City of Corvallis Salmon Response Plan

Chapter 5. Baseline Conditions

Prepared for:

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August 20, 2004

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Disclaimer

The authors have attempted to replace all references to Squaw Creek with the creek's new name, Dunawi Creek. This includes replacing the creek's full name as well as changing Squaw Creek Reach reference labels to indicate Dunawi Creek.

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CHAPTER 5. BASELINE CONDITIONS

INTRODUCTION

The purpose of this chapter is to present an overview of the baseline conditions for Chinook salmon habitat. This covers the data collected and evaluated in Phase One of the project (see *Baseline Habitat Evaluation and Evaluation of the Impacts of City Activities*, February 2002) and the technical memorandum titled *Description of Habitat for Upper Willamette River Spring Chinook ESU* (March 3, 2003). The stream and river reaches identified in the baseline descriptions are displayed in Figure 3 (Chapter 3).

Dixon Creek (From Corvallis Stormwater Master Plan, 2000)

Dixon Creek originates in the hills to the northwest of Corvallis. Most of its length lies within the City, where it is an important feature of many residential backyards. It also runs through several school properties and parks before reaching commercial property at 9th Street and Reiman Avenue and shortly thereafter, the Willamette River. The Dixon Creek watershed contains 2,712 acres. The largest land use is low-density residential, which covers more than one-third of the watershed. In addition, medium density residential, OSU forest (McDonald-Dunn Forest) land, and vacant parcels each cover approximately 400 acres. Estimated current impervious surface coverage is 897 acres, which is approximately 33% of total watershed acreage

If the watershed is developed to full build-out according to the City of Corvallis' Comprehensive Plan (1998), the current vacant land may be largely converted into low- and high-density residential use. Other changes may also include a decrease in medium-density residential and an increase in commercial land use. Overall, the number of impervious acres is estimated to increase by 13%, from the current 897 acres to 1,017 acres, or nearly 38% of the watershed acreage.

The following habitat evaluations summarize the information from the Streamwalks conducted by Watershed Applications and field analyses conducted by the ESA project team.

Temperature

The City is evaluating temperature at four permanent monitoring sites in Dixon Creek. Thermistors at the sites record the water temperature hourly.

Sediment/Turbidity

The high levels of fine sediment found throughout the Dixon Creek watershed are likely a function of the local geology and urbanization. In the vicinity of Dixon Creek, the Willamette valley floor is composed nearly entirely of silty-loam soils. Therefore, high levels of fine and suspended sediments are likely natural features of the stream. Stream incision and bank erosion likely have added to the natural loads of fine and suspended sediments. Nutrient inputs from urban landscaping and fertilizing likely have increased the amount of algae in the stream and contributed to higher turbidity levels.

Chemical and Nutrient Contamination

The U.S. Geological Survey (USGS) assessed Dixon Creek during its sampling in the mid-1990s. The chemicals found in it placed it in the non-agricultural chemical source category. These included Carbaryl (Sevin), used for both home and landscape applications; Dichlobenil (Casoron) and Tebuthiuron, used to control broadleaf weeds and applied under asphalt and on railway rights-of-way (ROW); Diazinon, whose use is similar to Carbaryl; and Prometon, which is used in urban landscaping, ROW, and industrial applications, and by homeowners. Dixon Creek also exceeded standards for temperature, fecal coliform, and *E. coli* bacteria. It appeared to have no excessive nutrients. This stream likely carries the "usual" urban runoff components of metals and petroleum products.

Physical Barriers

A partial barrier exists at the confluence of Dixon Creek and the Willamette River. The box culvert under Highway 20 has been modified to promote fish passage by creating deeper, slower flows through a portion of the culvert. However, because the culvert is perched and falls onto riprap, access to the culvert's fishway is restricted to times when the water level in the Willamette reaches the culvert outfall (mainly during winter and spring flows).

Flat-bottomed box culverts located at 3rd Street, 4th Street, Buchanan Avenue, Kings Boulevard, 29th Street, and Walnut Boulevard may pose additional passage problems during high and low flows. Dace were observed in the stream up to 29th Street, indicating that all of these box culverts are likely passable during some flow conditions.

Substrate

Exposed clay layers, silt, and riprap are the most common substrates in Dixon Creek. The high levels of silt and lack of gravel are likely a function of the local geology. No rock outcroppings or colluvial debris slides occur in the watershed to serve as a source of coarse stream sediments. Moreover, the silt loam soils that dominate this area of the Willamette valley (USDA 1975) are likely the dominant streambed material in the small wetland channels that historically occurred in the Corvallis area. The exposed clay substrate likely results from urbanization along Dixon Creek. Channelization and changes to the creek's hydrograph have led to increased downcutting of the streambed and the exposure of clay layers formerly covered by the more erodible silt soils. The large quantities of riprap in the channel result from the frequent bank stabilization efforts needed to protect the highly erodible streambanks.

Large Wood (LW)

The small amount of LW in Dixon Creek does not contribute significantly to stream complexity or aquatic refuge and represents a distinct change from the high amounts expected, historically. Most of the wood in the creek consists of small-diameter deciduous logs that decay rapidly and have little potential to create significant instream cover. The highest concentrations of LW are in the small headwater streams of Dixon Creek where fish presence is unlikely, as is downstream transport of the LW. Future LW recruitment potential is limited by the reduced size of the riparian zones and channel incision.

Pool Frequency

Trench scour pools, with long glide-like tail-outs, were the dominant habitat types in reaches of Dixon Creek that could potentially support salmonids. However, pool frequency does not meet the standard established by NOAA Fisheries. The long pool lengths precluded sufficient numbers of pools from occurring in any 1.6 km length of stream.

Pool Quality

Pool quality in Dixon Creek is poor. Deep scour or trench pools are abundant in Dixon Creek; however, they lack structure such as LW and undercut banks that provide cover for fish. Reduction of pool depth because of sediment deposition is not a concern in Dixon Creek. The channelized nature of the stream ensures that all deposited sediments are washed out of the system during high flow events.

Off-Channel Habitat

Channel entrenchment in the lower reaches of Dixon Creek precludes the formation of off-channel habitat. No off-channel habitat exists in stream reaches along the mainstem of Dixon Creek or the lower portions of the tributary streams.

Refugia

Dixon Creek was likely bordered by upland gallery forests and lowland prairies before settlement by Euro-Americans. Land conversion and urbanization have dramatically changed the nature of the stream and its riparian areas. While a small amount of remnant aquatic refugia may exist in the headwater streams, none was observed during the survey. The natural wetland channels have been converted to a single entrenched channel. Gallery forests and riparian wetlands have been replaced with residential developments. Riparian buffers are narrow and have been overrun by invasive species such as Himalayan blackberry (*Rubus discolor*) and bedstraw (*Galium* sp.).

