Finally, the length of river with an “intact” riparian zone and the length of channel bordered by vegetation similar to the potential natural community was estimated. For the purposes of this report, an “intact” riparian zone was defined as a segment of the 300-foot wide analysis area extending from each bank that contained no roads, houses, or buildings, yards, grass or agricultural fields, regardless of vegetation type. The presence of levees did not exclude a channel segment from being classified as having an intact riparian zone unless there was clear evidence of a regularly used road on top of the levee. However, as noted in Chapter 2.3 (Hydromodification), levees and revetments have a profound influence on channel morphology and natural geomorphic processes, and thus impede some important riparian functions such as LWD recruitment. For the mainstem Green River, deciduous, coniferous, or mixed stands of trees of any size were considered to be representative of the potential natural community.

As defined by NMFS (1999), if the riparian community in any sub-watershed is more than 80 percent intact and at least 50 percent of the vegetation community is similar to the potential natural community, the riparian management zone is considered to be “properly functioning” (which was considered equivalent to “good” in the rating system employed for this assessment). If the riparian community is less than 70 percent intact and less than 25 percent of the vegetation community is similar to the potential natural community, the riparian management zone is considered to be “not properly functioning” (which was considered to be equivalent to “poor” in the rating system employed for this assessment). Conditions between these criteria are considered to be “at risk” (which is considered to be equivalent to “fair” in the rating system employed for this assessment). Intact riparian and channel migration zones with vegetation similar to the potential native vegetation represent locations where good habitat conditions could be restored, even if the current vegetation type or age does not provide for optimal riparian habitat function.

The following sections qualitatively describe the historic riparian zone characteristics associated with the mainstem Green River, and they provide a reconnaissance level evaluation of current riparian conditions and function based on the widths identified in Table RIP-1.

UPPER GREEN RIVER (RM 64.5 TO RM 93)

Riparian conditions in the Upper Green River Sub-watershed were evaluated based on data generated for watershed analyses conducted by the USFS (USFS 1996) and Plum Creek Timber Company (Plum Creek 1996; 1997). One limitation of the Plum Creek watershed analyses is that riparian conditions were evaluated only within 100 feet on either side of the channel, as recommended by the Washington Forest Practices Board Methodology (WFPB 1997). The USFS riparian reserve stand data were used to estimate whether the conditions described by Plum Creek extended out to 300 feet. Although the USFS data are considered less accurate due to the original source of the data, they were assumed to be representative of the outer portion of the riparian zone unless maps indicated that roads, railroads, or cleared areas were present within 300 feet of the stream.

HISTORICAL CONDITION

Little specific information is available on the historic condition and composition of riparian zones along the mainstem Green River in the Upper Green River sub-watershed. The Upper sub-watershed is located predominately in the western hemlock potential vegetation zone (USFS 1996). In this zone, western hemlock and western redcedar represent climax species, while Douglas-fir is the sub-climax species (Franklin and Dryness 1973). Tree species commonly found in early seral riparian zones consist of red alder, black cottonwood, bigleaf maple and Oregon ash. Western redcedar and western hemlock will eventually develop in the absence of disturbance. Large cedar stumps observed on the floodplain and terraces along the Green River and lower Sunday Creek provide evidence that the riparian zone historically supported large coniferous trees (Ehlert 1997).

CURRENT CONDITIONS

Currently, riparian stands along the mainstem Green River within the Upper Green River sub-watershed are composed primarily of small to medium-sized deciduous or mixed deciduous and coniferous stands (Figure RIP-3). Pure stands of coniferous trees account for only 0.2 miles (<1 percent) of the total 39.5 miles of riparian habitat between RM 64.5 and 84.2. Overall, 67 percent (26.5 miles) of the riparian zone is intact and support vegetation similar to the potential natural community. The remainder is composed of cleared fields or bare ground and emergent wetlands formed due to seasonal inundation of the mainstem Green River and its floodplain by the Howard Hanson Dam reservoir. Because of the relatively young age of the trees and the amount of riparian zone that is less than 300 feet wide or has been converted to other habitat types, cumulatively riparian zones along the mainstem Green River in the Upper Green River Sub-watershed is considered to be functioning at risk according to the NMFS criteria. Changes in channel morphology and the sediment transport regime that are not explicitly considered by the riparian assessment approach utilized for this report may further impair existing riparian function.

BANK STABILITY

Based on the criteria in Table RIP-3, bank stability is rated good along 21.6 miles (50 percent) of the river bank downstream of RM 84.2 (Table RIP-4). Bank stability is rated fair along 17 percent of the banks, primarily because of the small size of existing riparian trees. Bank condition is rated poor along the remaining 14 miles of river bank (33 percent of all mainstem riparian zones). Riparian zones in poor condition include the seasonally inundated zone of Howard Hanson Reservoir (RM 65.5 to RM 69) and locations where roads or railroads are located within 25 feet of the channel, which, as noted in Chapter 2.3, affect approximately five total miles of riparian zone.

The bank stability ratings developed for this are based solely on current vegetation conditions as identified by remote sensing data or aerial photo analysis and may not accurately reflect existing bank stability on the mainstem Green River in the Upper Green River sub-watershed. For example, in the Lester WAU, increased sediment delivery has destabilized the mainstem channel in many locations, resulting in fluctuating channel widths and conversion of Floodplain channel types to braided reaches. In 1995, bank erosion near the Lester airstrip at RM 83 resulted in a major channel avulsion where the channel moved out of a reach with a densely forested riparian zone and into an area where all the trees had been cleared and converted to a grassy field (Goetz 2000; Cupp and Metzler 1996). No field data were located describing bank conditions in the remainder of the mainstem, but similar instances of unstable banks are expected to occur there.

SHADE

The area of a stream channel shaded by the riparian zone is directly related to the height and density of vegetation, particularly in unconfined Floodplain channel types such as the mainstem Green River between RM 64.5 and RM 88. Because the riparian zone along the mainstem is currently dominated by small trees, shade is rated as poor in approximately 50 percent of the riparian zone assessed along the mainstem Green River in the Upper Green River sub-watershed (Table RIP-4). The remaining 50 percent of the riparian zone has fair shade, primarily because the trees there are currently only medium sized and are not yet tall enough to shade the entire wide mainstem channel. None of the riparian zone is considered to provide good shade. Shade was mapped as “naturally low” along the mainstem Green River in the Lester Watershed Analysis (Doughty 1996). However, mature riparian stands composed of 150 to 200 foot tall coniferous trees such as western redcedar or western hemlock would be expected to provide substantial shade to the 100 to 200 foot wide mainstem. While it is difficult to estimate the length of channel that such conditions might prevail upon under natural conditions, it is anticipated that shade would be substantially greater than it is currently.

ORGANIC MATTER AND TERRESTRIAL INVERTEBRATE RECRUITMENT

Like shade, organic matter (OM) and terrestrial insect inputs are directly related to the height and density of riparian vegetation. While shrubs and small trees may provide substantial amounts of litter to small channels, recruitment of OM on larger rivers is reduced when riparian zones are dominated by small trees or shrubs. Under current conditions, only about 22 percent of the 42.8 total miles of riparian zone provides good OM and terrestrial insect inputs (Table RIP-4). The majority of the remaining riparian zone provides only fair to poor recruitment of organic matter and terrestrial insects.

SEDIMENT FILTRATION

Even low growing vegetation such as shrubs or small trees can be very effective at filtering fine sediments as long as the stand is dense (Wenger 1999). The ability of the existing riparian zone to filter sediment is considered to be good in approximately 56 percent of the riparian zone evaluated along the mainstem Green River. Sediment filtration is poor along the 7.0 miles of bank within the seasonally-inundated reach (RM 65.5 to 69) and at locations where roads, powerline corridors, or railroads are located within 200 feet of the stream.