Width-to-depth Ratio

Width-to-depth ratio is estimated to be approximately 8, and meets the NOAA Fisheries criteria for PFC. However, because the channel is entrenched and revetments often prevent the stream from widening, this indicator may not be appropriate for use in evaluating stream health. This relatively low width-to-depth ratio likely results from urbanization than preservation of natural habitat conditions. Habitat features usually associated with low width-to-depth ratios, such as lower stream temperatures and instream cover, are not characteristic of the current conditions in Dixon Creek.

Streambank Condition

The conditions of streambanks in Dixon Creek are variable. Root masses of living trees are being undercut by the stream and bank erosion is common in the upper watershed. In areas where root masses are being undercut, future bank erosion is likely as the trees fall and expose unstabilized soils. Large portions of the streambanks have been armored with riprap, gabions, and log bulkheads. As more impervious surface is added to the watershed, bank erosion and undercutting will likely increase.

Floodplain Connectivity

Channel incision has severed much of the natural hydrologic link between the floodplain and the stream channel. Incision depth in the mainstem of Dixon Creek averages approximately 2.5 m. Any flows that once may have regularly exceeded the streambanks and inundated the floodplain are now confined to the entrenched channel. Overbank flooding now occurs only during extreme runoff events. Wetland riparian areas that once bordered the creek have become perched and drained as the water table has deepened.

Peak and Base Flows

Peak and base flows undoubtedly have been altered by the loss of riparian wetlands, channel incision, land conversion, and the addition of large amounts of impervious surface to the watershed. The loss of floodplain wetlands caused by historic and present-day channel incision decrease the watershed's capacity to store water and likely has resulted in decreased base flows. Channel incision has increased the conveyance capability in the watershed and contributed to sharper peaks in the stream hydrograph. The addition of large amounts of impervious surface, coupled with stormwater conveyance systems, creates a pathway by which precipitation is collected and quickly piped to the stream rather than percolating into the groundwater or slowly trickling into the stream. This rapid transformation of precipitation to runoff creates unnaturally high and sharp spikes in the hydrograph of Dixon Creek.

Road Density and Location

Road density in the urban environment of Dixon Creek is very high. A significant portion of the watershed is covered with impervious surface. Roads closely parallel the stream in many places and numerous road crossings fragment the aquatic and riparian habitat.

Disturbance History

More than 60% of the Dixon Creek watershed has been developed for commercial or residential purposes. Very little late successional or old growth forest remains in the area. Because of the permanent nature of urban development, no significant improvements to this indicator are expected.

Riparian Reserves

Approximately 80% of the riparian area in the watershed is developed. Riparian vegetation in the developed areas is confined to the land at or below the top of bank. At least 33 road crossings occur on Dixon Creek. These crossings reduce the connectivity and create a discontinuous series of isolated riparian areas.

Dunawi Creek (From Corvallis Stormwater Master Plan, 2000)

Dunawi Creek runs from Bald Hill Park west of Corvallis eastward to its conjunction with the Mary's River at Brooklane Drive. The Dunawi Creek watershed contains 2,363 acres. The largest land uses in the watershed are low-density residential (766 acres) and vacant land (609 acres). Some land in the watershed is used for industry and commerce, although this is mostly limited to the Sunset Research Park and along Philomath Boulevard (Highway 20/34). If the watershed is developed according to the City of Corvallis' Comprehensive Plan (1998), all of the vacant land may be developed, with most of it converted to residential use. In addition, medium- and high-density dwellings will make up an increasingly larger portion of the residential land use. As a result of these changes, the amount of impervious surface could increase from 762 to 968 acres, an increase of 27%.

Temperature

Temperature was not assessed because the survey period did not overlap with the summer months when stream temperatures are of greatest concern. The City of Corvallis currently is conducting a temperature assessment.

Sediment/Turbidity

Dunawi Creek contains high levels of fine sediment. Silt, sand, and organic matter are the most common substrates. The water in the creek had low visibility at the time of survey. The high level of fine sediment and turbid nature of the water likely are caused by the wetlands in the watershed and the presence of the predominant substrates (clays and other fine sediments). The slow, flat nature of the watershed allows for accumulation and decomposition of organic material, as well as benthic algae blooms. The high color of the creek is likely caused by tannic acid or other solutes produced by decomposing organic material.

Chemical Contamination

The urban chemicals that may be present in this basin are the same as those potentially present in Dixon Creek.

Physical Barriers

A retaining wall just upstream from the confluence of Dunawi Creek and the Mary's River creates a 1-meter drop that creates a barrier to Chinook salmon fish passage. The height of the falls and the lack of a plunge pool below it eliminates fish migration from the Mary's River into the Dunawi Creek watershed. Reconstructing the retaining wall to make it passable to Chinook salmon would have limited benefits because of the poor quality of upstream salmonid habitat.

Substrate

Clay, silt, sand, and organic materials dominate the substrate in Dunawi Creek. The natural geology of the watershed, as opposed to the human disturbance, likely is the cause of the high level of fine sediment. Coarse substrates other than riprap were not found in significant quantities in any portion of the watershed and appear to be absent from all alluvial layers exposed by the stream. Moreover, the flat topography of the watershed does not create enough stream energy to produce the downcutting needed to expose sources of coarse sediment or transport such sediment once it has been exposed. Without a source of gravel and cobble substrates, Dunawi Creek appears always to have been devoid of coarse substrates.

Large Wood

LW is scarce in the Dunawi Creek drainage. No pieces that match the NOAA Fisheries definition of 24-inch diameter and 5-foot length were observed in the stream channel. Small accumulations of woody debris are common in many reaches. Because of the small size of Dunawi Creek and the low energy of the flows, these accumulations are able to persist within the active channel, functioning similarly to pieces of LW. These accumulations create small pockets of scour and could provide cover to any fish that potentially inhabit the creek.

Pool Frequency and Pool Quality

Pool frequency and pool quality are very poor. Aquatic habitat is largely composed of slowly moving, slack-water glides. Riffles are short and infrequent. Pools with significant scour are even more infrequent. The one wide pool is present in Reach 2, which results from a relatively large debris jam.

Off-Channel Habitat

The pond near the top of the south fork and the millpond on the north fork (both artificial situations) are the only two significant areas of off-channel habitat.

Refugia

Intact, well-buffered riparian areas exist in few areas of the Dunawi Creek watershed. Residential and commercial developments, city parks, and agricultural fields all encroach into Dunawi Creek riparian areas. This disturbance to riparian habitat has aided the invasion of species such as reed canarygrass (*Phalaris arundinacea*) and Himalayan blackberry. Approximately 33% of the total stream habitat has been straightened and channelized. In other areas, the channel appears to have been excavated for the purpose of enhancing stream conveyance. Encroachments into the riparian areas and channel modification limit the amount of suitable habitat available to sensitive aquatic species.

Width-to-depth Ratio

The width-to-depth ratio in Dunawi Creek is less than 10. The glide-like streambed common in the creek averages approximately 0.15 to 0.2 m in depth. The channel width averages about 1.5 m across.

Streambank Condition

Bank erosion in Dunawi Creek is uncommon. Eroding banks are present in small areas of Reach 2 and the upper portion of Reach 3. The erosion in Reach 3 is just below the stormwater outfalls and box culverts located at 35th Street, where large sections of the bank are collapsing into the creek. In other portions of the creek, low stream gradients do not appear to generate enough energy to undermine rooted vegetation and erode bank substrates. Streambank conditions in the Dunawi Creek watershed appear stable, with little evidence of erosion.

Floodplain Connectivity

With the exception of the channelized portions of Dunawi Creek (approximately one-third of the watershed) most of the stream regularly exceeds its banks and inundates the local floodplains. Evidence of ephemeral side channels is apparent in many wetland riparian areas.

Changes in Peak and Base Flow

Some changes in peak and base flow likely have occurred as a result of channelizing and increasing impervious surface. Approximately 33% of the channel has been straightened or confined within artificial banks. These channelized stream segments have a reduced capacity to detain flows during peak runoff events, and have little water storage potential. The increase in impervious surface creates quicker, higher spikes in runoff after rainfall events. The magnitude of the changes has not been quantified; however, based on instream indicators such as increased frequency of erosion and channel downcutting, the hydrologic changes associated with development have not been great enough to produce large changes in the channel morphology. The extent to which summertime flows have been altered because of decreased storage capacity has not been evaluated.

Disturbance History

Dunawi Creek is an urbanized stream. Nearby forest clearing, development, and agriculture have disturbed the entire watershed. Very little mature forest exists in the watershed.

Riparian Reserves

Riparian corridors and setbacks have been established along much of Dunawi Creek. These vary in width from a few meters to nearly 100 meters. In corridor areas, near Technology Loop for example, reestablishment of native riparian vegetation appears to be impaired by invasive species. Overstory trees do not appear to be recolonizing these areas, and riparian shading and function have been lost. Many of the undisturbed riparian areas are functioning in a limited capacity. The overstory in these areas provides good canopy closure and shade to the channel. However, invasive species such as Himalayan blackberry and reed canarygrass are colonizing many areas.

Oak Creek (From Corvallis Stormwater Master Plan, 2000)

The Oak Creek Watershed is the largest watershed within the study area of this plan. The upper reaches of Oak Creek lie outside the city limits and the UGB. The stream's headwaters are located northwest of Corvallis in McDonald State Forest, on the southern slopes of Cardwell Hill at about 747 meters in elevation. Oak Creek follows logging roads southward past Dimple Hill and the OSU Experimental Station. The creek follows Oak Creek Drive, where it is joined by Alder Creek downstream from Skillings Drive. Mulkey Creek joins Oak Creek from the west, downstream from Bald Hill Park. Oak Creek flows under 53rd Street just north of Harrison Boulevard.

The lower reaches begin just outside the UGB beginning where Oak Creek crosses Harrison Boulevard to the south and then crosses into the city limits. The stream then flows southeast toward OSU. It flows through pastures, farm buildings, and research facilities before reaching the main body of the campus. On the south side of the OSU campus, the creek is bounded by the Reser Stadium parking lot to the northeast and mixed residential use to the southwest. As Oak Creek leaves OSU, it flows through a short residential section before flowing under Highway 20/34 and entering Mary's River.

The Oak Creek watershed contains 8,300 acres. The largest land use type is McDonald-Dunn state forest (managed by Oregon State University), which covers almost 5,900 acres, representing more than 70% of the watershed. Approximately 12% of the watershed (1,030 acres) is used for agricultural purposes. OSU manages both the forestland and most of the agricultural land. With the addition of the campus itself, OSU manages almost 90% of the land in the watershed. More than 500 acres are listed as undeveloped.

Under future development, the undeveloped land may be built out as residential and some of the OSU agricultural land may be developed for university non-agricultural purposes. The amount of impervious surface in the watershed will increase only slightly under these conditions.

Temperature

The City is assessing temperature regimes in the stream.

Sediment/Turbidity

High, fine sediment loads and turbidity are likely natural features of the Oak Creek drainage. The banks of the creek are composed of alluvial soils that are easily eroded and suspended in the water column. Because of its low gradient (less than 1% slope), the stream often lacks the velocity to transport eroded fine sediment out of the drainage. Instead, it settles out in areas with lower velocities. The naturally occurring high level of turbidity and fine sediment in Oak Creek have likely been augmented with fine sediment loads brought about by human activity. Many portions of the upper watershed have been logged, with historic practices likely contributing fine sediment to the stream. Agricultural fertilizers and manure undoubtedly have leached into the stream, increasing the amount of algae in the water and leading to high turbidity.

Chemical Nutrient Bacteria Contamination

Data collected by the City indicates that concentrations of *E. coli* bacteria in Oak Creek exceed the Oregon Department of Environmental Quality's (DEQ) standard of 126 organisms per 100 milliliters of water. The urban chemicals that may be present in this basin are the same as those potentially present in Dixon Creek. Some agricultural chemicals such as atrazine and related compounds may also be found in Oak Creek.

Physical Barriers

The concrete exit skirt of the twin box culverts at the Highway 20 creek crossing creates a barrier falls. The incision downstream has deepened since construction of the culverts and left the exit apron perched approximately 1 meter. No adequate jumping pools exist immediately below the perched apron. Although the falls created by the culverts appears impassable at all times of the year, juvenile Chinook salmon have been observed upstream from the barrier as recently as 1994. The pop-up dam near the top of Reach 3 creates a second fish passage barrier. The dam is used by OSU to create a pool for irrigation withdrawals and is therefore only in place during the dry season (May through October).