LARGE WOODY DEBRIS RECRUITMENT

To achieve a good rating for large woody debris (LWD) recruitment, riparian stands must contain trees of the appropriate species that are large enough to provide functional or key-sized pieces of LWD. The mainstem Green River is a large channel that ranges from 100 to 200 feet wide. Consequently, only very large pieces of wood are expected to be functional. Although coniferous species are preferred, a variety of stand types would occur naturally adjacent to large Floodplain channels such as the mainstem Green River and large trees of any species were considered to provide good LWD recruitment. At present, only one of the riparian stands evaluated contained large trees, and this stand is truncated by a road within 100 feet of the channel. Approximately 50 percent of the riparian habitat is rated fair, because the stands currently consist of medium-sized trees. Those areas should develop good LWD conditions within several decades provided they are undisturbed by harvest or floods. The remaining 50 percent of the riparian zone was considered to be in poor condition. Of this, at least 12 of the 21.2 miles (approximately 28 percent of the entire mainstem riparian zone) is classified as poor because of the presence of roads or railroads, or because it is seasonally inundated by Howard Hanson Reservoir. Seasonal inundation prevents establishment and growth of native trees. Roads adjacent to the mainstem Green River in the Upper Green River sub-watershed are mainline roads that are expected to be permanently maintained throughout the foreseeable future. For these reasons, this habitat can never be expected to develop good LWD recruitment conditions.

CHANNEL MIGRATION ZONE

In moderate to high gradient contained reaches such as the Green River upstream of RM 88, the primary modes of LWD recruitment are windthrow and mass wasting. Unconfined channels, such as the mainstem Green River downstream of RM 88, generally occupy a CMZ. Wood is recruited to the river from throughout the CMZ via bank erosion as the channel slowly migrates across the floodplain or during rapid channel avulsion when new channels are cut through existing stands of vegetation. Large, unconfined Floodplain channels also receive LWD from upstream reaches. To date, there have been few investigations of the proportion of wood generated on-site versus from upstream in unconfined floodplain-type channels. However, as a general rule, the contribution of LWD from upstream reaches would be expected to increase as the contributing drainage area increased.

The draft Upper Green/Sunday Watershed Analysis is the only source of information on the current vegetation communities of the channel migration zone in the Upper Green River sub-watershed. The Floodplain segment between RM 84 and RM 88 has an associated CMZ that is approximately 300 feet wide. The CMZ in this reach currently supports sparse to dense stands of small deciduous trees. Because the CMZ represents the area from which most LWD will be recruited via bank erosion in the near future, LWD recruitment in this reach is generally rated poor. The CMZ is bordered by stands of young to mature coniferous and mixed coniferous and deciduous trees.

No information was available on the channel migration zone downstream of RM 84. The valley widens below RM 84 and it is assumed that the CMZ width increases. Most of the 300-foot wide riparian reserves mapped and characterized by the USFS Watershed Analysis are therefore probably located within the CMZ.

MICROCLIMATE

According to the studies reviewed by Knutsen and Naef (1997), dense stands of mature vegetation at least 200 feet wide are required to produce microclimate conditions that would be rated good. It is unknown whether the minimum riparian zone width required to maintain microclimatic conditions adjacent to large alluvial rivers would be substantially greater than 200 feet or whether microclimate conditions that differ substantially from the surrounding uplands even develop in such situations.

Assuming that the width required to maintain microclimate conditions cited by Knutsen and Naef (1997) are relevant to the mainstem Green River, none of the stands along the mainstem Green River in the Upper Green River sub-watershed provide good microclimate. The reason is that the existing stands consist primarily of small to medium sized trees. As with LWD, existing small and medium sized stands of trees will eventually develop conditions that could provide good microclimate if they are not subject to disturbance. However, the 12 miles of habitat in that is seasonally inundated or truncated by roads can never be expected to develop good microclimate conditions.

MIDDLE GREEN RIVER SUB-WATERSHED (RM 32 TO RM 64.5)

HISTORICAL CONDITIONS

A map of vegetation types produced by the U.S. Geological Survey (USGS) in 1894 depicts the Green River valley between RM 32 and RM 47 as “burnt areas not restocking.” This suggests that historically the valley was forested and logged by early settlers. Based on the fact that the Middle Green River between RM 32 and RM 47 was laterally-mobile Floodplain channel type with braided sections, it is likely that the historic riparian vegetation community was comprised of a mix of species and age types. Young, early successional deciduous species such as willow, red alder, and black cottonwood probably occupied recently exposed bar surfaces, with older stands of coniferous or mixed coniferous and deciduous trees growing on terraces or stable floodplain surfaces. Western redcedar and Douglas-fir were reportedly the most common indigenous forest species in the Green River Valley (Wharton 1990). Other riparian tree species found in the Middle Green River valley downstream of the Green River gorge probably included black cottonwood, bigleaf maple, Sitka spruce, and western hemlock.

Little specific information is available on historic vegetation types in the gorge and upstream to RM 64.5. The downstream end of the gorge is mapped as "burnt areas restocking" on the 1894 USGS Land Classification Map. Based on channel type, it is assumed that laterally-stable moderate to high gradient contained reaches such as the Green River gorge and the section of river between RM 61 and RM 64.5 supported dense stands of coniferous trees including Douglas-fir, western redcedar, and western hemlock. Riparian communities associated with unconfined reaches such as the channel segment between RM 58 and RM 61 probably supported vegetation similar to that downstream of the Green River gorge.

CURRENT CONDITIONS

Current riparian conditions in the middle Green River sub-watershed were assessed using a combination of previously completed maps of riparian communities and direct aerial photo interpretation. In 1996, King County compiled detailed maps of existing vegetation types within a 300-foot wide band along each side of the mainstem Green River from RM 32 to RM 45. Tree-size and density in deciduous or coniferous communities depicted on these maps was estimated using 1:7920 scale color aerial photos taken in 1992. Vegetation stands within 300 feet of either side of the mainstem Green River between RM 47 and RM 64.5 were delineated on black and white orthophoto quads dating from 1999.

Riparian conditions in the Middle Green River sub-watershed vary in direct relation to the channel types described in Chapter 2.3 (Hydromodification). The riparian zone within the reach between HHD and Tacoma's Headworks (RM 61 to RM 64.5) is forested, but frequently truncated by roads or railroads, as the narrow valley bottom historically provided the easiest access route to the Upper sub-watershed. The unconfined Floodplain channel segment between RM 58 and RM 61 is also forested, but the vegetation stands immediately adjacent to the channel are composed primarily of small deciduous trees that became established on formerly active bar surfaces and channel margins following initiation of flood control at HHD in 1964. Most of the riparian zone associated with the Large Contained channel type known as the Green River gorge (RM 45 to RM 57) is intact and composed of large, mixed coniferous and deciduous trees because the steep, rocky canyon walls make forest harvest and development difficult. Agricultural development and flood control structures (levees and revetments) have altered the riparian community somewhat in the wide valley associated with the Floodplain channel type between RM 32 and RM 45. However, riverside parks (including Metzler-O'Grady Park RM 38.5 to RM 40; and Flaming Geyser Park RM 43 to RM 45) and steep bluffs the river impinges on in several locations still support largely intact stands of small to medium sized deciduous trees and mixed coniferous and deciduous forest.

Cumulatively, approximately 84 percent of the riparian zone along the mainstem Green River in the Middle Green River sub-watershed still supports stands of native deciduous or coniferous forest (Figure RIP-4). However, only 53 percent of the Middle Green River has an intact riparian zone at least 300 feet wide. According to the NMFS criteria for riparian function, with the exception of the Green River gorge, riparian zones in the Middle Green River sub-watershed are currently not functioning properly because most are too narrow or support non-native vegetation (bare ground, grass, shrubs or development).

BANK STABILITY

Riparian communities with a width less than that sufficient to maintain bank stability (i.e., ≤50 feet in width) comprise approximately 24 percent of the banks in the Middle Green River sub-watershed. However, in many cases, where the riparian zone consists of a narrow strip of shrubs or trees, levees provide artificial bank stability. Levees and revetments affect approximately 40 percent of the channel between RM 31 and RM 45, primarily at the downstream end of that reach (Chapter 2.3).