Substrate

Gravel dominates the substrate in the mainstem of Oak Creek; however, silt, sand, bedrock, and native clay layers are also common substrate components. Observed gravel substrates were almost always embedded in sand and silt that clogged interstitial spaces and restricted flows through the substrate. Estimates of embeddedness in mainstem reaches decreased from 50% in the lower two reaches to between 20% and 30% in Reach 3.

Silts and other fine sediments dominated substrates in the tributary streams. These small streams appear to lack a source of coarse substrate and have insufficient energy to transport and distribute such substrates. The high level of fine sediment in these streams is more a function of the surrounding geology and hydrologic state of the streams than any human habitat alterations.

Large Wood

The concentration of LW in the watershed is estimated to be approximately 87 pieces per kilometer. The NOAA Fisheries standard for PFC is 80 pieces of LW per 1.6 km; defined as 60 cm in diameter and at least 15 m long. In the survey, woody debris was counted as LW if it was 10 cm in diameter and 3 meters long. Because very few pieces of woody debris counted in Oak Creek would meet the NOAA Fisheries criteria, concentrations of LW do not meet the NOAA Fisheries standard for PFC.

Downed trees contribute little habitat in the lower reaches of the creek. While concentrations of LW are more substantial in Reaches 2 and 3, they do not approach the amount of LW that historically occurred in the creek. At current levels, LW does not contribute significantly to habitat complexity and only rarely creates deep sheltering pools important for salmonid rearing.

Pool Frequency

Pool frequency may not be an appropriate indicator for evaluating the aquatic habitat in Oak Creek. Because of its low gradient, the creek contains an abundance of pool habitat. These pools are often extensive (one measured 64 meters in length) and contain long glide-like tail-outs. The length of many pools limits the frequency with which they occur.

Pool Quality

Pool quality in lower Oak Creek tends to be poor. Most pools are less than 1 meter deep and frequently lack objects such as LW or boulders that provide instream cover and shelter from high stream flows. The most common form of cover in the creek is undercut living root wads. These provide fish with hiding places for predator avoidance but may not be suitable for shelter from fast current during high flow events. With the exception of the one large debris jam in Reach 3, LW in the creek at the time of the survey did not provide significant sheltering areas that juvenile salmonids would use to avoid high wintertime flows.

Off-Channel Habitat

The deep and narrow incision of the creek offers little opportunity for development of off-channel habitat. Important slack-water features such as side channels, oxbows, and large root wads are absent or rare in Oak Creek. With few structures to deflect the current and no floodplain to disperse the energy of the stream, fish have few places to take refuge from the high flows that fill the incised channel. Many are likely washed out of the drainage during high flow events.

Refugia

Historically Oak Creek was a sinuous stream likely bordered by floodplain wetlands, prairies, and gallery woodlands. Euro-American settlement of the area has resulted in stream channelization, riparian forest clearing, and wetland conversion (OSU 2001), although the lower reaches of Oak Creek now contain more riparian forest than historically. As a result of these activities, very little aquatic refugia still exists on Oak Creek. The deeply incised channel precludes formation of off-channel habitat and floodplain wetlands that are usually associated with refugia. The riparian corridor is narrow, often ending at or near the top of the streambank, and is insufficient to buffer any areas of refugia that may exist. Invasive species such as Himalayan blackberry and reed canarygrass are prominent species along many portions of the creek. As a result, very little remnant habitat for sensitive aquatic species exists in the watershed.

Width-to-depth Ratio

The width-to-depth ratio of Oak Creek was estimated to be less than 10. Channel incision prevents the channel from spreading out into shallow riffles or glides. The high proportion of pool habitat, especially in Reach 2, gives the stream consistently deep residual depths. Due to its low width-to-depth ratio the creek is less prone to temperature fluctuation. The relatively large volume of water in the channel may buffer the stream against rapid temperature increases during periods of high temperature in summer heat waves.

Streambank Condition

The surveyed portion of Reach 2 was the only surveyed area in Oak Creek in which more than 10% of the streambanks were eroding. Approximately 14% of the banks in the surveyed stretch of Reach 2 were eroding, whereas only 9% of the streambank in Reach 1 was eroding. Reach 3 had the lowest proportion of eroding bank with only 3% of the bank showing signs of active erosion. Bank erosion in the tributary streams was uncommon and was estimated to be well below the 10% threshold established by NOAA Fisheries as properly functioning.

The relatively low amount of bank erosion in such a highly disturbed watershed may be attributed to two factors. First, the bulk of channel incision probably occurred in the early part of the century as wetlands were drained and channels modified to create agricultural lands and development of the City of Corvallis. The channel may now be approaching a stage of equilibrium. The channel likely has carved away enough width and depth to accommodate its bankfull flows without eroding its banks. Second, the lower streambank in many portions of the creek is composed of clay layers and cemented alluvial materials that are only slightly erodible. These slightly erodible bank substrates likely slow the rate of erosion in many parts of the creek.

Floodplain Connectivity

Floodplain connectivity along Oak Creek may have degraded dramatically since the 1940s. Benner (1984) describes the Oak Creek channel near the current location of Reser Stadium as being braided as recently as 1936. The land near Oak Creek was described as "low, wet, and especially prone to flooding." By 1956 the channel continued its historic incising, further isolating the forest/prairie from the creek (Benner 1984). The increased channel incision also perched the riparian wetland above the streambed. Floodwaters inundated and recharged the riparian areas less frequently, the water table deepened, and the wetlands were converted to agricultural uses. Hyporheic connections between the stream and floodplain were severed as the channel began to erode into non-permeable clay layers and cemented alluvium.

In its current entrenched condition, the creek has little or no connectivity with its historical floodplain. The low terraces present in Reach 3 have created a new, narrow floodplain below the high terraces of the creek bed.

Changes in Peak and Base Flow

Changes in the peak and base flows of Oak Creek undoubtedly have resulted from channelization, deforestation, and wetland conversion. Channelization of Oak Creek has reduced the capacity of the stream to detain and store water during periods of high runoff. Spikes in discharge are generally greater in magnitude and shorter in duration than historically occurred. Loss of riparian wetlands has likewise reduced the watershed's capacity to store water and likely results in higher peak flows and lower base flows. Deforestation in the Oak Creek drainage also likely resulted in changes to the stream's hydrologic regime. Removal of vegetation from a watershed or changes in vegetated communities from communities with high rates of transpiration to communities with low rates of transpiration may result in higher magnitude peak flows (Brooks et al. 1991).

The precise nature of the changes to the hydrograph of Oak Creek is unknown. It is likely that current peak flows are greater than historical magnitudes because of channel incision, wetland conversion, urban development, and deforestation. Changes in base flow levels are difficult to evaluate because of the opposite and competing effects of deforestation and wetland conversion.

Disturbance History

Timber harvest and the conversion of land for agricultural and municipal purposes have disturbed much of the Oak Creek watershed. The headwaters of Oak Creek are in McDonald Experimental Forest, which has been extensively harvested. The Oak Creek valley between the experimental forest and the Willamette valley is a mosaic of private properties, with high levels of disturbance. Where the Oak Creek channel meets the Willamette valley, commercial, residential, and agricultural land uses have resulted in riparian degradation and loss of wetlands.

Riparian Reserves

The riparian areas along Oak Creek are highly fragmented, narrow bands of vegetation that often inadequately shade the stream channel. The riparian vegetation along much of the creek is restricted to the area between the edge of the stream and the top of the bank. Although stream shading in these areas is sometimes adequate, gaps in the canopy occur in many places, leaving the channel exposed to solar heating. The lack of a riparian buffer in these areas also decreases the potential for LW recruitment into Oak Creek.

In areas where the riparian vegetation extends beyond the top of bank, it is often limited to 10 or 15 meters beyond the top of bank. Stream shading in these areas is generally better than in stream segments with narrower riparian zones, but the lack of a floodplain and riparian wetlands limit riparian functioning. Few large tracts of wide riparian areas exist in the watershed. Large tracts of native riparian forest occur near the covered bridge and bike path crossing in Reach 3, and along the Bald Hill tributary. These areas contain remnants of the gallery forests and riparian wetlands that were once common along the stream.

Sequoia Creek (From Corvallis Stormwater Master Plan, 2000)

The Sequoia Creek headwaters originate near Chip Ross Park. The creek runs generally southeast through residential development then turns eastward near Sycamore Avenue. The creek crosses beneath Highway 99W and the Willamette and Pacific Railroad trestle before turning to the northwest at its junction with Village Green Creek. After being joined by Village Green Creek, Sequoia Creek turns eastward, where it is known as Stewart Slough. The creek crosses beneath Highway 20 and ultimately discharges into the Willamette River.

The Sequoia Creek Watershed contains 1,357 acres. The largest land use at present is low-density residential, which covers approximately 34% of the watershed. Fourteen percent of current use is for medium- and high-density residential. City streets and rights-of-way take up approximately 14% of the available area. Approximately 12% of the land use is industrial, primarily located downstream of Highway 99W. Open spaces make up about 11% of the watershed. Land use in the remaining areas of the watershed includes a mixture of commercial properties, OSU, and vacant land.

As future development occurs, the vacant land may be converted to low-, medium- and high-density residential areas. Other changes may include a decrease in industrial land-use and an increase in commercial use. The number of acres of impervious land will increase from 543 acres to 650 acres (29% increase in impervious surface), thus affecting the quantity and quality of stormwater runoff in the watershed.

Watershed Findings (From Corvallis Stormwater Master Plan, 2000)

The condition of the watershed was evaluated using information from a number of sources, including public comments collected at open houses, City of Corvallis (City) staff input on maintenance and operation issues, a technical stream evaluation of selected reaches, and modeling the stormwater conveyance system for existing and future build-out scenarios.

The elevation of the channel drops quickly relative to the horizontal distance, thus defining a steep gradient upstream of Walnut Boulevard. The gradient flattens out below that point, creating the potential for flooding in the transitional area between the hills and the flat area near the mouth of the creek. The gradient is very flat downstream of 9th Street, thereby increasing the potential for flooding during large storm events.

Riparian conditions vary along the length of the stream. Unlike those of other Corvallis streams, the riparian corridors of Sequoia Creek have more shrub area toward the downstream end. Industrial land-use encroaches on the creek near Jack London Street. Also, a large number of natural debris dams in the creek downstream of Jack London Street obstruct flows. An example of industrial land-use encroaching on the stream occurs at the recycling facility (Corvallis Disposal) located along the north bank of the creek downstream of Highway 99W. Sediment accumulation at the culverts under 9th Street may restrict higher flows.

Mary's River (From Corvallis Stormwater Master Plan, 2000)

The Mary's River watershed portion of this planning effort contains three small drainages that lie south of the Corvallis Country Club. The drainages lie outside the city limits, but inside the UGB. Flows from the drainages run southward underneath Brooklane Drive before entering the Mary's River floodplain. The 78 acres of drainages were modeled from the culverts underneath Brooklane Drive to the top of their drainages at the crest of the hill. The existing land use is split between low-density residential and open space, but the area is undergoing significant development. In the future, low-density residential will cover 69 acres, with the rest preserved with an open space conservation designation. Another subdivision, Brooklane Estates, also is being constructed further to the east in the Mary's River watershed. Brooklane Estates is located south of the Oak Lawn Memorial Park and has its own piped drainage system. This subdivision was not examined in detail or modeled, but is included for the sake of completeness.

Temperature

The Mary's River is listed on the DEQ's 303(d) list for temperature exceeding the 64°F (17.8° C) standard for rearing salmonids. Temperatures exceed the standard on a yearly basis and have been recorded as high as 82.4° F (DEQ 2001).

Chemical/Nutrient Contamination

The Mary's River is listed on the DEQ's 303 (d) list of water-quality limited bodies for bacterial contamination. Fecal coliform levels exceeded state standards in 24% of the samples taken. The Mary's River also contains some levels of atrazine compounds according to the USGS.

Sediment/Turbidity

The Mary's River is turbid and has a high level of fine sediments. Visibility at moderate to low flows was approximately 0.6 m. (2 ft.). Fine sediments are the dominant substrate types. The turbidity and high level of fine sediments is a function of the local geology and land usage. The soft, loamy soils that dominate the banks of the river are easily eroded and suspended in the water column. Deforestation of riparian areas and headwater streams also likely contribute to high levels of suspended sediment. Turbidity also may be affected by increases in nutrient levels from agricultural fertilizers. Increased phosphorous and nitrogen levels will lead to increased concentrations of free-floating algae.

Physical Barriers

No potential barriers to fish passage occur in the surveyed reach of the Mary's River.

Substrate

In areas where the river was shallow enough to assess the substrate, sand and fine sediments or gravel were dominant. However, a layer of non-erodible, cement-like alluvium is also common on the channel bottom.

Large Wood

Fifty-four individual pieces of LW, 16 accumulations, and 10 jams were present in the portion of Mary's River within the UGB. Many of these create small back eddies that would provide refuge during high flows.