Bank stability is currently rated good in all three channel segments located upstream of the Green River gorge. In the floodplain channel segment downstream of the Green River gorge (RM 32 to RM 45), notable areas of bank erosion occur where agricultural fields are located immediately adjacent to the right bank near RM 36, RM 37.2, and RM 38.3, and on the left bank near RM 39.6. Large landslides have resulted in bare, eroding banks near RM 36 and RM 42.3. Elsewhere, riparian conditions are generally sufficient to maintain fair to good bank stability (Figure RIP-4).

SHADE

For most of its length, the mainstem Green River in the Middle Green sub-watershed is a wide, shallow river with little riparian shade. Upstream of the Green River gorge (elevation 800 feet to 1,000 feet MSL), the target shade required to maintain water temperatures at or below 16 ^{o}C is 70 percent (WFPB 1997). The bankfull channel width is approximately 120 feet in this reach, indicating that riparian trees at least 103 feet tall are required to provide shade to the entire river channel (Figure RIP-2). Evaluation of aerial photos taken in 1987 suggests that the current riparian stand provides approximately 40 percent shade in this reach. Conditions may have improved somewhat since 1987, but shade is still probably only fair in this reach.

Within the Green River gorge (RM 45 to RM 58), shade is currently in good condition based on tree species, size, and the width of the existing riparian zone. In addition, the steep sideslopes provide topographic shade in this segment.

Downstream of the Green River gorge between RM 32 and RM 45 (elevation 50 to 220 feet MSL), the target shade to maintain stream temperature of 16^{o}C is 90 percent (WFPB 1997). Although the majority of this reach (64 percent) had good shade conditions based on the vegetation classification and width (Table RIP-3), the actual shade provided to the stream channel is probably lower than the target shade. Evaluation of aerial photographs taken in 1992 indicated that the existing riparian stand provides approximately 20 to 40 percent shade along most of this reach, well below the target amount.

ORGANIC MATTER AND TERRESTRIAL INVERTEBRATE RECRUITMENT

Based on width and vegetation, existing riparian conditions provide for good organic matter (OM) and terrestrial invertebrate recruitment along approximately 40 percent of the mainstem Green River in the Middle Green River sub-watershed (Table RIP-5). Areas where the existing riparian zone is not sufficiently wide to maintain OM and terrestrial insect inputs occur primarily where agricultural fields are located directly adjacent to the channel or on bar surfaces that are just being colonized by perennial riparian vegetation. The distribution of habitat conditions along the mainstem in this sub-watershed with respect to organic matter recruitment is similar to that described above for shade.

SEDIMENT FILTRATION

Approximately 40 percent of the mainstem riparian habitat in the Middle Green River sub-watershed is sufficient to provide good sediment filtration. Riparian areas that rated fair for sediment filtration generally support dense shrub or tree communities but are too narrow to completely filter sediment from overland flows. Between RM 64.5 and RM 61, sediment filtration is considered poor because gravel roads within the riparian zone restrict the width to less than 75 feet in many areas and serves as a source of increased fine sediment delivery. Riparian conditions currently meet the width and vegetation type requirements for good sediment filtration in the upper Floodplain channel type (RM 58 to RM 61) and the Green River gorge (RM 45 to RM 58). Downstream of the Green River gorge (RM 32 to RM 45), locations where sediment filtration is rated poor occur primarily where farm fields or residences occupy sites directly adjacent to the river or where the riparian community is composed of sparse stands of small trees that are in the process of colonizing former bar surfaces (Figure RIP-4).

LARGE WOODY DEBRIS RECRUITMENT

Riparian stands provide good LWD recruitment along approximately 26 percent of the banks in the Middle Green River sub-watershed (Table RIP-5). The potential for recruitment of LWD is currently poor in the channel segment upstream of Tacoma's Headworks (RM 61 to RM 64.5). Riparian stands in that segment are truncated by stream-adjacent road and railroad right of ways, which have reduced LWD recruitment and will prevent recovery of recruitment as long as they remain in place.

Between the upstream end of the gorge (RM 58) and RM 61, LWD recruitment is currently rated fair. In general, the width of the riparian zone in this segment is sufficient to provide LWD, but the existing vegetation stands are currently composed of small to medium sized trees that are not yet large enough to act as functional LWD or key pieces in the Green River (Figure RIP-4). Between RM 58 and RM 61, the channel formerly migrated back and forth across the floodplain. This channel was straightened prior to 1953 (Chapter 2.3), and formerly active bars and islands have become fixed in place by encroachment of riparian vegetation as a result of flood control by HHD (Perkins 1993). In combination, these changes in geomorphic processes have likely substantially reduced in-situ LWD recruitment in this reach. In addition, HHD blocks the downstream movement of wood from the upper watershed, further reducing LWD recruitment to the Middle Green River.

Recruitment of LWD within the Green River gorge (RM 45 to RM 58) is generally rated good. With few exceptions, the riparian zone is intact (300 feet wide) and supports native vegetation (Figure RIP-4). Trees in the riparian zone are large, and along this reach include a substantial number of conifers.

The potential for recruitment of LWD downstream of the Green River gorge is currently highly variable (Figure RIP-4). The riparian zone is generally intact in Flaming Geyser and Metzler O'Grady Parks (located at RM 42 to RM 45 and RM 38 to RM 40, respectively), but the trees there are currently too small to provide functional or key-sized pieces of LWD. Most of the riparian zone in the Middle Green River sub-watershed that is rated poor (narrow width of small trees and shrubs) occurs where agriculture or residential development extends to the stream bank or where the riparian zone consists of formerly active gravel bar surfaces that are being successfully colonized by shrubs and small deciduous trees as a result of flood control by HHD.

Downstream of the Green River gorge, between RM 38 and RM 45, the river generally remains unconstrained and recruitment of LWD from bank erosion and channel migration can still occur. However, establishment of shrubs and young deciduous trees on formerly active bar surfaces suggests that flood control by HHD has reduced the rate of channel migration, thereby suppressing the recruitment of LWD. Downstream of RM 38, much of the river is artificially confined between levees (Chapter 2.3) that prevent channel migration and bank erosion, effectively halting natural recruitment of LWD.

CHANNEL MIGRATION ZONE

From RM 64.5 to approximately RM 61, the mainstem Green River is tightly confined between steep sideslopes and effectively has no channel migration zone. Between RM 57 and RM 61, the valley width increases to approximately 1500 feet across, and the Green River appears to have formerly had a channel migration zone that covered the entire valley floor. Transportation routes constructed through the valley adjacent to the channel in this reach cut off the river from much of its former channel migration zone. The earliest available aerial photos reveal that two large former meander bends had been disconnected from the river as early as 1942 (Chapter 2.3). Since that time, the channel planform has not changed dramatically and the function of the channel migration zone essentially has been lost in this channel segment. Downstream of RM 58, the mainstem enters the Green River gorge and has no channel migration zone until it emerges around RM 45.

The Middle Green River between RM 32 and RM 45 historically had a very active channel migration zone. Based on a map of former channel locations from 1906 to 1992, the width of the channel migration zone in this reach historically ranged from 300 to 2500 feet wide (Perkins 1993). Since human settlement, levees, stream adjacent roads, and the reduced frequency of floods have reduced the width of the channel migration zone by 75 to 90 percent (Perkins 1993). In addition, much of the remaining channel migration zone has been converted to agricultural or residential landuses and no longer supports native riparian vegetation.

MICROCLIMATE

Microclimate conditions are currently poor along most (52 percent) of the Middle Green River. Stands of small deciduous trees and shrubs or artificially narrow riparian zones downstream of the Green River gorge account for the majority of riparian habitat classified as poor. Microclimates within the Green River gorge are currently considered to be in good condition. Because the riparian zone is still largely intact, stands within the Metzler O'Grady Park area also in good condition, or on a trajectory to develop good microclimate conditions within the next few decades as medium size trees mature.

LOWER GREEN RIVER SUB-WATERSHED (RM 11 TO RM 32)

HISTORICAL CONDITIONS

The historical vegetation map produced by the U.S. Geological Survey (USGS) in 1894 depicts the Green River valley between RM 11 and RM 32 primarily as "cut areas not restocking." There are also patches of ground mapped as "cut areas restocking" near Auburn. This suggests that historically the valley was timbered. Historically, the lower Green underwent a gradual transition from a gravel-bedded Floodplain channel type to a highly sinuous silt and sand bedded Palustrine channel type between RM 32 to RM 11 (Chapter 2.3). Soils data and anecdotal accounts suggest that the historic riparian vegetation community was comprised of a mix of coniferous-dominated riparian stands, forested wetlands, and swampy meadows (Wharton 1990; Dunne and Dietrich 1978; Mullineaux 1970; Pence 1946). Young, early successional deciduous trees such as willow, red alder, and black cottonwood probably occupied recently exposed bar surfaces, with older stands of coniferous or mixed coniferous and deciduous trees growing on terraces or stable floodplain surfaces. Western redcedar and Sitka spruce may have dominated forested wetlands. Other riparian tree species that were found in the lower Green River valley probably included black cottonwood, bigleaf maple, and western hemlock.

CURRENT CONDITIONS

Current riparian conditions in the Lower Green River sub-watershed were assessed using detailed maps provided by King County that depict existing vegetation and cover types within a 300-foot wide band along each side of the mainstem Green River from RM 11 to RM 32 (Figure RIP-5). Tree-size and density in deciduous or coniferous communities was estimated using 1:660 scale color aerial photos taken in 1992 where available.

Cumulatively, there is less than one mile of intact riparian zone comprised of medium to large mixed deciduous and coniferous trees along the lower mainstem Green. This area is located on the right bank near RM 32. Approximately 18 percent (12.4 miles) of the riparian zone in the Lower Green River sub-watershed supports native deciduous trees; however in most cases deciduous stands are narrow (<100 feet) or comprised of sparse young trees mixed with patches of grass, pavement, or bare ground (Figure RIP-5). Almost 50 percent of the riparian zone is comprised of forbs and grass, or shrubs, many of which are non-native (Chapter 2.6). Pavement and bare ground account for approximately 33 percent of the total area within 300 feet of the river. None of the mainstem riparian habitat in the Lower Green River sub-watershed is in good condition (Table RIP-6) or is considered to be functioning properly based on the NMFS criteria.

BANK STABILITY

While there are some areas of riparian vegetation that have a width and vegetation type sufficient to maintain good bank stability, over 80 percent of the banks in the Lower Green River are comprised of levees or revetments (Chapter 2.3). These structures artificially maintain bank stability and prevent erosion. Erosion control structures prevent many natural geomorphic processes from occurring, such as LWD recruitment or formation of undercut banks, both of which provide important habitat for salmonids. In addition, construction of artificial channel constraints has effectively eliminated the channel migration zone. Therefore existing riparian stands were not evaluated with respect to bank stability in this sub-watershed.

SHADE

Only 3 percent of the riparian stands along the lower mainstem Green River consist of vegetation communities that are considered to provide good riparian shade (Table RIP-6). The majority of the channel between RM 11 and RM 32 is exposed to direct solar radiation and has poor shade; the presence of roads and development within the floodplain will effectively prevent establishment of riparian vegetation that could provide adequate shade in the future. However, there are approximately five miles of riparian zone that currently supports stands of shrubs or small deciduous trees that are wide enough to provide adequate shade and could eventually develop good shade conditions in the future if left undisturbed. The majority of riparian zone where shade could develop in the future is located between RM 26 and 28 (Figure RIP-5).

ORGANIC MATTER AND TERRESTRIAL INVERTEBRATE RECRUITMENT

Existing riparian conditions provide for good organic matter (OM) and terrestrial invertebrate recruitment along only 3 percent of the mainstem Green River in the Lower Green River sub-watershed. Areas dominated by pavement, bare ground, or grass are not expected to ever provide good OM and terrestrial insect recruitment. However, if left undisturbed, shrub and young deciduous communities between RM 26 and 28 could eventually provide better OM and terrestrial invertebrate recruitment to the river if trees are established and allowed to mature.

SEDIMENT FILTRATION

The presence of roads, pavement, and developed areas within 300 feet of the stream severely restricts the effectiveness of sediment filtration in riparian zones in the Lower Green River sub-watershed. Only 1.8 miles of habitat presently provides good sediment filtration (Table RIP-6). An additional 5.9 miles provide fair sediment filtration, but in general the presence of contributing activities near the stream will prevent future improvements in sediment filtration by riparian zones.

LARGE WOODY DEBRIS RECRUITMENT

None of the riparian habitat in the lower Green River provides good LWD recruitment (Table RIP-6). Approximately one mile of habitat on the right bank between RM 31 and RM 32 currently supports a mixed stand of medium-sized trees that could eventually grow to a size sufficient to serve as key or functional large woody debris. Portions of the area between RM 31 and RM 32 are confined by levees. In general, however, the channel is more mobile here than elsewhere in the Lower Green River sub-watershed. Steep sideslopes also may contribute LWD via mass wasting from outside of the 300-foot riparian zone in this area.

Recruitment of large woody debris from the remainder of the Lower Green River sub-watershed is currently considered poor and will continue to be limited by the activities near the stream that prevent development of mature forests and by artificial bank protection structures that prevent bank erosion and channel migration. These are the mechanisms by which most LWD is recruited in Floodplain and Palustrine channel types.

CHANNEL MIGRATION ZONE

Levees had been constructed along the mainstem Green in the Lower Green River sub-watershed at the time the earliest maps of the river channel were produced in 1907. Consequently, it is difficult to evaluate the historic extent of the channel migration zone in this sub-watershed. However, old meander scars suggest the channel had access to the entire valley bottom at some time in the past and the channel migration zone likely encompassed the whole area (Chapter 2.3). Over 90 percent of the channel in this sub-watershed is currently confined between levees or revetments, and the channel planform has changed little since 1907. Consequently, there is now effectively no channel migration zone associated with the river in the lower Green River sub-watershed (Chapter 2.3).

MICROCLIMATE

Microclimate conditions are currently rated as poor along almost all (97 percent) of the lower mainstem Green River. As for LWD recruitment, the area on the right bank between RM 31 and 32 provides the only remaining intact riparian stand, which will eventually provide functional microclimate if allowed to develop into a mature forest. Land use activities within the remainder of the riparian zone will continue to preclude development of forest stands required to provide good microclimate conditions.

GREEN/DUWAMISH ESTUARY (RM 0 TO RM 11)

HISTORICAL CONDITION

Riparian conditions along the Duwamish River are vastly different today from their condition in 1850. In the historical condition, approximately 1,230 acres of freshwater forested wetlands were found along the river (Blomberg et al. 1988). These areas, which were only inundated by flood events, likely included Sitka spruce (*Picea sitchensis*), willow (*Salix* spp.), red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa*), roses (*Rosa* spp.), and Douglas spirea (*Spirea douglasii*) (Tanner 1991).

Approximately 1,170 acres of tidal marshes occupied areas between +8 feet to +11 feet Mean Low Low Water (MLLW) (Blomberg et al. 1988). These areas were likely vegetated by bullrush (*Scirpus maritimus* and *S. americanus*), Lyngby's sedge (*Carex lyngbyei*), and sea arrow grass (*Triglochin maritimum*) (Tanner 1991). Vegetation found higher in the marsh probably included tufted hairgrass (*Deschampsia caepitosa*), saltgrass (*Distichlis spicata*), pickleweed (*Salicornia virginica*), Baltic rush (*Juncus balticus*), silverweed (*Potentilla pacifica*), and red fescue (*Festuca rubra*) (Dethier 1990).