Pool Frequency

Pool or pool-like run habitat comprises more than 95% of the habitat in the Mary's River. The scarcity of riffle habitat and abundance of slack water habitat may limit salmonid use of the river. Riffles are important in creating foraging opportunities for salmonids, and the lack of such habitat may decrease its suitability as habitat for these species. Therefore, the high amount of pool and slack water habitat in the Mary's River indicates degraded habitat quality.

Off-Channel Habitat

Only three small areas of off-channel habitat were observed on the Mary's River. The incised nature of the channel limits the formation of off-channel habitat.

Refugia

No significant aquatic refugia occur on the Mary's River within the UGB. Water withdrawals outside of the City, riparian degradation, and alteration of the historic floodplain and hydrograph have led to systemic changes in the aquatic habitat. Remnant areas of pristine habitat or refuges for sensitive aquatic species do not occur on the Mary's River within the UGB.

Streambank Condition

Approximately 570 meters of eroding stream bank was present in the 6,100 meters of surveyed reach of the Mary's River. The large amount of erosion is likely the result of historic human activities, as well local geology and the sinuous nature of the river. Most of the erosion occurs on the outside edge of channel meanders or is associated with LW accumulation and jams. Bank erosion appears to be just as common in areas with extensive riparian buffers as in those developed for agriculture or residential purposes. A variety of bank stabilization strategies such as planting, concrete retaining walls, and riprap revetment are employed in the lower portion of the reach.

Floodplain Connectivity

Floodplain connectivity of the Mary's River is low. The channel is incised 4 to 5 m, making over-bank flows uncommon. Potential riparian wetlands are perched; hyporheic nutrient and water exchanges have been severed or substantially altered.

Change in Peak/Base Flows

Water rights in the Mary's River (outside of the city) have been over-allocated. Instream withdrawal rights exceed flows during the months of September, October and November. Instream withdrawal rights plus allocated rights exceed flows from June through November. The over-allocation of water has been implicated as a likely cause of the decline in the Mary's River cutthroat trout population (Ecosystems Northwest 1999).

Disturbance History

The Mary's River watershed is highly disturbed. Private and public timberlands in the upper reaches of the watershed have been heavily logged in the last century. Very little late successional stage old-growth stands exist in the timberlands of this region of the coast range. Many stands are young second- or third-growth forests. The Willamette Valley portion of the watershed has also been heavily altered. Once covered in native wetland and upland prairies and gallery forests, the valley bottom portion of the watershed has been largely converted to agricultural lands.

Riparian Reserves

Riparian reserves have been significantly depleted along most of the Mary's River within the UGB. Agricultural fields, residential developments, roads, parks and a golf course are all located adjacent to the river. Riparian vegetation is often restricted to a narrow strip of streambank between the top of bank and the wetted channel. Invasive species have colonized much of the riparian area. Himalayan blackberry commonly grows on the stream banks and reed canary grass is the dominant species along the margins of the channel.

Willamette River (From Corvallis Stormwater Master Plan, 2000)

Habitat Features

The Willamette River forms the eastern edge of Corvallis' UGB. Project team biologists walked the western shoreline to identify important habitat features and problem spots.

The western shoreline can be divided into three distinct and approximately equal reaches: a side channel reach, a mainstem reach, and a mainstem reach with revetted banks (see map).

Near its southern end, the UGB is bordered by a series of side channels of the Willamette River. These side channels are deeply incised, and contain very little off-channel habitat. Narrow, low terraces are present on both banks. The low terraces increase in width near their confluence with the Willamette River. Substrate in the side channels was an even mix of fine sediments and gravel. Riffle habitat was uncommon. LW concentrations were low, probably the result of channel incision and width as well as lack of upstream recruitment. The channels are separated from agricultural fields by narrow strips of riparian vegetation. The widths of these riparian areas average approximately 50 feet and are often limited to the area below the top of bank. Riparian vegetation was composed of cottonwood, Oregon ash, and Douglas fir. Reed canary grass was the dominant species near the water's edge.

Between the south UGB boundary and the mouth of the Mary's River, the mainstem Willamette River is only partially incised. In Willamette Park, despite the revetted areas, much of the west bank slopes gently and has been contoured into several overflow channels. These overflow channels create alcoves of off-channel habitat. The substrate of the mainstem appears to be dominated by cobble and gravel substrates. Fine sediment and gravel are the dominant and subdominant substrates in the overflow channels. The riparian overstory is dominated by cottonwood and Oregon ash. Himalayan blackberry is the dominant understory shrub.

Downstream from the confluence with the Mary's River, the mainstem channel becomes confined between riprap lined banks. No off-channel habitat or refuge occurs in this reach. The riparian area is very narrow and is largely composed of willow and blackberry bushes. The instream habitat is composed of a single continuous run. The downtown area and Highway 20 closely parallel much of this reach and limits the potential for any rehabilitation activities.

The Willamette River receives all the agricultural and urban chemicals listed for the previous streams. It also receives treated effluent from the City's Wastewater Treatment Plant. These wastewater discharges are monitored by the City and form part of the baseline

Temperature

The Willamette River is currently listed on the DEQ's 303 (d) list for temperature during the summer months. The City of Corvallis currently conducts temperature monitoring in association with its facilities, which forms part of the baseline dataset.

Sediment/Turbidity

The river is currently considered to be properly functioning in this category.

Chemical Contamination

See Dixon Creek for a list of urban chemicals that may occur in this basin. The river also may have some agricultural chemicals, such as atrazine and related compounds. Nutrient levels are considered to be properly functioning. The Willamette River has a mercury advisory in this area and also is listed for fecal coliforms (e. coli).

Physical Barriers

There are no physical barriers to fish movement in the Willamette River in this area.

Substrate

NOAA Fisheries likely considers the Willamette River as "not properly functioning" in this category, due to the perception of increased fine sediment inputs upstream.

Large Wood

Habitat surveys have indicated that there is little large wood in the system, due to changes in the riparian forests, natural river geomorphology, and river maintenance activities.

Pool Frequency and Pool Quality

This is considered to be properly functioning in this section of the river, but there are areas at risk. The construction of revetments in the area has changed the way the river responds, but as these generally occur on one side only, they shift the stream activities to the other side.

Off Channel Habitat

This is considered to be properly functioning in this section of the river, as there exists off-channel habitat upstream on the east bank.

Refugia

Intact, well-buffered riparian areas exist in very few areas. Residential and commercial developments, city parks, and agricultural fields all encroach on Willamette River riparian areas. This disturbance to riparian habitat has facilitated the introduction of invasive species such as reed canary grass and Himalayan blackberry. Encroachments into the riparian areas and channel modification limit the amount of suitable habitat available to sensitive aquatic species.