Prior to settlement, approximately 1,450 acres of intertidal flats and shallows occupied areas below +6 to +8 feet MLLW. Although devoid of macrophytes, small patches of eelgrass (*Zostera marina*) or the green alga *Ulva* may have been present (Tanner 1991). The intertidal flats and shallows were concentrated at the mouth of the estuary bordering the south margin of Elliott Bay

(Blomberg et al. 1988). Approximately 440 acres of mostly unvegetated medium-depth water was also present between MLLW and -15 feet; this area too represents important feeding and refuge habitat for juvenile salmonids during low tide.

By 1940, filling of low-lying areas had eliminated virtually all of the fringing riparian surge plain forested wetland (termed tidal swamps in Blomberg et al. 1988) or isolated it from the river. In addition, Blomberg et al. estimated that 98 percent of the pre-contact tidal marsh, mud flats, and shallows had been eliminated by dredging and filling, with most of this loss coming by 1940 (Table RIP-8). The majority of the near-natural estuarine habitats that remained were at Kellogg Island, which itself has been altered by disposal of dredged materials (Grette and Salo 1986). Small areas of *Carex*-dominated marsh, generally under one acre in size and widely dispersed, and the unvegetated intertidal benches adjacent to the channel or along the river banks, are all that remained. LWD delivery to the estuary was greatly reduced by loss of riparian forests locally, upstream, and by debris removal to aid navigation. Consequently, habitat complexity, as well as area, was greatly reduced. Blomberg et al. (1988) calculated that in 1986 only 45 acres of tidal marshes and mudflats remained.

Blomberg et al. (1988) estimated that the pristine Duwamish Estuary had about 93,000 linear feet of channel shorelines supporting riparian vegetation below the location of the oxbows (present RM 7). Only a very small proportion of that shoreline retains a semblance of the natural sequence of shallow mudflat, sloping up to a saltmarsh bench, transitioning into freshwater marsh and riparian forest. The upper bank along the majority of the shoreline has been hardened with riprap or vertical bulkheads and little natural vegetation remains.

CURRENT CONDITIONS

Several data sources were used to determine the present condition of riparian zones in the Duwamish Estuary and Elliott Bay. The upper Duwamish Estuary from RM 11.0 to RM 5.3 was traversed by canoe in May 1999 and shoreline habitats noted and later mapped. For the lower estuary, between RM 5.3 and the mouth, habitat and substrate data collected by the Port of Seattle were used to characterize the riparian zone (Port of Seattle unpublished data). In Elliott Bay, the primary data used to characterize riparian habitat were aerial photos (Port of Seattle 1993) with limited ground truthing conducted during a field reconnaissance in May 2000. King County mapped riparian conditions along the Duwamish River from aerial photos dating from 1992 (Figure RIP-6).

A majority of the shoreline along the upper reaches of the Duwamish River is densely vegetated, typically by shrubs (Figures RIP-7 and RIP-8). Riprapped shorelines and levees are often overgrown with this shrub community, which is usually dominated by willows (*Salix* spp.) and non-native blackberries (*Rubus* spp.; e.g., Figure RIP-8). These shrubs provide some cover and shade, overhanging the water at middle and higher water levels, and may provide litter and insect production to the aquatic system. The total length of shoreline shrub cover between RM 11.0 and RM 5.3 is approximately 45,140 linear feet or 75 percent of the shoreline (Table RIP-9).

Trees taller than about 25 feet are most abundant along the Duwamish River shoreline in the reach between RM 8.0 and RM 7.0 (e.g., Figure RIP-7), forming a continuous line along the west bank and portions of the east bank. Trees are somewhat less dense upstream and considerably less dense downstream of this reach. The majority of larger trees are black cottonwood (*Populus trichocarpa*), bigleaf maple (*Acer macrophyllum*), and red alder (*Alnus rubra*). These species also provide shade and litter and insect fallout to the aquatic system. They also occasionally fall into the river and provide the additional functions of LWD.

The total length of shorelines with tree cover between RM 11.0 and the Turning Basin (RM 5.3) is approximately 21,340 linear feet or approximately 35 percent of the shorelines (Table RIP-9). Downstream of the Turning Basin, trees are very sparse except on, and adjacent to, Kellogg Island. Except for Kellogg Island, trees in the riparian zone are largely absent between RM 5.3 and RM 0.0 (Figure RIP-6). Few areas of upper bank (about 5 percent) between RM 11.0 and the Turning Basin are grass-lined (Figure RIP-9). A small area along the right bank at RM 6.3 is grass lined. Grass lines the left bank between RM 7.8 and RM 8.1 and the right bank at RM 8.5. Two small sections of left bank are grass-lined near RM 12.2. The total length of grass cover between RM 11.0 and RM 5.3 is approximately 3,130 linear feet (Table RIP-9).

The shoreline along Elliott Bay is dominated by overwater structures and industrial, urban, and residential development. The only areas of substantial riparian vegetation are found along Magnolia Bluff, at the southern portion of the Discovery Park property. Approximately 3,870 linear feet of undeveloped bluff is vegetated with deciduous trees and shrubs. South of Discovery Park, interrupted stands of trees and shrubs predominate in a residential bluff and beach community for approximately 11,010 linear feet. Immediately south of Magnolia Bluff lies a large marina and breakwater (Elliott Bay Marina) and two large overwater structures (Piers 90 and 91). South of these structures lies approximately 6,600 linear feet of riprap and grass cover along Myrtle Edwards Park. South of the park, over-water structures, seawalls, and industrial uses dominate the shore through downtown Seattle and Harbor Island. Seawalls, riprap, residential development, and intermittent grassy areas characterize the riparian zone west of Harbor Island to Duwamish Head. From Duwamish Head to Alki Point very little riparian vegetation is present, replaced with riprap, seawalls and a street running along the beach.

BANK STABILITY

Bank stability in the lower Duwamish below RM 11.0 is very similar to that found in the lower Green River between RM 11 and 32. Over 80 percent of the banks of the Duwamish Estuary are comprised of riprap, bulkheads, and levees (Chapter 2.3, Hydromodification). These structures artificially maintain bank stability and prevent erosion. However, erosion-control structures may prevent many natural geomorphic processes from occurring, such as LWD recruitment or the formation of undercut banks, both of which provide important habitat for salmonids. In addition, the construction of artificial channel constraints has effectively eliminated the channel migration zone. Therefore existing riparian stands were not evaluated with respect to bank stability in the estuary.

SHADE

Although much of the shore in the lower Duwamish below RM 11.0 is composed of artificial erosion-control structures, many of these structures are overgrown with dense shrubs or have tree stands immediately behind them. Between RM 11.0 and the Turning Basin (RM 5.3), approximately 35 percent of the shoreline is lined with large trees, although only sometimes are tree stands greater than 75 feet in width. Based on the width and vegetation type criteria provided in Table RIP-3, this portion of the shoreline provides 35.4 percent fair and 64.6 percent poor riparian shade (Table RIP-7). (Note that categorizations of riparian functions as good, fair, or poor based on criteria applicable to upper subbasins may not be fully relevant in the estuary and nearshore.) About 75 percent of this reach is lined with shrubs that provide nearshore shading for juvenile salmonids but do not provide significant temperature refuge, given the large width of the river.

Below the Turning Basin to the mouth, trees greater than 25 feet in height are very sparse, and shrubs line about 28 percent of the shore. Less than one percent of the river below the Turning Basin falls provides fair to good riparian shade. Most of this is on Kellogg Island and the adjacent secondary shore behind the island (RM 1.5 to RM 1.0; Table RIP-7).

Along the shore of Elliott Bay, large trees predominate only in undeveloped and less developed areas of Magnolia Bluff. Approximately 6,270 linear feet, or 6.3 percent of the shore, contain trees of a height and width to provide good riparian shading. Approximately 7,563 linear feet, or 7.5 percent of the shore, would provide fair riparian shading were it not for the southern exposure of this shoreline. Riparian vegetation along the remainder of Elliott Bay shore from West Point to Alki Point provides poor riparian shading (Table RIP-7). Substantial shoreline areas are shaded by buildings and overwater structures, however.

ORGANIC MATTER AND TERRESTRIAL INVERTEBRATE RECRUITMENT

Between RM 11.0 and RM 5.3 in the upper Duwamish River, over 35 percent of the shore is composed of trees, but only about 11.6 percent of the upper river has a riparian zone greater than 50 feet in width. Approximately 7,000 linear feet of shore between RM 7.0 and RM 8.0 has riparian tree habitat that provides fair to good organic matter (OM) and terrestrial invertebrate recruitment (Table RIP-7).

Below the Turning Basin, trees are sparse except for approximately 5,088 linear feet of shoreline on Kellogg Island and the adjacent shore, which has a riparian zone that provides fair to good organic matter and invertebrate recruitment. This represents about 6.1 percent of the shore between RM 5.3 and RM 0 (Table RIP-7). Limited areas of brackish marsh vegetation along the shoreline supplement riparian function of shrubs and trees. Marsh vegetation provides a source of organic matter to the estuary and insects that may be directly preyed upon by juvenile salmonids. As with riparian shading, the recruitment of organic matter and terrestrial invertebrates along Elliott Bay occurs primarily in the Magnolia Bluff area. Approximately 7.4 percent of shore provides good recruitment and 6.3 percent provides fair recruitment based on the criteria used in the upper river. The remainder of the Elliott Bay shore is poor in the recruitment of organic matter and terrestrial invertebrates because of sparse vegetation (Table RIP-7).

SEDIMENT FILTRATION

As previously described, much of the upper Duwamish Estuary (RM 11.0 to RM 5.3) is lined with shrubs, trees, or grass but rarely is the riparian zone wide enough to provide substantial riparian functions except for shading. Approximately 11.6 percent of the shore in the upper Duwamish Estuary has a riparian corridor between 75 and 150 feet in width, which can provide fair sediment filtration. Below the Turning Basin, trees are sparse except for approximately 5,088 linear feet of shoreline on Kellogg Island and the adjacent shore, which has a riparian zone that provides fair to good sediment filtration. This represents about 6.1 percent of the shore between RM 5.3 and RM 0 (Table RIP-7).

Much of the Magnolia Bluff area contains trees and shrubs that provides sediment filtration; however, this function is irrelevant given that the bluff itself is a major source of sediment that feeds the coastal drift cell from the Smith Cover Marina to West Point. Approximately 6,270 linear feet, or 6.3 percent of the shore, supports trees and shrubs at a width that provides good sediment filtration. About 7,563 linear feet, or 7.5 percent of the Elliott Bay shore, is vegetated with shrubs and small trees to at least 75 feet in width, and provides fair sediment filtration. The remainder of the Elliott Bay shore would likely provide poor sediment filtration (Table RIP-7).

LARGE WOODY DEBRIS RECRUITMENT

Most of the tree-lined riparian zone of the upper Duwamish, from RM 11 to the Turning Basin, is less than 100 feet in width, so it would be categorized as providing poor recruitment of LWD. About 7,000 linear feet between RM 8.0 and RM 7.0, or 11.6 percent of shoreline, has riparian trees of the size and extent to provide fair recruitment of LWD (e.g., Figure RIP-8). About 9.5 pieces of LWD per mile were observed during a recent habitat survey in the upper Duwamish, but much of this appeared weathered and probably came from historical upstream sources (e.g., Figure RIP-10). Below the Turning Basin, trees are sparse except for approximately 3,639 linear feet of shoreline on Kellogg Island, which has a riparian zone that provides good organic LWD recruitment. This represents about 4.4 percent of the shore between RM 5.3 and RM 0.

LWD recruitment in Elliott Bay is considered good at 6.3 percent of the shore and fair at 7.5 percent of the shore, all within the Magnolia Bluff region (Table RIP-7). During field observations in May 2000, several areas of the bluff had contributed large numbers of recently fallen trees to the upper intertidal zone. All other areas provide no recruitment of LWD because of a lack of trees.

MICROCLIMATE

Microclimate conditions are currently poor throughout the Duwamish River riparian zone. There was no direct information regarding microclimate and the effects on salmonids readily available for incorporation into this report.

MAJOR TRIBUTARIES

SOOS CREEK (RM 0 – RM 13)

HISTORICAL CONDITION

No information was located that described historical riparian conditions along mainstem Soos Creek. In general, it is likely that vegetation in the Soos Creek watershed was similar to that found elsewhere in the Puget Sound region. There were numerous small ponds and lakes in the upland areas that form the headwaters of Soos Creek. Soils and geology maps suggest there also were numerous wetlands in the upper Soos Creek basin (Mullineaux 1970; King County 1989). These areas were probably characterized by a mixture of emergent wetlands or wet meadows intermixed with forested wetlands and uplands supporting Douglas-fir on the dryer sites. The canyon reach (RM 2 to RM 5) most likely supported a dense stand of coniferous trees. Vegetation would have been similar to that described for the Middle Green River where Soos Creek leaves the canyon and flows across the Green River floodplain before joining the mainstem.

CURRENT CONDITIONS

Little mature native vegetation remains in the riparian zone along mainstem Soos Creek. There is still an intact riparian zone supporting native tree species between RM 1.5 to RM 2.8, and patches of native deciduous trees also occur elsewhere along the lower six miles of the Creek (Figure RIP-4). However, these trees are generally small. The remainder of the riparian zone is composed primarily of shrubs or grass. Development and roads limit the riparian zone width in many cases.

Bank Stability. Because riparian communities along Soos Creek are composed primarily of shrubs or small trees, none of the stream system is considered to have good bank stability (Table RIP-10). Areas such as the reach between RM 1.5 and RM 3 that now support stands of small deciduous trees or mixed coniferous and deciduous trees are considered to be in fair condition and will attain good condition if allowed to mature.

Shade. Like bank stability, shade is considered to be in good condition only where there are dense stands of medium or large trees. The Soos Creek channel was generally visible on aerial photos, indicating that existing shade levels are less than 40 percent; the target shade to maintain temperatures below 16 ^{o}C at this elevation ranges from 80 to 90 percent (WFPB 1997). None of the riparian habitat along Soos Creek is considered to provide good shade at the present time (Table RIP-10), although good shade could develop in the 4.5 miles of riparian habitat currently rated fair if the area remains undisturbed. Development precludes achievement of good shade conditions along the remainder of Soos Creek. In particular, cleared areas adjacent to the channel downstream of RM 1.5 and powerline corridors that parallel the stream upstream of RM 6 prohibit development of mature riparian vegetation.

Organic Matter and Terrestrial Invertebrate Recruitment. Current riparian condition along Soos Creek with respect to organic matter (OM) and terrestrial insect recruitment is similar to conditions described for shade. Recruitment of OM and insects are currently fair within the young deciduous stand located between RM 1.5 and RM 3.0. Elsewhere the lack of tall, mature trees limits the supply of OM and terrestrial insects delivered to Soos Creek.

Sediment Filtration. As noted previously, dense stands of young trees or shrubs are sufficient to provide good sediment filtration where the riparian zone is at least 150 feet wide. Approximately 45 percent of the existing riparian zone along Soos Creek provides good sediment filtration (Table RIP-10). Elsewhere roads, development, or other contributing activities near the stream reduce the ability of riparian area to filter fine sediment.

Large Woody Debris Recruitment. Because existing stands of riparian trees (where present) are small, LWD recruitment is currently considered poor all along Soos Creek (Table RIP-10). As the riparian stand between RM 1.5 and 2.8 matures, it will begin to provide functional LWD. However, wood recruitment along the remainder of Soos Creek is expected to remain low, as landuse activities effectively preclude the development of mature riparian stands.

Channel Migration Zone. Delineation of the channel migration zone associated with smaller streams such as Soos Creek requires field data. Consequently, channel migration zone conditions in Soos Creek were not assessed for this report.