Width-to-depth Ratio

The width-to-depth ratio is greater than 12 in most of the mid and upper reaches of the mainstem Willamette River. This resembles the historic condition, which was likely heavy braiding on a broad alluvial flood plain.

Streambank Condition

It would be difficult to classify this indicator as properly functioning, as there is riprap present in some areas. Portions of the stream still have streambanks more similar to the historic condition (see above).

Floodplain Connectivity

This feature is likely to be at risk or not properly functioning. Connectivity with the floodplain has been removed on the west side of the river to control flooding..

Changes in Peak/Base Flow

Some very small changes in peak and base flows probably occurred as a result of channelizing and increased impervious surface, but these are dwarfed by the changes resulting from upstream dam construction, and the high amount of flow in the river itself. These channelized stream segments have a reduced capacity to detain flows during peak runoff events, and have little water storage potential. The increase in impervious surface creates quicker, higher spikes in runoff after rainfall events. The hydrologic changes associated with development have likely produced little change in the channel morphology, despite the presence of revetments, given the geology of the area and the geomorphology of the river in the Corvallis area.

Disturbance History

The Willamette River in the study area is an urbanized system. Increased impervious surface, riparian forest clearing, development along the tributaries and the mainstem, and agriculture practices have disturbed the river. Very little mature forest exists in the area.

Riparian Reserves

Some riparian areas still exist, especially in the Willamette Park area, but riparian systems have been heavily altered.

Jackson, Frazier, Village Green Creeks (From Corvallis Stormwater Master Plan, 2000)

This watershed consists of the Jackson, Frazier, and Village Green Creeks that form a complex network of streams and wetlands to the north of the Corvallis city limits. Jackson and Frazier Creeks both originate in McDonald-Dunn State Forest. The headwaters of Jackson Creek are located near Dimple Peak while Frazier Creek originates further north near Lewisburg Saddle. The two creeks flow eastward through the state forest and into low-density residential developments prior to merging at Highway 99. East of Highway 99 their combined flow enters the Jackson-Frazier Wetlands, an important habitat area. The flow leaving the wetlands is split. Part of the flow heads northeast across farmland to connect with the Willamette River at Bowers Slough, downstream of Lower Kiger Island. The remaining flow runs south from the wetlands as Village Green Creek. Village Green Creek turns to the southeast, flows through largely residential neighborhoods, and eventually joins Sequoia Creek to the east of Conser Street.

The Jackson Creek portion of the watershed contains over 1,500 acres, of which forest land is currently the largest land use (approximately 700 acres). Over 400 acres is currently undeveloped. In the future, the forest land will still be present, but the undeveloped land may largely be replaced by low-density residential development. The Frazier Creek drainage area is larger, with over 2,200 acres within its drainage boundary. Like the Jackson Creek area, the largest land uses are forest (1,000 acres) and undeveloped land (approximately 600 acres). In the future, the undeveloped land may become part of almost 900 acres of new low-density residential development. Currently two-thirds of the 380 acres draining to Village Green Creek are residential. This mix of low-, medium-, and high-density residential will remain the same in the future according to the City's comprehensive plan. The area designated as open space will increase slightly, from 28% at present to 33% in the future.

Village Green Creek is typical of many urbanized streams. It is highly channelized and in many locations has little or no available shade. However, there are few structures encroaching on the stream bank unlike many other Corvallis streams. The open stream banks, such as at Village Green Park are potential sites for projects to enhance stream and riparian health. For instance, in many areas of this watershed the floodplain can be reconnected to the stream, thereby enhancing habitat as well as alleviating downstream flooding potential.

Other stream systems (Jackson and Frazier Creeks above the wetlands, Dry Creek, Ryan Creek, the Millrace) were not evaluated as they contained no potential for being utilized as salmonid habitat. The influence of these systems on overall stream water quality was evaluated in the pathways evaluation section of the report.

Corvallis Area ESA Riparian Area Mapping Summary

All comments apply only to the area within the 400-foot-wide riparian corridor evaluation area.

Dixon Creek

- The mainstem (south of Walnut Avenue) is almost completely residential.
- The majority of the mainstem, although residential, includes a narrow strip of deciduous forest canopy that shades the channel.
- Street crossings that dissect the riparian zone are common on the mainstem.
- Tributaries (north of Walnut Avenue) generally are either in strips of deciduous forest bordered by unmaintained herbaceous vegetation or in continuous deciduous forest.
- Street crossings north of Walnut Avenue are uncommon or non-existent.
- Some first-order tributaries are in herbaceous vegetation.

Oak Creek

- Nearly all of the stream is bordered by a narrow strip of forest canopy.
- The lower 0.9 km (downstream from 35th Street) includes commercial/industrial and residential development; road crossings are common.
- Upstream from 35th Street, the forested area varies from very narrow to the full width of the riparian area, averaging 1/3 to 1/2 of the corridor width.
- Agricultural lands make up most of the remainder of the corridor above 35th Street.

- Above 35th Street, road crossings occur every 0.4 to 0.8 km.

Mary's River

- The riparian buffer along the Mary's River consists mostly of contiguous deciduous forest that extends the full 200 feet on each side of the stream.
- The forest strip is contiguous on both sides of the stream, for the full length of the stream within the UGB.
- A small amount of agricultural lands are located on the outer edges of the corridor just downstream from the point where the Mary's River enters the UGB.

Dunawi Creek

- Six major or complex road crossings fragment the system.
- Scattered but generally small pockets of commercial/industrial and residential development impinge on the corridor in several places.
- A forested strip is adjacent to nearly all of the stream, both mainstem, north fork and south fork; it averages about 1/3 the total width of the corridor.
- South of Philomath Boulevard, the remainder includes residential, commercial/industrial, and infrastructure developments
- North of Philomath Avenue, the remainder mostly consists of agricultural lands.

Sequoia Creek

- Riparian conditions vary along the length of the stream.
- More natural (shrubby) toward the downstream end of Sequoia Creek
- Large number of debris dams in the creek downstream of Jack London Street obstruct flows.

BASELINE CONDITIONS – SUMMARY OF RESULTS

The available data from the streams in the Corvallis area, including the Willamette River, show that all have suffered considerable degradation from likely conditions prior to human settlement. They comprise typical urban streams with incised and straightened channels and riparian buffers reduced in size, continuity, and complexity. Off-channel habitat in the Willamette River has become considerably reduced, or disappeared altogether. While this plays a lesser role in the establishment of the baseline condition, the distinction becomes more important when a trajectory for recovery is considered.