Microclimate. Microclimate conditions are also currently poor throughout the Soos Creek riparian zone (Table RIP-10). As with LWD, when the riparian stand between RM 1.5 and 2.8 matures, it will begin to provide good microclimate conditions. However, the microclimate along the remainder of Soos Creek is expected to remain in poor condition, because existing landuse activities effectively preclude the development of mature riparian stands wide enough to provide good microclimate.

NEWAUKUM CREEK (RM 0-RM 12)

HISTORICAL CONDITION

No information was located that described historic vegetation patterns in the Newaukum Creek basin. In general, it is likely that vegetation there was similar to that elsewhere in the Puget Sound. Newaukum Creek originates in the Cascade foothills east of Enumclaw. Vegetation in this areas consists primarily of Douglas-fir and western Hemlock, with western redcedar and various deciduous species occurring along streams. The middle portion of Newaukum Creek (RM 3 to RM 9) flows across the Osceola mudflow deposit (Mullineaux 1970). Like the headwaters of Soos Creek, a geologic map of that area suggest there were numerous wetlands (Mullineaux 1970). These areas were likely characterized by a mixture of wet meadows or forested wetlands, while drier areas probably supported Douglas-fir. The canyon reach (RM 2 to RM 5) probably supported a dense stand of coniferous trees.

CURRENT CONDITIONS

The riparian assessment of Newaukum Creek covered only the areas downstream of RM 10. Much of the middle portion of the basin has been developed for agriculture. Little mature native vegetation remains along Newaukum Creek between RM 3 and RM 10. There is an intact riparian zone supporting native tree species from RM 3 to the confluence with the Green River. There are also intact riparian zones covered by shrubs or small trees between RM 6.7 and RM 7 and on the left bank between RM 7.5 and 8.2. These represent locations where functional riparian zones could develop in the future if they remain undisturbed. None of the riparian zone along Newaukum Creek is currently considered to be in good condition (Figure RIP-4) or functioning properly according to the NMFS criteria. However, there is approximately 6.8 miles of habitat that is currently in fair condition and that will develop into good riparian habitat if allowed to mature. Most of this habitat is located in the canyon between RM 0 and RM 3. There are also stands of dense young deciduous trees between RM 6.7 and RM 7 and along the left bank from RM 7.5 to RM 8.2 that could develop into good riparian habitat in the future.

Bank Stability. Overall, almost 40 percent of the stream banks along Newaukum Creek support riparian vegetation sufficient to maintain bank stability (Table RIP-10). An additional 8 percent (1.5 miles) is currently in fair condition. However, extensive agricultural development in the valley between RM 3 and RM 9 has substantially impacted bank stability; 53 percent of the habitat overall is in poor condition, and conditions are not expected to improve in those reaches unless native riparian vegetation is restored.

Shade, The canyon Newaukum Creek has cut through the bluff adjoining the mainstem Green River provides the best remaining riparian habitat along the mainstem of Newaukum Creek. Shade is currently good in this reach (RM 0.1 to RM 3). Shade is considered poor along the remainder of Newaukum Creek upstream of RM 3.

Organic Matter and Terrestrial Invertebrate Recruitment. The current condition of riparian zones with respect to organic matter (OM) and terrestrial insect recruitment are similar to conditions described for shade. Recruitment of OM and insects are currently good within the mixed stand of medium sized trees located between RM 0.1 and RM 3.0. Elsewhere the lack of tall, mature trees limits the supply of OM and terrestrial insects delivered to Newaukum Creek.

Sediment Filtration. Sediment filtration is rated good in 47 percent of the existing riparian habitat along Newaukum Creek (Table RIP-10). Elsewhere agricultural development has substantially reduced the ability of the riparian zone to filter sediment.

Large Woody Debris Recruitment. LWD recruitment is currently in fair condition along lower Newaukum Creek (RM 0.1 to RM 0.3). As the riparian stand matures, it will begin to provide functional LWD. Stands of young deciduous trees are also present between RM 6.7 and RM 7.0 and on the left bank from RM 7.5 to RM 8.2. These stands could serve as a source of LWD recruitment in the future if they are protected and allowed to mature. Wood recruitment along the remainder of Newaukum Creek is expected to remain low, as landuse activities effectively preclude the development of mature riparian stands.

Channel Migration Zone. Delineation of the channel migration zone associated with smaller streams such as Newaukum Creek requires field data. Consequently, channel migration zone conditions in Newaukum Creek were not assessed for this report.

Microclimate. Microclimate is currently in poor condition in 67 percent of the riparian habitat along Newaukum Creek, where trees have been removed and existing vegetation consists of grass or shrubs. As for LWD, when the riparian stand between RM 0.1 and 3.0 matures, it will begin to provide good microclimate conditions. However, the microclimate along the remainder of Soos Creek is expected to remain in poor condition, as landuse activities effectively preclude the development of mature riparian stands.

Table RIP-1. Range and average widths required to maintain proper riparian function as reported in the literature (after Knutsen and Naef 1997).		
Riparian Function	**Range of Reported Widths (Ft)**	**Average of Reported Width (Ft)**
Bank Stability	34-44	38
Shade	31-151	90
Organic Matter Recruitment	50-75	NA
Sediment Filtration	26-300	138
Large Woody Debris Recruitment	100-200	147
M icroclimate	200-525	287
NA=Not applicable		

Table RIP-2. Parameters used to characterize the current condition of riparian zones along the mainstem Green River (after WFPB 1997).	
Parameter	**Values**
Cover Type	Bare/Pavement Grass/Forb Shrub Deciduous tree Coniferous tree Mixed deciduous and coniferous tree
Size (tree only)	Small (<12 inches dbh) Medium (12 to 20 inches dbh) Large (>20 inches dbh)
Density	Sparse (>33 percent bare ground visible on aerial photo) Dense (<33 percent bare ground visible on aerial photo)

Table RIP-3. Criteria used to evaluate riparian function along the mainstem Green River.						
	Width			**Vegetation**		
Function	**Good**	**Fair**	**Poor**	**Good**	**Fair**	**Poor**
Bank Stability	≥50	25-50	<25	Dense Med/Lg trees	Dense small trees	Sparse trees, shrub, grass or bare
OM/Terrestrial Insect inputs	>75	50-75	<50	Dense Med/Lg trees	Dense small trees	Sparse trees, shrub, grass or bare
Shade	≥100	75-100	<75	Dense Med/Lg trees (mainstem) Dense trees (tributaries)	Dense small trees (mainstem) Dense shrubs (tributaries)	Sparse trees, shrub, grass or bare
Sediment filtration	≥150	75-150	<75	Dense trees or shrubs	Dense trees or shrub; or contributing activities 200-300 ft	Sparse trees, grass, bare; or contributing activities within 200 feet
LWD	≥150	100-150	<100	Large, dense, conifer, deciduous or mixed (mainstem) Medium to large, dense conifer or mixed (tributaries	Medium, dense deciduous; sparse, large conifer or mixed	Sparse medium of large trees, small trees, shrub, grass or paved
Microclimate	≥300	200-300	<200	Dense large trees	Dense medium trees	Sparse or young trees; shrub, grass or paved

Table RIP-4. Summary of riparian condition functional status in the Upper Green River sub-watershed, RM 64.5 TO 84[1].				
Function	**Good (miles/percent)**	**Fair (miles/percent)**	**Poor (miles/percent)**	**Comment**
Bank Stability	21.6 (50%)	7.2 (17%)	14.0 (33%)	Raw eroding banks or slides at RM 32.5, 36.1, 37.5, 39-40, RM 43, and 44
Shade	0 (0%)	21.6 (51%)	21.2 (49%)	Based on criteria table; actual shade is naturally low due to channel width
OM/terrestrial invertebrate recruitment	21.6 (51%)	6.1 (14%)	15.1 (35%)	
Sediment Filtration	26.8 (63%)	0.9 (2%)	15.1(35%)	
LWD recruitment	0 (0%)	21.6 (51%)	21.2 (49%)	Majority of properly functioning located within gorge and Metzler O'Grady Park
Micro-climate	0 (0%)	21.1 (49%)	21.7 (51%)	
[1]Data for RM 64.5 to RM 76 from USFS watershed analysis GIS data; Data for RM 76 to RM 84 from Lester Watershed Analysis.				

Table RIP-5. Summary of riparian condition functional status in the Middle Green River subwatershed.				
Function	**Good (miles/percent)**	**Fair (miles/percent)**	**Poor (miles/percent))**	**Comment**
Bank Stability	40.05 (64%)	6.95 (11%)	15.4 (24%)	Raw eroding banks or slides at RM 32.5, 36.1, 37.5, 39-40, RM 43, and 44
Shade	39.45 (63%)	4.85 (8%)	18.1 (29%)	Based on criteria table; actual shade is naturally low due to channel width
OM/terrestrial invertebrate recruitment	40.05 (64%)	5.35 (9%)	17.2 (27%)	
Sediment Filtration	40.80 (65%)	7.25 (12%)	14.35 (23%)	
LWD recruitment	22.6 (36%)	16.35 (26%)	23.45 (38%)	Majority of properly functioning located within gorge and Metzler O'Grady Park
Micro-climate	18.2 (29%)	11.65 (19%)	32.55 (52%)	

Table RIP-6. Summary of riparian condition functional status in the Lower Green River subwatershed.				
Function	**Good (miles/percent)**	**Fair (miles/percent)**	**Poor (miles/percent)**	**Comments**
Bank Stability	NA	NA	NA	Actual bank stability driven by levees/revetments
Shade	1.1 (3%)	5.0 (12%)	35.9 (85%)	
OM/terrestrial invertebrate recruitment	1.1 (3%)	5.0 (12%)	35.9 (85%)	
Sediment Filtration	1.8 (4%)	5.9 (14%)	34.3 (82%)	Greater functional habitat because shrubs and young trees provide filtration
LWD recruitment	0	1.1 (3%)	40.9 (97%)	
Micro-climate	0	1.1 (3%)	40.9 (97%)	

Table RIP-7. Summary of riparian condition functional status in the Duwamish Estuary and Elliott Bay.				
Function	**Good (miles/[%])**	**Fair (miles/[%])**	**Poor (miles/[%])**	**Comment**
Duwamish River RM 11.0 – 5.3 (both banks)				
Bank stability	NA	NA	NA	Actual bank stability driven by levees/revetments
Shade	0	4.0 (35.4)	7.4 (64.6)	Temperature moderation function less relevant in estuary than upstream
OM/terrestrial invertebrate recruitment	0	1.3 (11.6)	10.1 (88.4)	Invertebrate recruitment supplemented by tidal marsh vegetation in limited areas
Sediment filtration	0	1.3 (11.6)	10.1 (88.4)	Function in estuary less critical than in upstream areas
LWD recruitment	0	1.3 (11.6)	10.1 (88.4)	Function in estuary less critical than in upstream areas
Microclimate	0	0	0	Not relevant in estuary
Duwamish River RM 5.3 – mouth (both banks up to the East and West waterways)				
Bank stability	NA	NA	NA	Actual bank stability driven by levees/revetments
Shade	0.7 (4.4)	0.02 (1.7)	14.4 (93.9)	Temperature moderation function less relevant in estuary than upstream
OM/terrestrial invertebrate recruitment	0.7 (4.4)	0.02 (1.7)	14.4 (93.9)	Invertebrate recruitment supplemented by tidal marsh vegetation in limited areas
Sediment filtration	0.7 (4.4)	0.02 (1.7)	14.4 (93.9)	Function in estuary less critical than in upstream areas
LWD recruitment	0.7 (4.4)	0	14.6 (95.6)	Function in estuary less critical than in upstream areas
Microclimate	0.7 (4.4)	0	14.6 (95.6)	Not relevant in estuary
Elliott Bay – West Point to Alki Point (including the East and West waterways)				
Bank stability	NA	NA	NA	Actual bank stability driven by levees/revetments
Shade	1.2 (6.3)	1.4 (7.50)	16.4 (86.3)	Important primarily in potential surf smelt spawning areas
OM/terrestrial invertebrate recruitment	1.4 (7.5)	1.2 (6.3)	16.4 (86.3)	
Sediment filtration	1.2 (6.3)	1.4 (7.50)	16.4 (86.3)	Function in nearshore less important than in riverine areas
LWD recruitment	1.2 (6.3)	1.4 (7.50)	16.4 (86.3)	Function in nearshore less important than in riverine areas
Microclimate	0.5 (2.6)	0	18.6 (97.4)	Not relevant in estuary
Sediment supply/feeder bluffs	Unriprapped section of Magnolia to West Point	0	All the rest of shoreline	

Table RIP-8. The Duwamish Estuary habitat changes from 1854 to 1986 (Blomberg et al. 1988).					
	Year (percent change)				Cumulative Percent Change
Habitat Types	**1854**	**1908**	**1940**	**1986**	
Medium depth water (acres)	440	410 (-7%)	390 (-5%)	360 (-8%)	-18%
Shallows and flats (acres)	1,450	1,080 (-26%)	130 (-88%)	25 (-81%)	- 98%
Tidal marshes (acres)	1,170	970 (-17%)	160 (-84%)	20 (-88%)	- 98%
Tidal swamps (acres)	1,230	590 (-52%)	0	0	- 100%
Riparian shoreline (ft)	93,000	90,000 (-3%)	38,000 (-58%)	19,000 (-50%)	- 80%
Development Conditions					
Deep water (acres)	—	240	210 (-12%)		
Developed shorelands and floodplain (acres)	0	1,210	3,750 (+310%)	5,220 (+39%)	+430%
Developed shoreline (ft)	0	4,000	47,000 (+1175%)	53,000 (+12%)	+1,430%
New shoreline from fill (ft)	—	21,000	28,000 (+33%)	28,000	—

Table RIP-9. Elliott Bay/Duwamish Estuary riparian habitat (Pentec Field Survey 1999, Port of Seattle unpublished data).			
Riparian Zone	**Linear Ft**	**Miles**	**Percentage of Shoreline (both banks)**
Duwamish Estuary RM 11.0 to RM 5.3			
Trees	21,340	4.04	35.4
Shrubs	45,140	8.55	75
Grass	3,130	0.59	5.2
Duwamish Estuary RM 5.3 to RM 0.0			
Vegetated shoreline*	22,400	4,024	27.6
Elliott Bay – Don Armeni Park to Terminal 91			
Vegetated shoreline*	3,150	0.6	4.5
* Port of Seattle data were not broken into riparian type, but limited aerial photographs indicate that few trees are present.			

Table RIP-10. Summary of riparian condition functional status in the Major Tributaries to the Green River.				
Function	Good (miles /(%))	Fair (miles /(%))	Poor (miles /(%))	Comment
Soos Creek				
Bank Stability	0	7.0 (35)	13.0 (65)	
Shade	0	4.5 (22)	15.5 (78)	
OM/terrestrial invertebrate recruitment	0	4.5 (22)	15.5 (78)	
Sediment Filtration	9.12 (45)	2.35 (12)	8.5 (43)	
LWD recruitment	0	0	20 (100)	RMZ intact, but trees appear small from RM 1.5 to 2.8
Micro-climate	0	0	20 (100)	
Newaukum Creek				
Bank Stability	6.7 (39%)	1.35 (8%)	9.05 (53%)	
Shade	6.7 (39%)	1.35 (8%)	9.05 (53%)	
OM/terrestrial invertebrate recruitment	6.7 (39%)	1.35 (8%)	9.05 (53%)	
Sediment Filtration	8.05 (47%)	0	9.05 (53%)	
LWD recruitment	0	6.8 (40%)	10.4 (60%)	At risk in canyon because of tree size; small dense stands 6.7-7 and 8.4-8.9 patches with future potential
Micro-climate	0	5.7 (33%)	11.3 (67%)	

LIST OF TABLES

LIST OF FIGURES