The streams in the Corvallis area, with the exception of the Willamette River, likely contain no listed chinook salmon, except as occasional visitors to the systems during some portion of the winter high flow period. A cursory review of those characteristics required for successful spawning and rearing demonstrate why.

Chinook salmon selectively spawn in the tributaries to major rivers, in third- to fifth-order streams. In order for any of the Corvallis streams to be considered this complex, it would be necessary to include the uppermost tributaries of Dixon and Oak Creek, which have low or no year-round flow, and are unsuitable for spawning or rearing. Chinook spawn in streams classified as Rosgen-type C-3. This describes a stream with moderate sinuosity, a gradient less than 2%, and a high width-to-depth ratio, with numerous gravel pool-riffle complexes and side channels. No Corvallis stream resembles this description except in gradient. They more closely resemble Rosgen-type G-6 streams; low to no sinuosity and low width-to-depth ratio, and containing mainly silt-clay substrates.

Chinook salmon require gravel to cobble substrates in riffle areas for spawning (approximately 16 m^2 area per redd or spawning site), with high amounts of groundwater flow to irrigate the eggs, and low (less than 25%) amount of fine substrate materials that tend to clog intra-gravel spaces (Healey 1991). Preferred spawning areas consist of the transitional areas between pools and riffles found at the nickpoints between bounded and unbounded valley segments (Bjornn and Reiser 1991). This provides downwelling of streamflow into the gravels and upwelling of groundwater. The upwelling appears the most critical of the hyporheic functions for chinook spawning at the reach-level scale of habitat characteristics. Surveys in the Corvallis streams found none of this habitat present.

Throughout their range Chinook salmon spawn at different water depths. Water velocities vary as well. The lack of gravel, high degree of incision, and low flow rates in Corvallis streams make them unsuitable for chinook salmon spawning. While adult Chinook salmon can venture up Corvallis streams, and indeed one was caught in Dixon Creek in the 1950s, spawning adults actively select habitat, and show a preference for the above-mentioned habitat features. Clearly, no successful spawning could occur in these streams, as they contain no habitat.

After hatching, spring chinook salmon spend a more extended portion of their life cycle in fresh water, unlike fall chinook, which migrate to the estuaries after a few weeks. Rearing areas consist generally of side channel areas with deep pool-riffle complexes with an abundance of overhead cover, cool temperatures, and drifting stream insects. These pool-riffle complexes play an important role in salmonid growth and survival (Healey 1991). As salmon are visual predators, water clarity is highly important.

None of the surveyed streams contain any of these elements. Flows are often intermittent, even in the mainstem of some of the streams (e.g. Dunawi Creek), temperatures are high, when flows are high the water is quite turbid, pool-riffle complexes are generally absent, and existing pools are quite shallow. Existing gravels were quite embedded (filled in by sand or silt). This armoring makes them quite difficult to use effectively, whether by juvenile salmon as cover, or as habitat for macroinvertebrate prey species. The lack of these necessary elements of chinook rearing habitat makes Corvallis streams unsuitable for this life history stage, as any rearing habitat in Corvallis streams would be of extremely low quality. Habitat existing in this area would likely only comprise of winter refuge habitat, occupied when flows in the Willamette River become too strong.

When juvenile chinook salmon move from one habitat to another upon hatching, this movement initially goes downstream, not up, essentially a drift. The fact that juvenile chinook salmon barely swim fast enough to stay ahead of the river current strongly suggests that they can spend little time or effort searching out tributary habitat upstream of where they end up, and indeed, likely often find themselves transported by flood flows into areas not suitable for rearing (Healey 1991). Juveniles generally don't drift for long before finding suitable habitat within their natal stream. Juvenile salmon will move as much as 6 km from their natal stream in search of suitable cold, clear pool-riffle complexes to overwinter and rear (Murray and Rosenau 1989). Therefore, juvenile chinook salmon from the Mollala and Santiam Rivers are not likely to seek habitat upstream in the Willamette River, particularly as this necessitates swimming against the current. Following establishment of residence, movements become relatively restricted (Richards and Cernera 1989).

The vast majority of fish moving downstream from the tributaries of the McKenzie and Coast Fork-Willamette likely find sufficient suitable habitat associated with those streams. Studies done as part of the McKenzie Confluence Study and the McKenzie Subbasin Assessment confirm this. Very few fish were found in the Willamette River and the lower McKenzie River during the studies, despite the presence of "above-average" habitat in this area.

There exists no historical record of spawning or productive rearing in any of the streams in and around Corvallis, excepting the Willamette River. It is likely, given their size, hydrology, and geomorphology, that they have never been "chinook" streams. Therefore, impacts to spawning and rearing areas are not critical elements in determining the potential for take resulting from actions by the City.

Despite this, Corvallis streams play a role in the baseline water quality of the Willamette River, and may provide high-water refuge habitat to a small percentage of the total population. As a result, barriers at the mouths of some of the streams could impede use of these areas as refuge habitat. However, during the winter months, flows in Corvallis streams, though quite flashy, may ensure no barriers to access to the lower ends of Oak and Dixon Creeks, the two urban streams likely to serve as refuges.

Riparian areas also play a critical role as shade sources to decrease temperatures, as filters for removing contaminants, and in preventing instream and bank erosion. Especially in the lower reaches of the streams, riparian areas have been severely diminished through development activities.

Channelization results from increased development in the floodplain of the stream, and causes degradation of instream habitat through erosion and simplification, or lack of structures and elements that are necessary to create habitat. The use of streams as stormwater conduits in urban areas further contributes to incision, and diminishes and eventually removes altogether the floodplain connectivity of the system.

Therefore, despite the lack of any focused use of the systems by Chinook salmon, the impacts from contaminants, impervious surface, riparian buffers, and instream habitat conditions (erosion and excessive sedimentation) all play a critical role in the determination of water quality. The result of all this activity, along with the basic human activities associated with living, be they urban, suburban or rural, leads to diminished water quality in these streams. Eventually, this makes its way to the Willamette River, where it may result in a "take."

The Willamette River differs from the other streams, however, as both immigrating adults and emigrating juveniles use the area fronting Corvallis. Adults move upstream from April through June and juveniles move downstream from February through May. Some additional movement occurs in October and November. Conditions in the mainstem Willamette in this area appear mainly unsuitable for any extended rearing or successful spawning, despite the presence of fish in these areas, and so these habitat types are not affected by City activities. It may be that some use the off-channel habitat on the east side of the river, and the presence of structures on the west side as resting areas. This makes activities both in and ultimately affecting the Willamette more critical in terms of take of listed species.